Compendium of honey bee research

Australia and New Zealand 2020

December 2020

CRCHBP
FOR HONEY BEE PRODUCTS

ISBN

ISSN

TITLE: Compendium of Honey Bee Research 2020

Project No. 44

Researcher contact details

Kylie Black and Terena Solomons
Science (University Library) M312
University of Western Australia
Email:

Electronically published by CRC for Honey Bee Products at www.CRChoneybeeproducts.com in 14th July 2022

Contents

INTRODUCTION

The objective of this compendium was to identify and map the literature that describes the academic enquiry into the honey bee (*Apis mellifera*) since it arrived in Australia and New Zealand. Taking a northern hemisphere colony insect into the southern hemisphere will require adaption. This literature is a capture of this change process.

The honey bee was introduced to both Australia and New Zealand in the 1820's and has become a backbone to our agriculture systems and food security as well as supporting a growing honey bee product industry.

Historically honey bee husbandry relied on methods and equipment developed elsewhere in the world, however with adaption, many inventions are locally inspired with the flow hive being a standout example. Biosecurity defines the movement of the livestock, especially with the arrival of pests and diseases. The growth in popularity of managing bee hives, together with climate and land use change, is causing resource competition with Australia and New Zealand entering a new challenge of resource limitation. The academic literature shows change in enquiry as the industry has matured over the last two centuries.

This publication will be for the Australian and New Zealand honey bee industry which includes commercial beekeepers, hobby beekeepers, government officials and the researchers investigating the honey bee and the industry this livestock supports.

Inclusion criteria:

- Honey bees (Apis mellifera) managed in bee hives (hobby and commercial) or feral
- Research undertaken within Australia and New Zealand by researchers based in these countries and publishing world-wide on local research.
- Peer reviewed scientific research, reviews, theses, research undertaken by Government bodies, and articles written by respected peers in the industry. Excluded are the RIRDC/AgriFutures Australia reports as these were not identified on library database searches in 2020. Agrifutures Australia compiled their research in a compendium and provided this at the 4th Bee Congress in 2022.

METHODOLOGY

An extensive search of multiple databases (both freely available and subscription), and grey literature will be undertaken.

Key words informing the search:

Honey bee, Apis mellifera, apiary, apiary site, beekeeper, hive, flow hive, melliferous flora, bee flora, pollination, nectar, pollen, pollinators, biosecurity, disease, Nosema, Amercian Foulbrood, (latin name), European Foulbrood, (Mellissacocyx ..), Varroa destructor, Varroa jacobsoni, deformed wing virus, hive beetle, (latin name), artificial feeding, nutrition, amino acids, sugar, electronic monitoring, packer, honey, honeycomb, pollen, wax, propolis, venom, royal jelly, healing, wound care, prebiotic, oligosaccharides, antimicrobial, methylglyoxal, peroxide, antioxidant, phenolics, economics, marketing, label, traceability

The following databases were searched: Agricola, Biosis, CAB abstracts, Scopus, WoS, ProQuest, Ebsco, Informit, Medline. Embase (Ovid)

Search strategies for Ovid databases CAB Abstracts, Agricola and Biosis.

Database(s): **CAB Abstracts** 1910 to 2020 Week 35
Search Strategy:

#	Searches	Results
1	exp honey bees/	35980
2	exp Apis mellifera/	20799
3	exp honey bee colonies/	3720
4	exp apiaries/	576
5	exp hives/	3319
6	exp beekeeping/	13462
7	exp honey bee venom/	1942
8	Apis mellifera.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	22570
9	apis melifera.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	68
10	Honey bee.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	16286
11	honeybee.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	16421
12	Western honey bee.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	171
13	Western honeybee.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	107

14	European honey bee.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	250
15	European honeybee.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	187
16	apiar*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	3396
17	beekeep*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	13261
18	apiculture.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	11377
19	bee hive*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	636
20	beehive*.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	1421
21	or/1-20	52620
22	Australia.gl.	188196
23	new zealand.gl.	71249
24	australia/ or australian capital territory/ or new south wales/ or northern territory/ or queensland/ or south australia/ or tasmania/ or victoria/ or western australia/	188197
25	new zealand/ or north island/ or snares islands/ or south island/ or stewart island/ or southern alps/ or tasman sea/	71302
26	Australia.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	199804
27	new zealand.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	86271
28	western australia.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	17263
29	queensland.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	31600
30	new south wales.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	30282
31	victoria.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	23444
32	south australia.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	12089

33	northern territory.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	4396
34	australian capital territory.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	2480
35	tasmania.mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	7044
36	or/22-35	282866
37	21 and 36	1484

Date searched: 9th September 2020
Database(s): **AGRICOLA** 1970 to August 2020
Search Strategy:

#	Searches	Results
1	exp honey bees/	6964
2	exp Apis mellifera/	6460
3	exp honey bee colonies/	1671
4	exp apiaries/	740
5	exp beehives/	432
6	exp beekeeping/	2888
7	Apis mellifera.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	11869
8	apis melifera.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	27
9	Honey bee.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	5895
10	honeybee.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	6248
11	Western honey bee.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	75
12	Western honeybee.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	57
13	European honey bee.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	111
14	European honeybee.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	82

15	apiar*.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	1214
16	beekeep*.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	4227
17	apiculture.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	31952
18	bee hive*.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	183
19	beehive*.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	1837
20	australia/ or australian capital territory/ or new south wales/ or northern territory/ or queensland/ or south australia/ or tasmania/ or victoria/ or western australia/	54652
21	new zealand/ or north island/ or snares islands/ or south island/ or stewart island/ or southern alps/ or tasman sea/	18060
22	Australia.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	81502
23	new zealand.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	30867
24	western australia.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	9765
25	queensland.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	11370
26	new south wales.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	10111
27	victoria.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	6560
28	south australia.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	4252
29	northern territory.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	1567
30	australian capital territory.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	339
31	tasmania.mp. [mp=meeting information, title, original title, map information, note, abstract, heading words]	3256
32	or/1-19	39009
33	or/20-31	124113

34	32 and 33	663

Database(s): **BIOSIS Previews** 1969 to 2020 Week 41
Search Strategy:

#	Searches	Results
1	Apis mellifera.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	21775
2	apis melifera.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	105
3	Honey bee.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	15421
4	honeybee.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	12620
5	Western honey bee.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	297
6	Western honeybee.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	190
7	European honey bee.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	409
8	European honeybee.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	309
9	apiar*.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	2038
10	beekeep*.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	3194
11	apiculture.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	10127
12	bee hive*.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	542
13	beehive*.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	1057
14	Australia.ge.	132149
15	new zealand.ge.	41810
16	australia/ or australian capital territory/ or new south wales/ or northern territory/ or queensland/ or south australia/ or tasmania/ or victoria/ or western australia/	132971

17	new zealand/ or north island/ or snares islands/ or south island/ or stewart island/ or southern alps/ or tasman sea/	42284
18	Australia.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	193264
19	new zealand.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	103835
20	western australia.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	18531
21	queensland.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	23216
22	new south wales.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	19326
23	victoria.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	23404
24	south australia.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	8710
25	northern territory.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	3620
26	australian capital territory.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	1042
27	tasmania.mp. [mp=abstract, original language book title (non-english), book title (english), title, heading words]	8164
28	or/1-13	39311
29	or/14-27	296059
30	28 and 29	734
31	limit 30 to english language	677

RESULTS

AGRICULTURE CHEMICALS

Ardley, J. H. (1999). "Pesticide considerations: an environmental concern." Agricultural Science 12(2): 21-24.

Environmental losses from pesticide use affect the community as a whole. Often less than 0.1% of applied pesticide spray reaches the target pests, leaving the bulk to affect the environment. The article discusses pesticide use on the following: public health, domestic animal poisonings, contaminated products, destruction of beneficial natural parasites and predators, pesticide resistance in pests, honey bee and wild bee poisonings, reduced pollination, crop and crop product losses, surface water contamination, damage to micro-organisms and invertebrates and government funds for pollution control. Comparisons are made between Scandinavia, The Netherlands and Australia in their response to pesticide pollution.

Berry, I. (1983). "Horticulture boom putting pesticide pressure on expanding apiaries Toxicity to honeybees, New Zealand." New Zealand beekeeper.: 6-7.

Broadley, R. H. (1992). Protect your strawberries. Australia, Dept of Primary Industries Brisbane.

In this book aimed at growers of strawberries in Queensland, the first chapter consists mainly of a list of the pests and diseases encountered in that area. The other 11 chapters discuss pest management before planting, during plant growth and fruiting, after harvest and in ratoon crops; weed management; birds and animals; honey bee management; pesticide data; pesticide application equipment and technology; pesticide safety and handling; and pesticide compatibility. Appendices list commercial suppliers of pesticides, biological control agents, equipment, and safety information and conversion tables for common measurements are included. Some further reading is recommended.

Broadley, R. H. and P. D. Rossiter (1982). "Incidence of Nysius spp. (Hemiptera: Lygaeidae) in south Queensland sunflowers." General and Applied Entomology 14: 69-71.

Populations of *Nysius* spp. were studied in crops of sunflower on the Darling Downs, Queensland, in the growing seasons of 1978-81. Adults predominated in the budding and flowering periods, and nymphs were markedly confined to the post-flowering period. Infestation was higher on early- than on late-season crops, with breeding being insignificant in late-season crops. *N. vinitor* Bergr. was more numerous than *N. clevelandensis* (Evans). These results are discussed in relation to the timing of chemical control and the avoidance of damage to pollinating honey bees (*Apis mellifera* L.). ADDITIONAL ABSTRACT: Populations of 2 *Nysius* species, major pests of sunflowers, were studied on unsprayed crops. Adults predominated during the budding and flowering periods; nymphs were confined to the post-flowering period. From this information and further data on population build-up, it is concluded that pesticide applications during flowering (which are likely to poison honeybees) can be avoided. Early adult *Nysius* infestations should be treated during budding, and if populations still increase, spraying after flowering gives adequate control.

Broadley, R. H. (1980). "Pesticides, bees and sunflowers." Advisory Leaflet, Queensland Department of Primary Industries (1492): 6-pp.

Reprinted from Queensland Agricultural Journal 106(3): 255-258 (1980).

Broadley, R. H. (1978). "Insect pests of sunflower." Queensland Agricultural Journal 104(4): 307-314.

Notes are provided on the biology, injuriousness and chemical control of insect pests on sunflower in Queensland. Most are generalised feeders; routine control is not required as the plant is able to tolerate a considerable degree of damage. Pests of the seedlings include *Gonocephalum* spp., *Pterohelaeus* spp., elaterids, the crickets *Gryllotalpa africana* P. de B., *Teleogryllus commodus* (Wlk.) and *Modicogryllus lepidus* (Wlk.) (*T. lepidus*), and the earwig *Nala lividipes* (Duf.); the predacious earwig *Labidura riparia truncata* Kby. also occurs in sunflower fields. Pests of older plants include *Nysius vinitor* Bergr., *N. clevelandensis* Evans, *Diachrysia orichalcea* (F.) (*Trichoplusia orichalcea*), *Heliothis punctigera* Wllgr. and (to a lesser extent) *H. armigera* (Hb.). About 6 other insects associated

with sunflower are discussed. The relation between insect damage (especially by *Heliothis*) and head rot (caused by *Rhizopus*) is also discussed. The insecticides recommended for the control of various pests on older plants include malathion, methidathion, endosulfan and chlorpyrifos, and the importance of avoiding applications at the peak periods of activity of pollinating insects (especially honeybees [*Apis mellifera* L.]) is emphasised.

Bryant, T. (1983). "Slipshod pesticide practices put pollination services at risk Toxicity to honeybees, New Zealand." New Zealand beekeeper.: 12-12.

Clemson, A. A. (1979). "Insecticides can kill bees." Agricultural Gazette of New South Wales 90(4): 4-5.

The author describes how the careful use of insecticides can minimise injury to honey bees [*Apis mellifera* L.], with special reference to conditions in New South Wales.

Clinch, P. G. (1969). "Laboratory determination of the residual fumigant toxicity to honey bees of insecticide sprays on white clover (*Trifolium repens* L.)." New Zealand Journal of Agricultural Research 12(1): 162-pp.

The following is based on the author's abstract. In an experiment in New Zealand, various insecticides were applied as sprays to the flowers of white clover (*Trifolium repens*) standing in jars of water, and their persistent fumigant effects determined by enclosing honey bees above the flowers for an hour either 3 or 18 hr. after application [cf. RAE A 57 439]. Of the 18 compounds tested, only Cyanox (O, O-dimethyl O-p-cyanophenyl phosphorothioate), diazinon and gamma BHC (lindane) showed persistent toxicity. Initial fumigant toxicity tests were shown to be unreliable guides to persistent fumigant toxicity.

Clinch, P. G. (1970). "Effect on honey bees of combs exposed to vapour from dich-lorvos slow-release strips." New Zealand Journal of Agricultural Research 13(2): 448-pp.

The following is virtually the author's abstract. An experiment in New Zealand is described in which empty honeycombs were exposed for four months to vapour from dichlorvos slow-release strips. The combs absorbed the insecticide and were toxic to honey bees for approximately one month after exposure ceased.

Clinch, P. G. and T. Palmer-Jones (1971). "Effect on honey bees of dicrotophos applied as a pre-blossom spray to raspberries (*Rubus idaeus* L.)." New Zealand Journal of Agricultural Research 14(4): 927-930.

The following is virtually the authors' abstract of this account of investigations in New Zealand. Dicrotophos applied in a spray at the rate of 0.43 lb toxicant/acre to raspberry plants six days before flowering continued to kill honey bees 16 days after application but had little or no effect after 21 days. Differences in the persistence and toxic effect on honey bees of residues of dicrotophos on various flowering crops [cf. RAE A 55 2074; 58 2995] are discussed.

Clinch, P. G. and T. Palmer-Jones (1974). "Effect on honey bees of azinphos-methyl applied as a pre-blossom spray to Chinese gooseberries." New Zealand journal of experimental agriculture 2(2): 205-207.

Azinphos-methyl was applied in pre-blossom sprays to Chinese gooseberry (*Actinidia chinensis*) in four orchards in New Zealand for the control of Tortrix spp. The crop is dependent on cross-pollination, and hives of honey bees were brought into the orchards for this purpose. In samples of bees collected at flowering and kept in the laboratory for 24 h, there was no evidence of mortality caused by azinphos-methyl, except in bees from one orchard where it was considered that they had been affected by the compound applied in a neighbouring Citrus grove against Tortrix spp. It is considered that previous losses in hives in Chinese gooseberry orchards had occurred in a similar way. ADDITIONAL ABSTRACT: Pre-blossom sprays to chinese gooseberries had no effect on honeybees subsequently visiting the flowers. All the bees, however, gathered pollen and no nectar secretion by either male or female flowers was observed. It is recommended that azinphos-methyl spraying be carried out before the first flowers open.

Clinch, P. G., et al. (1966). "Effect on honey bees of diazinon and phenthoate applied as sprays to white clover (*Trifolium repens* L.)." New Zealand Journal of Agricultural Research 9(4): 980-pp.

Diazinon and phenthoate are of potential value in New Zealand for the control of Coleophora spp., which damage seed crops of white clover (*Trifolium repens*) [cf, RAE A 52 392], but in a. test in which they were applied at respective rates of 1 and 1.25 Ib. per acre to white clover in flower, they proved highly toxic to honey bees.

Clinch, P. G., et al. (1973). "Effect on honey bees of dicrotophos and methomyl applied as sprays to white clover." New Zealand journal of experimental agriculture 1(1): 97-99.

It was shown in field tests in New Zealand in December 1971 that dicrotophos and methomyl, applied in sprays at 0.5 kg/ha to flowering white clover (*Trifolium repens*) in the evening after bees had ceased flying caused mortality for 7 and 8 days, respectively, after treatment. With dicrotophos, mortalities amongst samples of bees collected in the treated plots were highest (98-100%) on the second and third days after treatment. Observations of activity at the hives showed that colonies returned to normal within three days. With methomyl, the effects were more prolonged and severe and nectar collection ceased for four days. Observations on the behaviour of bees in the field indicated that neither compound had a repellent effect.

Clinch, P. G. and J. G. M. Ross (1970). "Laboratory assessment of the speed of action on honey bees of orally dosed insecticides." New Zealand Journal of Agricultural Research 13(3): 717-pp.

The following is based largely on the authors' abstract of this account of investigations in New Zealand. A laboratory test to determine the times taken by insecticides administered orally to affect and paralyse honey bees is described. Ten insecticides were tested at concentrations 1.5, 2 and 4 times that of their LD90's. The results are expressed as the times taken after consumption of the test doses for 50 and 90% of the bees to become affected and later paralysed. At the lowest dose, methomyl, the fastest acting insecticide, affected bees approximately 16 times as fast as did monocrotophos, the slowest. Possible difficulties in interpreting the results of field trials with fast-acting compounds are discussed.

Colin, T., et al. (2019). "Long-term dynamics of honey bee colonies following exposure to chemical stress." Science of the Total Environment 677: 660-670.

Pesticide residues have been linked to reduced bee health and increased honey bee colony failure. Most research to date has investigated the role of pesticides on individual honey bees, and it is still unclear how trace levels of pesticides change colony viability and productivity over seasonal time scales. To address this question, we exposed standard bee colonies to chemical stressors known to have negative effects on individual bees and measured the productivity of bee colonies across a whole year in two environments: near Tucson Arizona and Sydney Australia. We exposed hives to a trace amount of the neonicotinoid imidadoprid and to the acaricide thymol, and measured capped brood, bee and honey production, as well as the temperature and foraging force of the colonies. The effect of imidacloprid on colony dynamics differed between the two environments. In Tucson we recorded a positive effect of imidacloprid treatment on bee and brood numbers. Thymol was associated with short-term negative effects on bee numbers at both locations and may have affected colony survival at one location. The overall benefits of thymol for the colonies were unclear. We conclude that long-term and colony-level measures of the effects of agrochemicals are needed to properly understand risks to bees. (C) 2019 Elsevier B.V. All rights reserved.

Cook, V. A. (1972). "Protecting bees from insecticides." New Zealand Journal of Agriculture 123: 61-62.

Cook, V. A. (1977). "Protecting honey bees by controlling pesticide applications to cruciferous and leguminous seed crops in New Zealand." Proceedings of the XXVIth International Apicultural Congress, Adelaide.: 448-451.

Ferguson, F. (1988). "Long term effects of systemic pesticides on honey bees." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 137-141.

The effects of feeding sub-lethal doses of systemic pesticides in sugar syrup to honeybees in 6-frame nucleus hives were evaluated in Queensland, Australia. Brood mortality occurred within 6 days in colonies receiving dimethoate, methamidophos, monocrotophos and omethoate at 2.5 and 5.0 ppm; these colonies died out or were robbed. In colonies treated with the 1.0, 0.5 and 0.1 ppm concentrations of these pesticides larval mortality occurred at between 14 and 40 days of feeding, but the majority of these colonies recovered. Colonies fed methidathion, 2,4-D, demeton-s-methyl, fenthion and fenamiphos at 2.5 and 5.0 ppm were devoid of larvae within 17-25 days of feeding, but the effects of this group of pesticides were not as severe as those of the former group. Glyphosate did not significantly affect adult bees or brood. Pesticide residues in pollen collected by honeybees from sunflower and oil seed rape crops treated with pesticides at recommended field rates were at a level that caused larval mortality. Queens in colonies fed methamidophos ceased laying and did not recommence for up to 52 days. Management of colonies which may be exposed to systemic pesticides is discussed.

Goodwin, R. M. and A. t. Houten (1991). "Poisoning of honey bees (*Apis mellifera*) by sodium fluoroacetate (1080) in baits." New Zealand Journal of Zoology 18(2): 45-51.

Some high honey bee mortalities have been reported in areas (in New Zealand) where sodium fluoroacetate (1080) + jam baits are used to kill opossums. Of 4 samples of dead bees, 3 contained 1080 (3.1, 3.8 and 10 mg/kg). In trials, baits placed near hives were consumed within 8 h; bees started to die after 1.5-2 h, but during this time a forager could make up to 4 visits to the bait and also recruit other foragers. Black strap molasses added to the bait had a repellent effect on honey bees. Foragers could detect differences in concentration as small as 5%; the addition of 20% molasses strongly repelled inexperienced foragers but did not repel opossums. The addition of 2% oxalic acid (a component of molasses) to sugar syrup or to the bait also repelled foraging honey bees.

Harrington, K. C., et al. (2015). "Field assessment of herbicides to aid establishment of manuka (*Leptospermum scoparium*)." New Zealand Plant Protection 68: 132-138. Herbicide treatments were assessed in two concurrent experiments for improving the establishment of manuka seedlings (three provenances) transplanted into hillside pastures for honey production. Height and trunk diameters 18 months after planting were still significantly reduced by initial poor control of weeds. Controlling weeds in a patch of 1.0 m diameter gave better manuka growth than doing so in a 0.5 m diameter patch. Two of the more effective treatments were a mixture of glyphosate, simazine and clopyralid applied before planting, and a post-planting application of glyphosate and simazine sprayed while shielding the manuka. A mixture of haloxyfop, clopyralid and simazine applied in August then again in December following planting in July gave no further improvement in manuka growth than when applied only in August. Residues of metsulfuron equivalent to 120 g ai/ha applied just prior to transplanting caused no adverse effects in any of the three provenances of manuka.

Hertel, K. and K. Woodlands (1998). "Insect and mite control in field crops 1998." Orange NSW Agriculture ISSN 1441-: vi-pp.

Information is given on the control of insect and mite pests in a wide range of field crops (adzuki beans, canola [rape], chickpeas, cowpeas, faba beans, peas, linseed, lupins, maize, mung beans, navy beans, groundnuts, pigeon peas, safflower, sorghum, soyabeans, sunflowers and winter cereal crops) [in New South Wales, Australia] with particular reference to the significance and control of the more common pests or potential pests of these crops. Information on the toxicity of insecticides to humans, bees, fish and birds and herbicide/insecticide compatibilities is also given, with a guide to retail product prices.

Jones, W. A. and R. H. Holtkamp (1991). "Pesticides and bees (pesticides affecting beekeeping and crop pollination)." Agnote (Darwin) (485): 6-pp.

This leaflet on nontarget effects of pesticides from Australia was copied almost verbatim from NSW Agriculture & Fisheries Agfact No. A8.9.7; changes were made only where necessary for the publication to be relevant to the Northern Territory. It contains notes on poisoning of honey bees [*Apis*] by pesticides (including insecticides, acaricides, herbicides and fungicides), pesticide toxicity, and how bee losses can be reduced.

Kessell, A. C. (1972). "Effect on bees of insecticides used on rape." Journal of Agriculture, Western Australia 13(3): 83-86.

Rape is being grown on an increasing scale in Western Australia. The danger to honey bees (both as pollinators and honey producers) from insecticides applied to control insect pests (including aphids, *Heliothis punctigera* Wllgr., *Hellula* sp., *Pieris rapae* (L.) and *Plutella xylostella* (L.)) on rape in flower is emphasised, and recommended precautions are described. In a field test in spring 1971, methyl-demeton-S was applied in sprays after dark. Bees from several apiaries within one mile were working the crop early the following morning and there were no signs of losses of bees from these apiaries. In another test, caged bees were placed in the field and four insecticides were applied in sprays. With methidathion, methomyl (Lannate), trichlorphon and methyl-demeton-S, about 8, 20, 35 and 100%, respectively, of the bees were still alive one hour after treatment. Eight hours later, under 10% were still alive with the first three compounds and about 50% with methyl-demeton-S. The danger to the colonies from affected bees returning and causing contamination is discussed. Recommendations for the chemical control of pests, using carbaryl, DDT, methidathion, methyl-demeton-S and trichlorphon are tabulated, with special reference to the toxicity of these compounds to bees.

Kessell, A. C. (1983). "Pesticides and the apiculture industry." Apiculture Workshop Papers: Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 314-322.

Langridge, B. F. (1965). "Effects of acrolein weedicide on honey bees." Journal of the Department of Agriculture of Victoria, Australia 63(7): 349-351.

Acrolein is currently in extensive use by the State Rivers and Water Supply Commission of Victoria to control *Potamogeton* spp., *Elodea canadensis*, *Vallisneria spiralis* and *Myriophyllum elatinoides* in irrigation channels. In experiments to determine the toxicity of acrolein solutions to bees, sugar syrup containing 100 ppm acrolein was fed to marked bees for 2 days. There were no signs of significant mortality, nor was there any evidence that the solution was repellent to the bees. It was therefore concluded that under conditions of normal field application, acrolein did not constitute any hazard to bees. -P.J.B.

Langridge, D. F. and B. D. Wightman (1977). "Kill the pests, not the bees." Dept of Agriculture, Victoria ISBN 07241: 7-pp.

Notes on the pollination of oil crops in Victoria, and measures for protecting honeybees from pesticides.

Langridge, D. F. and B. D. Wightman (1977). "The management of insect pests and honey bees in crops." Australian bee journal 58(7): 4-6.

Levot, G., et al. (2016). "A six-month-long assessment of the health of bee colonies treated with APITHOR (TM) hive beetle insecticide." Journal of Apicultural Research 54(4): 386-393.

The safety of APITHOR((TM)) hive beetle insecticide on the health of honey bee colonies was assessed in a field trial in which 16 bee colonies that were exposed to two consecutive treatments each of three-months duration, were compared with 10 untreated (control) hives. Measurements of brood area, available hive frames occupied by bees (hive strength) and hive weight (as an indirect indicator of honey production) were recorded pre-treatment and after three-and six-months exposure to APITHOR (TM) treatment. Samples of honey and wax collected from six of the treated hives at the same times were independently tested for the presence of fipronil and its metabolites, and no residues were detected in any sample at either time. Mean net increases in the weights of the APITHOR((TM)) treated and control hives were not significantly different ($p > .05$). Similarly, neither mean brood area nor the mean proportion of available hive frames occupied by bees in the control and APITHOR((TM)) treated hives was significantly different from each other ($p > .05$) at both the three-and six-month post-treatment assessments.

Compared to the control hives, however, significantly ($p < .001$) fewer live beetles were recorded in the APITHOR((TM)) treated hives at these times.

Levot, G. W. (2008). "An insecticidal refuge trap to control adult small hive beetle, *Aethina tumida* Murray (Coleoptera: Nitidulidae) in honey bee colonies." Journal of apicultural research. 47(3): 222-228.

The establishment of the small hive beetle in eastern Australia and its subsequent economic impact on bee keeping prompted research into the insecticidal control of adult beetles inside the hive. A refuge trap comprising a two-piece rigid plastic shell encasing a fipronil-treated corrugated cardboard insert was developed. The precise dimensions of the harbourage entrance slots allow beetles to enter but prevent bee access or contact with the insert. Mean fiprole (fipronil plus its toxic metabolites) residues in honey ripened in research hives over one month while the devices were in place did not exceed 1 mg kg-1 and no ill effects on the bees were observed. A field trial was conducted at three western Sydney apiaries during autumn 2007 when beetle numbers were naturally increasing. Results demonstrated that deployment of a single harbourage on the bottom board of 26 infested hives caused an estimated 62% overall beetle mortality within 6 weeks and reduced mean live adult beetle numbers by 96%.

Lloyd, N. C. (1975). "Possible alternatives to DDT for control of plague thrips in apples." Australian Journal of Experimental Agriculture and Animal Husbandry 15(76): 715-720.

Seven insecticides were tested in sprays in the field in New South Wales in October 1971 as alternatives to DDT for the control of Thrips imaginis Bagn. on apples [cf. RAE/A 62, 2778, etc.]. On the basis of counts of thrips before and 4-7 days after treatment, and ratings of the injury caused to styles of the blossoms, none of the treatments was as effective as the standard one with 0.1% DDT, but 0.1% DDD (TDE), 0.066% endosulfan, 0.06% malathion (maldison), 0.2% methoxychlor and 0.1% tetrachlorvinphos were sufficiently effective to be considered as possible alternatives. Toxaphene (chlorcam) at 0.15% and phosalone at 0.06% were less effective in reducing thrips numbers, but phosalone was as effective as some other treatments in reducing damage to styles. In a further test, malathion, endosulfan and methoxychlor were less repellent to bees than was the standard DDT treatment, but DDD and tetrachlorvinphos were not significantly less repellent. The only significant tree injury was a severe browning and premature drop of petals when DDD and methoxychlor were applied to trees in full bloom.

Lowe, A. D. (1956). "Insecticides applied to crops in flower can poison bees." New Zealand Journal of Agriculture 93: 229-230.

Bee colonies were severely damaged when in the spring a brassica seed crop, 75-1, 000 yd. away, was dusted from the air with lindane (0.5 lb. active ingredient per acre). -D.S.I.R., Ashburton.

Maelzer, D. A., et al. (1982). "Pollination and arthropod pest management of lucerne seed crops in south Australia." Proceedings of the 3rd Australasian Conference on Grassland Invertebrate Ecology / K.E. Lee, editor.: 385-392.

Manning, R. (2018). "Chemical residues in beebread, honey, pollen and wax samples collected from bee hives placed on canola crops in Western Australia." Journal of Apicultural Research 57(5): 696-708.

Samples were collected from bee hives where bees had foraged on genetically modified, seed-treated and non-seed treated canola crops from July to September 2014. Chemical analysis of 240 beebread, honey, pollen and wax samples detected 14 chemical residues with overall detections averaging 1.22 chemicals per sample. Contamination was highest in pollen (2.31) followed by beebread (1.69), wax (1.43) and honey (0.32). The dominant chemicals were the herbicides atrazine and trifluralin, followed by the insecticide chlorpyrifos. Of the seed treatment neonicotinoids, imidacloprid was detected in ten beebread, pollen and honey samples and thiamethoxam was only found in one honey sample. None of the pesticide residues reported from bee hives were likely to pose a risk to honey bees as indicated by a comparison to the LD50 data. From September to December, bee hives produced honey with mean weights ranging from 18.6 to 35 kg/hives.

Mayer, D. F. (1997). "Effects of methyl salicylate on honey bee (*Apis mellifera* L.) foraging." New Zealand Journal of Crop and Horticultural Science 25(3): 291-294.

Bee poisoning from pesticides used in agriculture, forestry, urban environments, and public health is a serious problem affecting many bee colonies worldwide. A bee repellent adjuvant would be useful in reducing the bee injury when pesticides are applied to bloom. Applications of methyl salicylate to blooming apples did not appear to repel foraging honey bees (*Apis mellifera* L.) or reduce fruit set. Applications of methyl salicylate at the highest rate reduced honey bee foraging on blooming dandelions for 4 h or less, and probably not long enough to reduce bee kills.

Melksham, K. J., et al. (1985). "The problem of pesticide toxicity to honeybees in Queensland, Australia." Bee world. 66(4): 140-147.

Palmer-Jones, T. (1958). "Laboratory methods for measuring the toxicity of pesticides to honey bees." New Zealand Journal of Agricultural Research 1(3): 290-pp.

Palmer-Jones, T. (1959). "Effect on honey bees of thiodan applied to broad beans in a cage." New Zealand Journal of Agricultural Research 2(2): 229-233.

In a cage test, thiodan [endosulfan] was sprayed on *Vicia faba* at the rate of 56 gal. of a 1 % solution per ac. The experiment shows that thiodan [endosulfan] can be applied to broad beans in flower without causing bee mortality, provided that it is used when bees are not flying. It cannot be recommended for application to brassicas in flower. F. s.-M.H.

Palmer-Jones, T. (1960). "Effect on honey-bees of some chemical weedkillers." New Zealand Journal of Agricultural Research 3(3): 485-490.

In tests in the laboratory, in observation hives, and in the field, the butyl and butoxyethanol esters of 2, 4, 5-T were harmless to honeybees; dinoseb + dinosam and PCP were repellent to bees, and when sprayed on bees, killed them. There was no contamination of unsprayed by sprayed bees in these experiments. - J.W.F.

Palmer-Jones, T. (1964). "Effect on honey bees of 2,4-D." New Zealand Journal of Agricultural Research 7(3): 339-342.

After aerial applications of mixtures of 2, 4-D Na (dust) at 3 pounds per acre + superphosphate at 3 cwt/ac in December 1959 to control ragwort [Senecio jacobaea] in newly established pasture, serious mortality of adult honey bees, involving several hundred hives, was reported in the Rotorua-Taupo district of New Zealand. In experiments, the same rate of 2, 4-D + superphosphate was applied to a 20-ac area in November 1960. Bee mortality within 48 hr after application was 22%, though there was no adverse effect on brood or hive activity. Bees were not apparently affected by direct dusting with 2, 4-D and it was therefore concluded that poisoning may have occurred via the nectar. From the results, it was recommended that in the Rotorua-Taupo district, large-scale application of 2, 4-D should not be made during the period from mid-November to late February, during which time white clover is in flower. -P.J.B.

Palmer-Jones, T. (1965). "Toxicity of pesticides to honey bees." Proceedings 18th N.Z. Weed Pest Control Conf.: 203-207.

In New Zealand, the Apiaries Protection Regulations prohibit the application of pesticides toxic to honey bees in cruciferous and leguminous crops during the period between September and March. Dinoseb.+. dinosam, endothal, PCP and 2, 4, 5-T butyl and butoxyethanol esters are deemed non-toxic to bees. Though normal field applications of 2, 4-D are also considered to be innocuous to bees, the chemical may be severely toxic when applied on a large-scale (see Weed Abstr. 13: 1863). Laboratory and field techniques used at the Wallaceville Animal Research Centre to evaluate possible toxicity of pesticides to honey bees are briefly described. - J.L.M.

Palmer-Jones, T. and P. G. Clinch (1968). "Effect on honey bees of dichlorvos and bromophos applied as sprays to white clover (*Trifolium repens* (L.)." New Zealand Journal of Agricultural Research 11(1): 138-pp.

Since dichlorvos and bromophos are possible agents for the control of Coleophora spp. on clover in New Zealand, their effects on honey bees were investigated. As reported in the authors' abstract, emulsion concentrates of 50% dichlorvos and 20 bromophos were applied to flowering crops of white clover (*Trifolium repens*) at rates of 0.5 pint in 15 gal water and 2 pints in l3 gal water, respectively, per acre in the evening, when bees had ceased to fly. Both compounds proved safe to honey bees.

Palmer-Jones, T. and P. G. Clinch (1973). "Effect on honey bees of BTS 27419 applied as a spray to apple trees." New Zealand journal of experimental agriculture 1(2): 195-196.

Laboratory tests in New Zealand had shown that the acaricide 1,5-di(2,4-dimethylphenyl)-3-methyl-1,3,5-triazapenta-1,4-diene (BTS-27419) was only moderately toxic to honey bees. Consequently, a field test was carried out in October 1972 on a block of 216 apple trees in blossom. The compound was applied by hand in a high-volume spray at a concentration of 0.4 g/litre at 10 a.m. to half the trees when bees were visiting the flowers. Counts of bees visiting the trees in the following 28 h showed that the compound had no repellent effect. No mortality occurred in bees collected from treated trees, and no adverse effects were observed in hives about 100 m from the trees.

Palmer-Jones, T. and et al. (1954). "Effect on honey bees of DDT plus superphosphate applied as a dust to white clover pasture." New Zealand Journal of Science and Technology 36(2): 177-192.

DDT plus superphosphate was dusted over 12 acres of white clover pasture at the rate of 2 lb. of 100% p.p.i. DDT per acre. This mixture was applied in the manner recommended for grass-grub control. It was established by marking and counting that bees from a nearby experimental apiary were collecting nectar extensively from the dusted areas. Evidence was obtained that the DDT repelled bees for some days after application. Field bees collected from the dusted clover flowers did not show a high mortality [in 3 samples, each 14% after 24 hours and 38, 29, 27% respectively after 96 hours] and no adverse effects on the hives were observed. It is concluded that such dusting would cause only negligible losses of bees in neighbouring apiaries. -From authors' summary.

Palmer-Jones, T. and I. W. Forster (1958). "Effect on honey bees of DDT applied from the air as a spray to lucerne; notes on lucerne pollination." New Zealand Journal of Agricultural Research 1(5): 627-632.

Ten ac. of lucerne at Kurow were sprayed from the air with a DDT emulsion (stantox) at the rate of 2 lb. of 100% pp'-DDT in 10 gal. of water per ac. Before spraying, 23 hives of bees had been established on the crop. The spray was applied early in the morning when there was practically no bee activity, but shortly afterwards conditions were suitable for maximum bee activity. No adverse effect on adult bees or brood was observed. The crop was strongly repellent to bees for a day after spraying. The DDT spray can be used without harming honey bees or bumble bees, provided that it is applied when they are not on the lucerne. This insecticide is a logical choice for controlling the range of insects which attack lucerne. F. s. -M.H.

Palmer-Jones, T. and I. W. Forster (1958). "Effect on honey bees of some defoliants." New Zealand Journal of Agricultural Research 1(5): 620-626.

A mixture of 50% dinoseb + 10% dinosam at 2 pints in 10-gal diesel/ac, and 40% PCP 10 lb in 10-gal diesel/ac were applied from the ground as defoliants to fields of flowering white clover at a time when bees were visiting the flowers. Both defoliants acted as strong repellents and no bee mortality occurred. In plot tests similar results were obtained; the defoliant mixture in aqueous solution and dieseline alone were also strongly repellent. Endothal used as a defoliant at 2 gal in 40-gal water/ac caused no mortality even though it did not repel bees. Laboratory tests proved that endothal would cause negligible, and diesel moderate, bee mortality; the other repellent defoliants were highly toxic. - B.J.W.

Palmer-Jones, T. and I. W. Forster (1963). "Effect on honey bees of dipterex, thiodan, and phosdrin applied as sprays to white clover (*Trifolium repens* L.)." New Zealand Journal of Agricultural Research 6(3-4): 303-306.

When white clover seed crops were sprayed in the early morning before bee visitation began, dipterex at l.21b/ac and thiodan [endosulfan] at 0.71b/ac were safe to field bees, but phosdrin at 0.4 Ib/ac caused heavy mortality. F. s.-J.G.G.

Palmer-Jones, T. and I. W. Forster (1964). "Effect on honey bees of phosphamidon applied as a spray to white clover (*Trifolium repens* L.)." New Zealand Journal of Agricultural Research 7(4): 644-pp.

The following is virtually the authors' abstract. Phosphamidon applied at the rate of 5 oz. active ingredient per acre to a flowering crop of white clover (*Trifolium repens*) in the Christchurch district of New Zealand proved highly toxic to honey bees.

Palmer-Jones, T., et al. (1957). "Effect on Honey Bees of Metasystox applied from the Air as a Spray to Chou Moellier." New Zealand Journal of Science and Technology, Section A 38(7): 752-pp.

The following is based on the author's summary of this account of experiments to determine the effect on honey bees of Metasystox (dimethyl 2-(ethylthio)ethyl phosphorothioate [methyl-demeton]) applied to cruciferous seed crops against Aphids in New Zealand. Metasystox was applied in an emulsion spray from the air to 11 acres of marrow-stem kale (chou moellier) in flower, at a rate estimated at 16 fl. oz. per acre, in the evening when no bees were flying. Before the application, bees from a neighbouring experimental apiary were collecting nectar and pollen extensively from the crop. The spray killed virtually all foraging bees within two days, and nectar in the kale flowers was shown to be toxic to bees for five days after spraying. All bumble bees (*Bombus* spp.) visiting the crop were killed. It is concluded that plants that have flowers attractive to bees should not be sprayed with Metasystox for at least a fortnight before they flower.

Palmer-Jones, T., et al. (1959). "Effect on honey bees of DDT and Thiodan applied from the air as sprays to chou moellier." New Zealand Journal of Agricultural Research 3(2): 481-pp.

The following is based on the authors' summary which contains an account of work in New Zealand on the effect of insecticides on honey bees. Two flowering crops of marrow-stem kale (chou moellier) in flower were sprayed early in the day, one with an emulsion spray of 2 Ib. p, p'DDT in 7 gal. water per acre and the other with an emulsion spray of 1.2 Ib. Thiodan in 7 gal. water. Honey bees were repelled by the DDT for six days after application, but there was no evidence that it affected bumble bees (mostly *Bombus terrestris* (L.)). Some mortality occurred among the honey bees, though not enough to weaken the hives, and the brood was unaffected. Thiodan showed no repellence and was more lethal than DDT to the honey bees. Although no adverse effect on adult bees or brood was observed in the apiary, it is considered that the hives would have been seriously affected if an area of more than one acre had been sprayed, and this material should therefore not be applied to cruciferous crops in flower.

Palmer-Jones, T., et al. (1959). "Effect on honey bees of Rogor and endothion applied from the air as sprays to brassicas; trial of M.G.K. repellent 875." New Zealand Journal of Agricultural Research 3(2): 475-pp.

The following is based on the authors' summary of work in New Zealand on the effect of insecticides on honey bees. Turnips in flower were sprayed from the air with dimethoate as a proprietary preparation (Eogor 40) containing 40 per cent. (w/v) active ingredient, which was applied at 16 fl. oz. in 7 gal. water per acre to two acres of a seed-crop, and rape in flower with a 0.33 per cent. aqueous solution of endothion, of which 30 gal. was applied also over two acres; the dimethoate spray included 8 oz. of an emulsion concentrate containing 50 per cent. M.G.K. repellent 874 (a recently developed bee repellent). Both sprays were applied in the early morning, and neither repelled the bees that subsequently visited the crops. Dimethoate proved highly toxic to the bees, though the brood was not affected, but endothion caused no mortality. Endothion also had little effect on Brevicoryne brassicae (L.) infesting the rape, although it was stated to kill this aphid in Britain quite readily when applied from the ground at 0.02-0.04 per cent. and a rate of 100 gal. per acre.

Palmer-Jones, T., et al. (1958). "Effect on honey bees of toxaphene and Strobane applied to white clover pasture." New Zealand Journal of Agricultural Research 1(5): 694-pp.

Losses of seed-crops of white clover (*Trifolium repens*) in New Zealand following attack by *Coleophora spissicornis* (Haw.) and the species tentatively identified as *C. alcyonipennella* (Koll.) [cf. R.A.E., A 48 247] amount to about 10 and in some cases may be as high as 80 per cent. [cf. preceding abstract but one]. Insecticidal sprays applied in spring and summer, when bees are also present on the crop, appear to offer most promise for control. Since preliminary laboratory tests indicated that toxaphene and Strobane were the materials least likely to harm bees, their toxicity to bees in the field was tested, and the following is based on the authors' summary of the work. Toxaphene was sprayed and dusted over 12 acres of white-clover pasture at the rate of 5 Ib. actual toxaphene per acre, and Strobane was sprayed over eight acres of white-clover pasture at 5 Ib. actual Strobane per acre. All applications were made in the early morning, when no bees were flying. Bees from neighbouring experimental apiaries collected nectar extensively from the clover flowers in both experimental areas soon after all these applications; pollen was also collected. There was no evidence of bee mortality or adverse effect upon brood after the toxaphene applications. A slight mortality in field bees was apparent after the Strobane application, but no dead bees were brought out of the hives and brood was unaffected. It is considered that toxaphene causes no bee mortality when applied to clover pasture. Strobane causes only negligible losses of bees and is safe to use. These conclusions apply only when toxaphene and Strobane are applied at a time when bees are not flying. It is unlikely that toxaphene would cause bee mortality if put into general use on crops; Strobane can safely be used on clover pasture but should be applied with caution elsewhere.

Paynter, Q., et al. (2010). "Disruption of an exotic mutualism can improve management of an invasive plant: varroa mite, honeybees and biological control of Scotch broom *Cytisus scoparius* in New Zealand." Journal of applied ecology. 47(2): 309-317.

1. A seed-feeding biocontrol agent *Bruchidius villosus* was released in New Zealand (NZ) to control the invasive European shrub, broom *Cytisus scoparius*, in 1988 but it was subsequently considered unable to destroy sufficient seed to suppress broom populations. We hypothesized that an invasive mite *Varroa destructor*, which has caused honeybee decline in NZ, may cause pollinator limitation, so that the additional impact of *B. villosus* might now reach thresholds for population suppression. 2. We performed manipulative pollination treatments and broad-scale surveys of pollination, seed rain and seed destruction by *B. villosus* to investigate how pollinator limitation and biocontrol interact throughout the NZ range of broom. 3. The effect of reduced pollination in combination with seed-destruction was explored using a population model parameterized for NZ populations. 4. Broom seed rain ranged from 59 to 21 416 seeds from 2004 to 2008 and was closely correlated with visitation frequency of honeybees and bumblebees. Infestation of broom seeds by *B. villosus* is expected to eventually reach 73% (the average rate observed at the localities adjacent to early release sites). 5. The model demonstrated that 73% seed destruction, combined with an absence of honeybee pollination, could cause broom extinction at many sites and, where broom persists, reduce the intensity of treatment required to control broom by conventional means. 6. Nevertheless, seed rain was predicted to be sufficient to maintain broom invasions over many sites in NZ, even in the presence of the varroa mite and B. villosus, largely due to the continued presence of commercial beehives that are treated for varroa mite infestation. 7. Synthesis and applications. Reduced pollination through absence of honeybees can reduce broom seed set to levels at which biocontrol can be more effective. To capitalize on the impact of the varroa mite on feral honeybees, improved management of commercial beehives (for example, withdrawal of licences for beekeepers to locate hives on Department of Conservation land) could be used as part of a successful integrated broom management programme at many sites in NZ.

Reid, G. M. (1977). "Phosphorus baits not harmful to honey bees." New Zealand Journal of Agriculture 134(4): 26-27. Some Pest Destruction Boards in New Zealand use phosphorized jam or apple pulp baits for rabbit control. Only a few bees were observed foraging on these baits, which are placed in the open in early winter, and bees were not attracted to test baits placed near hives. To test the effect of feeding these baits to bees: (a) groups of 50 bees in cages were fed diets of jam (LT50 6 days), or jam and phosphorus (LT50 4 days), or jam, phosphorus and pollard (LT50 4 days) or sugar syrup (control) (LT50 12 days); and (b) each of 3 colonies was fed 30 samples of phosphorus in apple pulp; 20-30 g honey samples collected from the brood nest were analysed for phosphorus. No phosphorus was detected by the method used, for which the detection limit was 1 mg/kg. No increased mortality was observed in the colonies. It is concluded that the baits are not harmful to bees, if they are used in the autumn. G. M. Reid

Rhodes, J. (1974). "Pesticides in relation to Honey Bee pollination in the granite belt of Queensland." Harnaj, V. (Ed). Apimondia Scientific Bulletin, 1972. Symposia. 1972. 535p. Illus. Apimondia Publishing House: Bucharest, Romania: 420-422.

Rhodes, J. and I. McClement (1978). "Honeybees & agricultural chemicals on the Darling Downs." Australasian beekeeper: 38-41.

Robertson, L. N. and J. W. Rhodes (1992). "Honey bee (*Apis mellifera* L.) deaths near sprayed cotton and observations on bee foraging behaviour in flowering cotton (Hymenoptera: Apidae)." Journal of the Australian Entomological Society. 31(3): 243-246.

Roff, C. (1969). "Aerial application of dibrom, South Stradbroke Island, Queensland." Australian. Beekeeper. 71(pt. 6): 147-pp.

In Queensland, 22 cages, each containing ten honey bees, were exposed to an aerial spray of naled (Dibrom) at various concentrations. Spraying took place from 6.15 a.m. to 6.45 a.m., and within 2 hr. all bees in nine of the cages were dead. Two days later all the bees were dead. It is concluded that naled is highly toxic to honey bees and that severe losses of foraging bees may be expected at the time of treatment or shortly afterwards if naled is applied round bee colonies or where colonies are exposed to drift.

Roff, C. (1981). "The 1981 pesticide holocaust." Australasian beekeeper 82(10): 232-234.

Smaellie, E. (1974). "Legislation in New Zealand to protect honey bees against pesticides." Harnaj, V. (Ed). Apimondia Scientific Bulletin, 1972. Symposia. 1972. 535p. Illus. Apimondia Publishing House: Bucharest, Romania: 423-427.

Stone, D. (2011). "The decline and fall of the European honeybee." Food Magazine: 22-22.

The article reports on the plight of the honeybee. It highlights the global decline being experienced by the pollinating insect. It mentions the importance of the honeybee as a contributor to the success of Australian agriculture. The gradual fall in honeybee numbers has been attributed to changes in agricultural practices particularly the dependence on fertilizers and other chemicals. It discusses the problem facing Australian food production.

Taylor, G. G. (1952). "Spray Treatments with Lead Arsenate for Control of Codling Moth (*Cydia pomonella* L.) on Apple Trees." New Zealand Journal of Science and Technology, Section A 34(1): 59-pp.

Lead arsenate is the principal insecticide used against *Cydia pomonella* (L.) on apple in New Zealand, but it has not given satisfactory control in some districts, and its lack of success has been attributed to increased resistance of the larvae. Growers have consequently tended to use higher concentrations and make earlier and more frequent applications, but though the risk of spray injury to the foliage has been thereby increased [cf. R.A.E., A 39 325] and the high mortality to honey bees from early applications has necessitated legislation prohibiting the use of lead arsenate on trees in bloom, there has been no marked improvement in control. Many of the orchards in which lead arsenate fails to give control have large populations of overwintering larvae, which are responsible for the heavy infestation. In tests during 1935-47, lead arsenate applied at the recommended rate of 1.5 Ib. per 100 gals. at the usual intervals of 14-18 days from petal-fall failed to give adequate control in an orchard in which overwintering populations were heavy. Increasing the concentration to 4.5 Ib. in 1943-44 gave little improvement and increased the injury to the fruit and foliage but reducing the intervals between the sprays to eight days in 1944-45 significantly reduced damage by C. pomonella. Where lead arsenate sprays are efficiently applied, however, overwintering populations are reduced, and under these conditions, the normal lead-arsenate spray programme gave adequate control. Good spray coverage is of major importance in ensuring efficient control, and this is most usually attained in orchards in which the trees are sprayed individually. There are still many flowers on the trees at the time of the petal-fall application, and in a test in which this spray was omitted, the number of fruits showing superficial injury was increased by only 0.8 per cent. ; the amount of control given by this spray is not considered sufficient to warrant the risk of mortality among bees.

Théotime, C., et al. (2019). "Effects of thymol on European honey bee hygienic behaviour." Apidologie 50(2): 141-152.

The parasitic mite *Varroa destructor* is a major threat to the European honey bee *Apis mellifera*. Beekeepers apply the miticide thymol directly within the hives to kill this parasitic mite. Thymol is repellent to bees and causes them to ventilate the hive, yet its impact on bee hygienic behaviours that prevent the spread of diseases has never been studied. We measured the efficiency of colonies at removing dead adult bees, uncapping dead pupal cells and removing dead brood in two miticide-free Australian environments where the mite is absent. Thymol increased the uncapping and removal of dead brood by 24 to 36% after 48 h at both locations but had no effect on the removal of dead adult bees. The increased removal of brood could enhance the effect of thymol on *V. destructor*, especially if bees preferentially remove cells infected with the mite.

Théotime, C., et al. (2020). "The miticide thymol in combination with trace levels of the neonicotinoid imidacloprid reduces visual learning performance in honey bees (*Apis mellifera*)." Apidologie 51(4): 499-509.

Despite growing concerns over the impacts of agricultural pesticides on honey bee health, miticides (a group of pesticides used within hives to kill bee parasites) have received little attention. We know very little about how miticides might affect bee cognition, particularly in interaction with other known stressors, such as crop insecticides. Visual learning is essential for foraging bees to find their way to flowers, recognize them, and fly back to the nest. Using a standardized aversive visual conditioning assay, we tested how field exposure to three pesticides affects visual learning in European honey bees (*Apis mellifera*). Our pesticides were two common miticides, thymol in the commercial formulation Apiguard® and tau-fluvalinate in the formulation Apistan® and one neonicotinoid, imidacloprid. We found no effect of miticides alone, nor of field-relevant doses of imidacloprid alone, but bees exposed to both thymol and imidacloprid showed reduced performance in the visual learning assay.

Thomas, M. D., et al. (2003). "Attractiveness of possum apple baits to native birds and honey bees." New Zealand Plant Protection 56: 86-89.

This study investigated the potential risks of using 1080 apple bait for possum control on non-target species. Trials were conducted using captive native birds at Orana Park and honeybees (*Apis mellifera*) at Halswell to determine whether these species would feed on non-poisonous apple baits. Bird species were kaka (*Nestor meridionalis*), kea (*Nestor notabilis*), kakariki (*Cyanoramphus* sp.), silvereye (*Zosterops lateralis*), weka (*Gallirallus australis*) and kereru (*Hemiphaga novaeseelandiae*). Kaka, kea, kakariki and silvereye preferred to feed on apple bait over carrot bait, spending 74-100% of their feeding time on the apple bait. Honeybees were not attracted to the apple bait. It is concluded that there could be a greater risk to native birds when apple baits are used for possum control compared to the risk associated with using carrot bait. Consequently, it is recommended that aerial application of apple should not be undertaken and that apple baits should be used in bait stations only.

Urlacher, E., et al. (2016). "Measurements of Chlorpyrifos Levels in Forager Bees and Comparison with Levels that Disrupt Honey Bee Odour-Mediated Learning Under Laboratory Conditions." Journal of Chemical Ecology 42(2): 127-138.

Chlorpyrifos is an organophosphate pesticide used around the world to protect food crops against insects and mites. Despite guidelines for chlorpyrifos usage, including precautions to protect beneficial insects, such as honeybees from spray drift, this pesticide has been detected in bees in various countries, indicating that exposure still occurs. Here, we examined chlorpyrifos levels in bees collected from 17 locations in Otago, New Zealand, and compared doses of this pesticide that cause sub-lethal effects on learning performance under laboratory conditions with amounts of chlorpyrifos detected in the bees in the field. The pesticide was detected at 17 % of the sites sampled and in 12 % of the colonies examined. Amounts detected ranged from 35 to 286 ng.bee(-1), far below the LD50 of similar to 100 ng.bee(-1). We detected no adverse effect of chlorpyrifos on aversive learning, but the formation and retrieval of appetitive olfactory memories was severely affected. Chlorpyrifos fed to bees in amounts several orders of magnitude lower than the LD50, and also lower than levels detected in bees, was found to slow appetitive learning and reduce the specificity of memory recall. As learning and memory play a central role in the

behavioural ecology and communication of foraging bees, chlorpyrifos, even in sublethal doses, may threaten the success and survival of this important insect pollinator.

Wightman, J. A. (1983). "A comparison of insect management programmes in lucerne seed crops in New Zealand and South Australia." Proceedings of Australasian Workshop in Development and Implementation of IPM: 122-129.

Stresses the importance of using insecticides which do not poison honeybees and other pollinators.

Wightman, J. A. and D. N. J. Whitford (1982). "Integrated control of pests and legume seed crops 1. insecticides for mirid and aphid control." New Zealand journal of experimental agriculture 10(2): 209-215.

A series of field trials was carried out to find insecticides which would kill *Calocoris norvegicus* (the potato mirid) and *Sidnia kinbergi* (the Australian crop mirid) in lotus, white clover, and lucerne seed crops. Trichlorphon, bromophos, demeton-S-methyl and endosulfan performed satisfactorily in this respect; pirimicarb did not. Bromophos, demeton-S-methyl and endosulfan also killed aphids. Trichlorphon was the only insecticide which did not apparently kill predatory insects. Published evidence on the toxicity of these materials to bees does not always clearly demonstrate whether they are suitable for use in seed crops during the flowering period. A survey of the literature indicated that no insecticide is entirely 'safe' for use when honeybees, alkali, bumble, and leaf-cutting bees are present, and that there is disparity between laboratory assays and field trials.

Wightman, J. A. and D. N. J. Whitford (1984). "Insecticidal control of some pests of culinary herbs." New Zealand journal of experimental agriculture 12(1): 59-62.

It was shown from field trials in New Zealand of insecticides against pests on herbs for export in the fresh condition that *Philaenus spumarius* (L.) could be controlled on French tarragon (*Artemisia dracunculus*) with fenvalerate or malathion (maldison) in mid-late September when the insects were hatching. Further infestations with *P. spumarius*, together with aphids and thrips, could be eliminated with an ephemeral insecticide such as dichlorvos. Eupteryx melissae Curt. on sage (*Salvia officinalis*) was killed by dichlorvos, demeton-S-methyl, phosalone, acephate, carbaryl, fenvalerate, malathion and a mixture of permethrin with pirimiphos-methyl. Dichlorvos, demeton-S-methyl and phosalone controlled *Zygina zealandica* (Myers) and Myzus spp. on thyme. Spraying when crops were not in flower, and the application of bee-safe insecticides or short-lived insecticides in the evening when bees [*Apis mellifera* L.] are not in the crop, could reduce the numbers of bees killed.

Wood, S. C., et al. (2018). "Comparative chronic toxicity of three neonicotinoids on New Zealand packaged honey bees. Hazards of Pesticides to Bees, 137. https://doi.org/http://dx.doi.org/10.507." Hazards of Pesticides to Bees: 137-137.

AGRICULTURE POLLINATION

(1959). "White clover pollination." Rep. Anim. Res. Div., N. Z. Dep. Agric.: 40-40.

The pollination requirements of *Trifolium repens* grown for seed were studied for 2 seasons in the Timaru district and the Mackenzie Country. It is concluded that: (1) in districts where pollination is poor, incidence of case-bearer moth [*Coleophora* sp., see Herb. Abstr. 15: 277, 278] is low; (2) honey bees will effectively pollinate white clover seed crops located up to a mile from their hives; (3) up to a certain point the density of bees in an area is directly related to the amount of seed set. If bee density is increased beyond this point, however, there is no corresponding rise in seed yield. In the Timaru district about one hive per 35 ac provides efficient pollination; (4) in New Zealand pollination of white clover for seed production and pasture regeneration is carried out almost entirely by honey bees. Bumble bees are of no account as pollinators except in hill-country areas such as the Mackenzie Country where white clover is not grown for seed. Most bumble bees observed are the short-tongued *Bombus terrestris*. -M.H.

(1980). "Is the thyme right for diversification?" Apiarist (11): 1-3.

Thymus in New Zealand.

(1982). "Pollination services [kiwifruit]." New Zealand beekeeper 43(4): 17-19.

(1983). "The beekeeping industry can meet pollination needs." New Zealand beekeeper (177): 13-16.

Summary of seminars on kiwifruit (*Actinidia chinensis*) pollination in New Zealand; see also AA 1342/84.

(1983). "Proceedings of MAF beekeepers' seminar, Nelson, 26 July 1983." Proceedings of MAF beekeepers' seminar, Nelson, 26 July 1983.: iii-pp.

The 7 papers given at the seminar dealt with the following topics: high country white clover pollination, Broken River 1981-83; artificial and insect pollination of kiwifruit (*Actinidia chinensis*); preparing pollen for market; implications of biological weed control for New Zealand beekeeping (effects on bee forage); biological control of wasps (Vespula germanica); a community tree-planting programme that helps provide bee forage. the final paper includes tables of beekeeping statistics for New Zealand and a list of the plant species used in the tree planting programme.

(1992). "Increasing beekeepers' and commercial growers' income opportunities through improved yields of crops by managed honeybee pollination. Pollination workshop, April 1992." Increasing beekeepers' and commercial growers' income opportunities through improved yields of crops by managed honeybee pollination. Pollination workshop, April 1992.: vii-pp.

The fourth national workshop sponsored by the Honeybee Research and Development Council assessed the importance of pollination and the opportunities for Australian beekeepers to diversify into the provision of pollination services. The 26 papers which are included in this report cover the present state of pollination services in Australia, pollination requirements of common crops, various components in the provision of pollination services, options for the future and the workshop's recommendations.

(2013). "Special Issue: Recent advances in pollination biology in New Zealand." Special Issue: Recent advances in pollination biology in New Zealand. 51(3): 147-240.

This special issue contains papers dealing with recent advances in research on pollination biology in New Zealand. Recent studies on pollination requirements for commercial fruit production; role of pollinator diversity in arable seed crops; paternal effects on fruit characteristics; role of short-tailed bats (*Mystacina tuberculata*) as pollinators of native plants; and pollination of orchids are presented. Discussions on the successes and failures of restoration projects to restore bird-plant mutualisms are included. The importance of understanding the nutrition

requirements of honey bees in terms of pollen sources, and suggestions for tree plantings to benefit bee nutrition, are given. A study investigating automated image analysis to monitor native bee colonies is presented, and a video system for recording plant-pollinator interactions is described.

(2015). "Australia: riding on the insect's back." Ecos (207): 1-4.

The article discusses ecological and economic significance of insects in Australia, as of May 2015. It states data 2009 data about the total economic value of insect pollination of agricultural crops across the world, which has a substantial contribution from Australian pollinators like the European honeybee and mentions impact of the colony collapse disorder that killed a significant number of honeybees. It notes contribution to insects to biodiversity and cites lack of study on the insects.

Alexandrova, M., et al. (2002). "The role of honeybees in spreading *Erwinia amylovora*." Acta horticulturae: 55-60.

The purpose of the studies carried out in the spring of 2000 and 2001 under greenhouse conditions, was to evaluate the role of honeybees in the dispersal of *Erwinia amylovora* in pear blossoms and successive fire blight development. It was demonstrated that honeybees, while visiting for 24 h pear flowers experimentally inoculated with *E. amylovora* (10e cfu/ml), became contaminated with the pathogen and were able to disperse the bacteria to healthy pear trees in full bloom; 48 h after initial contact of honeybees with inoculated flowers no viable bacteria were detected on honeybee bodies and in honeybee intestines. In other trials, it was demonstrated that honeybees were able to disseminate *E. amylovora* from experimentally contaminated beehives (10i cfu/ml) to healthy pear flowers for less than 48 h after initial contamination of the beehives. No viable bacteria were re-isolated from analysed honeybee body and honeybee intestine samples 48 h after initial contamination of beehives. *E. amylovora* detection was based on quantitative re-isolations on CCT medium. The identity of the representative colonies was determined by Bio-PCR (Schaad et al., 1995) using the primers of Bereswill et al. (1992).

Alexandrova, M., et al. (2002). "*Erwinia amylovora* longevity in beehives, beehive products and honeybees." Acta horticulturae.: 201-205.

The purpose of our studies, carried out in 1998-2000, was to investigate *Erwinia amylovora* longevity in beehive products (honey, beeswax, pollen and propolis), on the honeybee body and in the honeybee intestine, as well as in beehives kept outdoors during spring and autumn. In the laboratory experiments, the maximum longevity period in honey was 42 days at 4°C; at higher conservation temperatures (28 and 35°C) the bacteria survived less than two days. In beeswax, the maximum longevity period was 21 days at 4 and 15pC, 16 days at 28°C, and two days at 35°C. In pollen, the persistence of *E. amylovora* exceeded 30 weeks at both 4 and 15°C, while at 28 and 35°C bacteria died during the first week after contamination. Regardless of the conservation temperature in propolis, bacteria died shortly after contamination. The longevity of *E. amylovora* on the honeybee body was 48 h at both 15 and 28°C; at 35°C, viable bacteria were detected up to 42 h after contamination. In the honeybee intestine, the bacteria survived for a maximum of 36 h at both 15 and 28°C; at 35°C, viable bacterial cells were re-isolated up to 30 h after contamination. In beehives kept outdoors during spring, E. amylovora survived for 30 h in honey, 36 h in beeswax, 60 h in pollen, 36 h and 30 h on the honeybee body and in the honeybee intestine, respectively. During autumn, bacteria survived for 36 h in honey (peripheral honey comb) and 36-48 h (brood area), for 48 h in beeswax, 72 h in pollen and 48 h and 36 h on the honeybee body and in the honeybee intestine, respectively.

Allan, L. F., et al. (1993). "Honeybee pollination of crops." Bulletin - Western Australian Department of Agriculture (4250): 35-pp.

The economic potential of honey bee pollination of crops, particularly in Western Australia, is outlined in the introduction to this bulletin. Section 2 explains the principles of pollination, including sex expression and mode of pollination, outcrossing mechanisms, agents of pollination and pollination management. Foraging by honey bees is described in section 3, which explains what makes a food source attractive to foraging honey bees, and how the foraging behaviour of a honey bee colony can be manipulated to maximize pollination benefits for the grower. Section 4 describes apiary management and nutrition in more detail and deals with topics such as pollination hives, colony population level, colony migration, selecting apiary sites, provision of suitable pollen, and crop isolation; this section concludes with an example of a pollination agreement. Section 5, on effects of pest control methods on

pollination, deals with how honey bees may be accidentally poisoned and includes a table of pesticides with their toxicities to honey bees. The bulletin includes a list of information sources, a glossary of technical terms and a subject index.

Arthur, A. D., et al. (2010). "Influence of woody vegetation on pollinator densities in oilseed Brassica fields in an Australian temperate landscape." Basic & Applied Ecology 11(5): 406-414.

Wild pollinators may benefit Brassica oilseed production in temperate Australia, yet it is not known how the density of potential pollinators varies in these landscapes. In this study we assessed whether the density of feral honeybees, hoverflies (probably 2 species) and native bees (multiple species) in temperate Australian Brassica oilseed crops was related to the composition of the landscape. The density of pollinators was measured at multiple points in six different Brassica oilseed paddocks (20-80 ha) at least 1.75 km apart. Landscape composition at multiple scales (radii 100-2000 m) was determined from GIS layers of Brassica paddocks, woody vegetation and non-woody vegetation, and a derived layer expected to reflect the condition of woody vegetation remnants (the 'Link' score). Densities of feral honeybees were higher near the edges of Brassica fields than towards the middle. Densities of feral honeybees were strongly positively associated with the summed 'Link' score within 300 m and with the amount of woody vegetation. Densities of native bees and hoverflies were not strongly associated with woody vegetation or with woody vegetation with a high 'Link' score. Our results suggest that maximising feral honeybee abundance within paddocks in these landscapes may require smaller paddocks than those typically used, interspersed with habitat beneficial to feral honeybees such as woody vegetation in good condition.

Austin, P. T., et al. (1996). "Cross pollination of 'Sundrop' apricot (*Prunus armeniaca* L.) by honeybees." New Zealand Journal of Crop & Horticultural Science 24(3): 287-294.

Pollinator foraging activity on 'Sundrop' apricots (Prunus armeniaca L.) in Hawkes Bay, New Zealand was investigated to see if restricted pollen transfer reduced fruit production. Honeybees (*Apis mellifera* L.) were the only significant floral visitors. Most bees collected pollen and therefore contacted the stigma. Pollen foragers worked flowers faster than nectar foragers (5.3 versus 2.7 flowers/min). Forager densities varied widely between days but under good weather conditions reached 9 bees/tree for up to 6 h a day. Neither nectar volume nor its composition appeared likely to reduce foraging activity. 'Sundrop' flowers held up to 20 mu-l of nectar at an initial concentration of approx. 5% sugar. Data gathered were used to estimate forager numbers needed for cross pollination of 'Sundrop'. The calculations indicated that adequate cross pollination is feasible under Hawkes Bay conditions with hive densities of c. 5.0 hives/ha, within the range normally recommended for stone fruit crops.

Beasley, D. R., et al. (2005). "Bees as Biocontrol Agent Delivery Vectors: A Preliminary Study for Geraldton Waxflower Flowers." Acta horticulturae.: 421-424.

Berry, R. (1982). "No long-term commitment by kiwifruit barons." New Zealand beekeeper 43(3): 32-33.

Pollination of *Actinidia chinensis* in New Zealand.

Blanche, K. R., et al. (2006). "Do flower-tripping bees enhance yields in peanut varieties grown in north Queensland?" Australian journal of experimental agriculture. 46(11): 1529-1534.

Blanche, K. R., et al. (2006). "Proximity to rainforest enhances pollination and fruit set in orchards." Journal of Applied Ecology 43(6): 1182-1187.

1. Tropical rainforests are potential reservoirs of insects that could enhance crop pollination, but only a few instances of the provision of such services by tropical rainforest insects have been reported. Our field study aimed to determine the relative importance of such insects to the pollination of macadamia *Macadamia integrifolia* and longan *Dimocarpus longan* crops on the Atherton Tableland, north Queensland, Australia.2. We quantified initial fruit set, a measure of pollination success, in treatments designed to assess the relative importance of the possible modes

of pollination. The treatments were applied in orchards that varied in distance from rainforest, in order to compare the effects of the contrasting pools of available pollen vectors. We also recorded the insect species present and estimated the number of visits each made to flowers in crops near and far from rainforest.3. For both crops there was an interaction between pollination treatment and distance from rainforest. Maximum fruit set was only achieved when pollen vectors had access to flowers and orchards were close to rainforest. Exclusion of pollinators near rainforest reduced initial fruit set to a greater extent than exclusion of pollinators far from rainforest.4. We confirmed that pollen transfer in macadamia is by autogamous self-pollination and by pollen vectors, but our design did not distinguish among pollen vectors. The only abundant insects in macadamia orchards were honeybees *Apis mellifera*. There were more honeybee visits to macadamia flowers in orchards near rainforest than far from rainforest, but we detected no relationship between honeybee visits and initial macadamia fruit set in our sample of observations on a per raceme basis. More detailed studies are needed to identify the pollen vector responsible for enhanced pollination of macadamia near rainforest.5. We established for the first time that pollen transfer in longan is by a combination of autogamous self-pollination, wind and bees. Longan flowers were visited by stingless bees and honeybees, but only stingless bees had a positive relationship with initial longan fruit set and higher visitation rates near rainforest than far from rainforest. This suggests that enhanced pollination in longan near rainforest resulted primarily from a more abundant supply of stingless bees from the rainforest.6. Synthesis and applications. By demonstrating that tropical rainforest can act as a reservoir of pollen vectors that benefit crops, our study highlights the existence of a largely unrecognized resource available to agriculture. At the same time our results make a significant contribution to the growing database of studies that underscore the importance of tropical rainforest conservation. Policy and management aimed at sustainable use of this resource would satisfy the goals both of agriculturalists, to improve crop yields, and conservationists, to conserve tropical rainforest.

Blanke, M. (2015). "Excursion report: pome fruit growing in Australia." Exkursionsbericht: kernobstanbau in Australien. 57(4): 165-170.

The post congress excursion of the IHC in Brisbane provided insights into the pome fruit industry in the granite belt. The combination of the granite hills with sufficient winter chilling and summer rain provides an unusual temperate zone microclimate despite the subtropical 28 degrees S latitude, which enables the earliest apple harvest in Australia. The major apple cvs 'Gala', 'Granny Smith' and 'Pink Lady' on M26 yield at least 80t/ha on average in pedestrian orchards, which waive the need for platforms. Alternate bearing is not a problem. Hail nets are widespread (90%), the netting often originates from New Zealand, the posts from 'gum trees' (hardwood Eucalyptus) in local clearings in dry sclerophyll forests; honey bees are used to pollinate the apple trees. The legal minimum wage of Euro 14/h is often exceeded; farm workers are backpackers visiting mostly from Europe including Germany, who earn their travel money. Local farm workers are difficult to recruit in an environment of low redundancy rate. Sustainability and carbon footprint score high in such a prosperous environment. Australia is officially free of the Varroa mite and fireblight, the latter often a cause for the dispute about apple imports from NZ.

Bosch, J. v. d., et al. (1996). "White clover breeding, flowering, and farm management as it relates to beekeeping." New Zealand beekeeper 3(9): 24-25.

Many cultivars of white clover (*Trifolium repens*) have been bred for different purposes in New Zealand. In some areas, fields grown for seed are important nectar sources for bees. As a result of changes in farming practices, fewer white clover flowers are being grown, but honey yield/colony does not seem to have decreased; climate/weather seems to be the main factor affecting honey production. Variations in nectar secretion by flowers indicate that suitable selection could result in plants with greater honey potential.

Bowman, F. T. (1937). "Cherry pollination and variety investigations in New South Wales 1930-4." Science Bulletin. Department of Agriculture and Forestry, Union of South Africa 55: 51-pp.

Self-and cross-pollination studies with the principal cherry varieties in New South Wales are reported and the more recent literature on the pollination of sweet cherries is reviewed. Data are given on the order of blossoming of cherry varieties, important variations between trees of the same variety being noted. The inter-sterility and partial incompatibility of certain varieties are discussed as well as the value of cross-pollination, the seasonal influences, the choice of pollinators and methods of introduction, handling of bees and other practical

points. The identity and commercial value of some cherry varieties is described briefly. Off-type strains of Early Lyons, which were found to be of common occurrence, are also described. The variant types of St. Margaret are stated to be partly due to rootstock influence and partly to impurity of variety. Careful bud selection is recommended for the propagation of suitable types. The report is amplified with figures and tables.

Brandenburg, W. (1961). "Broad beans. Causes of poor yields sought." New Zealand Journal of Agriculture 102: 277-280.

The principal cause is the poor setting of pods. Studies showed that the crop should be well sheltered and grown as late in the spring as possible, and that yields were significantly increased by placing beehives in the crop. -Dep. Agric., Christchurch.

Braybrook, L. H. (1972). "Fifteen years of lucerne seed pollination in Southern Victoria." 131-134.

Bryant, T. (1983). "A realistic approach to kiwifruit pollination." New Zealand beekeeper.: 27-29.

Bryant, T. G. (1988). "Kiwifruit (*Actinidia deliciosa*) pollination in the Bay of Plenty, New Zealand, using honey bees - conditions of supply, standards and quality control." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 127-129.

Calder, G. G. (1934). "A possible new market for our certified grass and clover seeds in South America." Papers. 3rd Annual. Conf. N.Z. Grassland Assoc.: 3-pp.

In view of the difficulty of finding markets for New Zealand certified grass and clover seeds in Great Britain and elsewhere the author suggests that Southern Patagonia deserves consideration as a possible customer. It is there being realized that the pastures are declining, and that new sowings of grass and clover seed will have to be made. Owing to the absence of bees, clover is unable to reproduce itself naturally and therefore a good type of white clover or Montgomery red clover (*Trifolium pratense*) would probably be of great value. -R.M.W.

Clinch, P. G. (1984). "Kiwifruit pollination by honey bees 1. Tauranga observations, 1978-81." New Zealand journal of experimental agriculture 12: 29-38.

Observations for 3 seasons during the flowering period of *Actinidia chinensis* cv. Hayward showed that honeybees were by far the most numerous visitors to flowers in orchards to which honeybee colonies had been introduced. Colletid bees (Leioproctus spp.) were observed on flowers in some orchards but their numbers were generally so low that, except in 1 orchard in 1978-79, and 2 in 1979-80, their effect on pollination was probably insignificant. Bumble bees (*Bomus* spp.) and other insects were also too few to be of importance at the sites observed. Visits by honeybees to kiwifruit flowers in 1978-79 were reduced by competition from other pollen sources, and fruit size was poor. Competition was minimal, and there was good bee visitation in 1979-80, when fruit size was generally good, and in 1980-81, when it was unsatisfactory. In 1980-81 there were more flowers and consequently more fruits, in all orchards compared with the 1979-80 season, and this physiological load probably caused some of the reduction in weight. In 1980-81, 32.7% of fruit weighed less than 72 g, even though fruit less than 93 g contained significantly more seed than in the previous 2 seasons. This suggests that pollination was satisfactory, but that adverse weather conditions may have retarded fruit growth. Factors such as position of male vines relative to females, cultural methods, and orchard microclimates may also have been important.

Clinch, P. G. and J. Faulke (1976). "Observations on the role of the honey bee in the pollination of black currants cultivar magnus." New Zealand journal of experimental agriculture 4(4): 399-402.

The pollination of black currants [*Ribes nigrum* L.] cv. 'Magnus' was studied in the Levin district [New Zealand] for 2 seasons. The variety depended only partially on insect visitation for pollination. Bushes sleeved to

exclude honey bees and bumble bees had approximately 30% fewer berries than those not sleeved. Honey bees were much more important pollinators than bumble bees. "Running off" occurred even on bushes caged with colonies of honey bees to receive abnormally high bee visitation. In some plantations heavier yields may be obtained if hives were brought in during the flowering period.

Clinch, P. G. and A. T. Houten (1987). "Pollination of pastures and crops - kiwifruit." Annual Report, 1985/86, Wallaceville Animal Research Centre, Ministry of Agriculture and Fisheries, New Zealand.: 105-105.

Kiwifruit [*Actinidia deliciosa*] flowers in an orchard at Te Puna, New Zealand, in 1985, were bagged just before they opened. They were then unbagged and exposed to pollination by honeybees (and wind) for 1, 2 or 3 days. The weather during the 11-day flowering period was very wet, and on 3 days no fruit of export weight (70 g or heavier) was formed from flowers exposed for 1 day only. The highest percentage of flowers exposed for 1 day that produced fruit of export size was 71% (mean 30%). Corresponding results for flowers exposed for 2 or 3 days were 67% (mean 43%) and 83% (mean 59%) respectively. Fruits were generally of a lower weight than expected. Of flowers left open to bee pollination throughout the entire flowering period, only 62% developed into fruit of export weight compared with 75% of those that were hand-pollinated (although the expected result following hand-pollination would be 95%). The results suggest that the weather or other factors prevented normal fruit growth. D. G. Lowe.

Cook, V. A. (1972). "The carrying capacity of beekeeping areas." New Zealand beekeeper 34(4): 16-21. Number of colonies per apiary and per unit area of land.

Cook, V. A. (1972). "Honey bee pollination of legumes, brassicas and sunflowers in North Otago." New Zealand beekeeper 34(4): 24-27.

Cook, V. A. (1974). "Pollination in North Otago." New Zealand Journal of Agriculture 128(1): 32-33.

The pollination of white and red clover, lucerne and marrow-stem kale by honey bees is discussed. It is suggested that white clover required 1 working bee/2 yd2 and red clover required 1 bee/2-3 yd2 for the pollination of all flowers. Trials in N. Otago over 4 seasons indicated that bees were needed for maximum seed yields of marrow-stem kale. ADDITIONAL ABSTRACT: The pollination of marrow-stem kale by honey bees is discussed and it was concluded from trials over 4 seasons in N. Otago that bees were necessary for maximum seed yields. ADDITIONAL ABSTRACT: The main entomophilous seed crops grown in the North Otago area of New Zealand are white clover, red clover, lucerne, kale and sunflower. The crops are effectively pollinated by the 4000 colonies of bees in 300 permanent apiaries which are fairly evenly distributed throughout the area. The value of the seed grown is estimated at NZ$200 000; the honey the bees produce is worth about NZ$135 000.V. A. Cook

Corbet, S. A. (1987). "Pollination of crops imported to new countries." Bulletin of the British Ecological Society 18(1): 22-23.

In New Zealand, growers of kiwifruit (*Actinidia deliciosa*), a native of China, hire honey bees for pollination during the brief flowering period, but honey bees do not thrive on the nectar less crop and the use of bumble bees as an alternative is being considered. Workers and queens of the imported British bumble bee, *Bombus terrestris*, buzzed flowers but their wingbeat frequency during buzzing poorly matched the optimal frequency for pollen discharge.

Cornish, D. A., et al. (1998). "Distribution of beneficial bacteria on nashi and apple flowers using honey bees." Proceedings of the Fifty First New Zealand Plant Protection Conference, Quality Hotel, Hamilton, New Zealand, 11-13 August 1998: 107-111.

Honey bees have previously been shown to disperse biological control agents of fire blight (caused by *Erwinia amylovora*), such as *Erwinia herbicola* [*Pantoea agglomerans*] Eh252, onto apple flowers. In this study we

investigated whether bees could also effectively disperse Eh252 onto nashi (*Pyrus pyrifolia*) flowers. After providing lyophilized bacteria to two bee hives in a commercial nashi orchard (New Zealand) for seven days, 83% of the flowers were colonized with Eh252. After removal of bacterial inoculum, 95% of newly opened flowers were still colonized, indicating transfer of beneficial bacteria from flower to flower. In a similar experiment carried out three weeks later in an apple orchard, the rate of colonization of apple flowers by Eh252 in the first three days was even greater.

Costa, G., et al. (1993). "Kiwifruit pollination: An unbiased estimate of wind and bee contribution." New Zealand Journal of Crop and Horticultural Science 21(2): 189-195.

The role of wind and bees in kiwifruit (*Actinidia deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson) pollination was investigated using large cages enclosing 80 mature vines and assembled so as to prevent insects entering without reducing wind flow within the cages. Monitoring wind speed within the cage and in the open orchard showed that the cages were suitable for such experimentation. Cages without hives, cages with hives, open pollination with hives, and hand pollination were compared during 1990 and 1991. Wind pollination led to an appreciable fruit set (81 and 98% in the first and second year respectively) but fruit weight was low, averaging 61 and 66 g. The use of hives resulted in 98-100% fruit set, but fruit size did not improve significantly, remaining far below that achieved by hand pollination (66 g versus 108 g, the first year; 78 g versus 119 g, the second year). The short flowering period, the frequent adverse weather conditions, and the unpredictable foraging efficiency of bee colonies, made both wind and honey bees inadequate for kiwifruit pollination. Only hand pollination guaranteed maximal fruit size in each year. © 1993 The Royal Society of New Zealand.

Cunningham, S. A. and D Le Feuvre (2013). "Significant yield benefits from honeybee pollination of faba bean (*Vicia faba*) assessed at field scale." Field crops research. 149(149): 269-275.

There is growing evidence globally that improved pollination practices can help support higher yield and reduced variability for a wide range of insect pollinated crops. Managed honeybees are provided to pollinate some orchard crops, but they are less commonly used for field crops, in part because of uncertainty as to whether the potential benefits are justified by the costs. This uncertainty comes from a lack of studies conducted at the appropriate scale. In this study we examine the yield benefits from managed honeybees applied to *Vicia faba* in field scale trials. We provided honeybee hives to 17 fields in South Australia and observed that bee activity and fruits per stem decreased with increasing distance from hives. We examined the spatial pattern of yield using yield map data collected at harvest and found there was an effect of distance from hives on mean yield (declining with distance) and spatial variability of yield (increasing with distance). The presence of a distance gradient was consistent across all fields, across two years, two *V. faba* varieties and two different bee-hive management methods. The average benefit is estimated to be an additional 17% yield, 90% of which is attained within 767m of hives. Our economic analysis indicates that provision of hives is profitable for a wide range of realistic values for crop value (dollars per tonne) and pollination cost (dollars per hive).

Cunningham, S. A., et al. (2002). "The future of pollinators for Australian agriculture." Australian Journal of Agricultural Research 53(8): 893-900.

Agriculture in Australia is highly dependent on insect pollination, in particular from the introduced western honeybee, *Apis mellifera*. Most agricultural pollination is provided as an unpaid service by feral *A. mellifera* and native insects. A smaller proportion of agricultural pollination is provided as a paid service by beekeepers. Insect pollination is threatened by misuse of insecticides and the loss of remnant vegetation, but most potently by the likelihood that the honeybee mite, *Varroa destructor*, will enter the country. Now is the time to prepare for the effect of these changes, and international experience with pollinator decline should serve as a guide. We need to protect and manage our remnant vegetation to protect wild pollinators. Insurance against declining *A. mellifera* will come through the development of management practices for alternative pollinator species. By developing native insects as pollinators, we can avoid the risks associated with the importation of additional introduced species.

Cunningham, S. A., et al. (2016). "Improving spatial arrangement of honeybee colonies to avoid pollination shortfall and depressed fruit set." Journal of Applied Ecology 53(2): 350-359.

Pollination shortfalls affect yield of many crops, and the use of managed honeybee colonies is a common practice for addressing the problem. However, colony density and arrangement strategies are not generally based on replicated scientific trials, so there is considerable uncertainty regarding effectiveness of different practices. We address this problem with experiments in almond orchards in south-east Australia, considering impacts on honeybee pollen foraging and fruit set. We examined the effect of distance from colony location on the depletion rate of pollen from flowers near (~40 m) and far (260-490 m) from colonies in almond orchards. We assessed pollen loads of 950 flowers in total, collected at four times of day (9-9:30 h, 11-11:30 h, 13-13:30 h and 15-15:30 h), from 8 near: far pairs. We also surveyed fruit set on nearly 900 trees in replicated transects over two seasons to determine the effect of distance from colony when using large placements of colonies (~120 colonies, N=581 trees), and effect of colony density when using smaller placements of colonies (N=313 trees). Flowers near colonies maintained an approximately constant mean pollen load over the course of the day, indicating that the rate of pollen released by flowers was matched by the rate of pollen collection by bees. Flowers far from colonies increased in pollen load over the course of the day, indicating relatively less pollen-collecting activity, so that by 15:30 h they had, on average, 46% more than flowers near colonies. Fruit set declined with distance by 22% over 850 m, consistent with the observation that pollen foraging declines over distance from colony. Fruit set also declined with colony density from 46% at 6.8 colonies per ha to 33% at 2.8 colonies per ha. Synthesis and applications. Pollen-collecting activity is relatively low at flowers far from honeybee colonies, creating a risk of lost yield through under pollination. Fruit set declines if colony density is reduced below 6.8 colonies per ha. Pollination outcomes in terms of fruit set are improved when fewer colonies are used per placement (<100) and placements of colonies are arranged with shorter distances (<700 m) between them, so that more trees are within 400 m of colonies.

Cunningham, S. A., et al. (2013). "Movement and phenology of bees in a subtropical Australian agricultural landscape." Austral ecology. 38(4): 456-464.

Bees are mobile organisms that seek food and nesting opportunities from a range of habitats. It is important to understand the way they move in agricultural landscapes if we are to conserve them and benefit from their activity as pollinators. We surveyed bees using directional flight interception (Malaise) traps over a 1year period in two agricultural landscapes in southeast Queensland, Australia. We placed traps at the ecotone between crops and remnant vegetation to establish the pattern of movement between these habitats. Species richness in these landscapes (70) was high relative to that in comparable studies. Some bees were active year-round, but most were caught in the period September to March. Across the whole assemblage there was a significant pattern where more species were detected leaving rather than entering remnant vegetation. The same bias was true for the number of individuals of the two most abundant species (Homalictus urbanus and *Apis mellifera*). Species exclusively found in crops were smaller on average (and therefore have smaller foraging range) than their non-crop counterparts. Together, these patterns indicate that while bees are abundant in crop habitat, the remnant vegetation is important as the point of origin for bee movements, and the riparian remnant in particular is richer than the dry native remnant. Compositional similarity among samples was significantly explained by landscape but also movement direction (i.e. to or from the riparian remnant) because different species showed different patterns of response. The landscape with greater native vegetation cover supported more species in and around crops than the landscape with less native vegetation.

Davidson, M. M., et al. (2010). "*Apis mellifera* and *Megachile rotundata*: A comparison of behaviour and seed yield in a hybrid carrot seed crop." New Zealand Journal of Crop and Horticultural Science 38(2): 113-117.

The movement of managed alfalfa leaf cutting bees (*Megachile rotundata* (F.)) in and around carrot flowers is compared with that of the honey bee (*Apis mellifera* L.) in a field trial to assess their relative efficacy as pollinators of hybrid carrot seed crops. Seed set is measured on carrot flowers inside cages with and without alfalfa leaf cutting bees and compared with seed set in open field conditions in the presence of honey bees. Non-caged alfalfa leaf cutting bees spend a similar amount of time on umbels and visit a similar number of umblets per umble as honey bees. Seed yield (number and weight of seeds) for flowers pollinated by caged alfalfa leaf cutting bees is similar to that of flowers pollinated mainly by honey bees. However, it is not known how effective alfalfa leaf cutting bees are compared with honey bees when not confined in cages (i.e. open pollination) under a range of commercial field conditions, particularly in the absence of plant species preferred by alfalfa leaf cutting bees. © 2010 The Royal Society of New Zealand.

Donovan, B. J. and R. P. Macfarlane (1984). "Bees and pollination." New Zealand pest and beneficial insects: 247-270.

Donovan, B. J. and P. E. C. Read (1991). "Efficacy of honey bees as pollinators of kiwifruit." Acta horticulturae.: 220-224.

Doull, K. M. (1961). "Insect problems of lucerne seed production in South Australia." Journal of the Australian Institute of Agricultural Science 27(1): 11-15.

The results and conclusions of a survey of the insects associated with lucerne in South Australia undertaken over the period 1956-9 are presented. Four species of insect are responsible for some loss, but poor pollination due to the shortage of bees is the main reason for low seed yields. Increased yields are dependent upon changes in management, better control of insect pests and more efficient pollination. -J.D. [CSRIO].

Doull, K. M. (1968). "Lucerne pollination." Biennial report of the Waite Agricultural Research Institute, South Australia 1968-1969.: 72-p.

Experimental results showed that high seed yields cannot be obtained where honey bees are the main or only pollinators. *Megachile rotundata* is being introduced from Canada in the hope that it will become established as the main pollinator of lucerne in South Australia.

Drane, D., et al. (1982). "Pollination studies in hybrid sunflower seed production." Proceedings of the International Sunflower Conference.: 95-100.

Dwyer, R. E. (1933). "New technique in lucerne breeding. With special reference to the use of honey bees." Herbage Reviews 1(December): 135-136.

Dwyer, R. E. P. and S. L. Allman (1933). "Honey bees in relation to lucerne seed setting." Agricultural Gazette of New South Wales 44: 363-371.

Under the conditions prevailing at Bathurst honey bees are important agents in tripping the flowers of lucerne and increasing the seed yield.

Ellis, R. W., et al. (1988). "Development of balansa clover for bee production." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 172-173.

Trifolium balansae was released in S. Australia in 1985. During October and November 1986, observations were made on 16 hives situated on 10-ha sites of flowering *T. balansae*, and 16 control hives kept in areas without *T. balansae*. All hives gained weight and there were significant increases in brood area, stored pollen and honey, but hives in areas of T. balansae were no more productive than controls. This clover flowers from late September to mid-November in S. Australia, and produces a light-coloured honey of acceptable quality, but its capacity to produce large amounts of nectar is not yet proven. The pollen contains 27-29% protein (dry wt.) and an amino acid composition satisfactory for honeybee nutrition.

Evans, L. J., et al. (2019). "Netted crop covers reduce honeybee foraging activity and colony strength in a mass flowering crop." Ecology & Evolution 9(10): 5708-5719.

The widespread use of protective covers in horticulture represents a novel landscape-level change, presenting the challenges for crop pollination. Honeybees (*Apis mellifera* L) are pollinators of many crops, but their behaviour can be affected by conditions under covers. To determine how netting crop covers can affect honeybee foraging dynamics, colony health, and pollination services, we assessed the performance of 52 nucleus honeybee colonies in five covered and six uncovered kiwifruit orchards. Colony strength was estimated pre- and post-introduction, and the foraging of individual bees (including pollen, nectar, and naive foragers) was monitored in a

subset of the hives fitted with RFID readers. Simultaneously, we evaluated pollination effectiveness by measuring flower visitation rates and the number of seeds produced after single honeybee visits. Honeybee colonies under cover exhibited both an acute loss of foragers and changes in the behaviour of successful foragers. Under cover, bees were roughly three times less likely to return after their first trip outside the hive. Consequently, the number of adult bees in hives declined at a faster rate in these orchards, with colonies losing on average 1,057 +/- 274 of their bees in under two weeks. Bees that did forage under cover completed fewer trips provisioning their colony, failing to re-enter after a few short-duration trips. These effects are likely to have implications for colony health and productivity. We also found that bee density (bees/thousand flowers) and visitation rates to flowers were lower under cover; however, we did not detect a resultant change in pollination. Our findings highlight the need for environment-specific management techniques for pollinators. Improving honeybee orientation under covers and increasing our understanding of the effects of covers on bee nutrition and brood rearing should be primary objectives for maintaining colonies and potentially improving pollination in these systems.

Evans, L. J., et al. (2011). "Honey bee (*Apis mellifera*) distribution and behaviour on hybrid radish (*Raphanus sativus* L.) crops." New Zealand Plant Protection 64: 32-36.

Commercial hybrid vegetable seed production involves movement of pollen between two distinct groups of plants (parent lines) - a pollen donor and seed production lines. The aim of this study was to observe the distribution and behaviour of honey bees (*Apis mellifera*) on hybrid radish (*Raphanus sativus* L.) crops in New Zealand. Honey bees were observed to have an even distribution across the parent lines, although individual bees largely maintained fidelity to the particular line on which they foraged. Of the bees observed on male-fertile flowers 72% did not switch to the other line. When plants from the different lines were manipulated so that they appeared to be a single plant, 69.5% of honey bees remained constant to the line visited. To maximise the effectiveness of honey bees as pollinators of hybrid radish, techniques should focus on better matching of lines or breeding of lines to reduce pollinator differentiation.

Forster, I. W. (1974). "Behaviour and effectiveness of bees in pollinating legumes." Proceedings of the New Zealand Grassland Association 36(1): 105-110.

Adequate pollination of white or red clover was obtained when the foraging honeybee population was 10 000/ha. This could be ensured with 1 hive per 3 ha. Bumble bees were equally effective as pollinators. In a survey of 32 lucerne crops, honeybee populations ranged from 2,250/ha to 16,250/ha, and bumble bee populations up to 4,250/ha were also present, but the average seed set was only 10%. When a hive that was short of stored pollen was enclosed on lucerne inside a cage, a 30% seed set was obtained, but attempts to obtain similar results in the field (by removing pollen from hives and using pollen traps) failed. D. G. Lowe ADDITIONAL ABSTRACT: Adequate pollination of red or white clover was obtained with 1 honeybee or bumble bee/m2. This could be obtained with 1 hive of honeybees to each 3 ha of flowering clover. In lucerne, seed set averaged 10% of the potential maximum in open fields with honeybees or bumble bees. In cages where honeybees were forced to gather pollen, this was raised to 30%, but it was not possible to increase seed set significantly in the field.

Forster, I. W., et al. (1973). "Observations on the pollination of chou moellier (*Brassica oleracea* L.)." New Zealand journal of experimental agriculture 1(1): 46-48.

Over 4 seasons in N. Otago, New Zealand, pollination of chou moellier (*Brassica oleracea* [var. viridis]) by honey bee [*Apis mellifera*] and bumble bee (*Bombus terrestris*) was examined. Honey bees and bumble bees appeared to be the only insects of importance as pollinators, although some self-pollination did occur. Honey bees were much more important than bumble bees, the latter being few or absent during spring flowering. In plants which were caged to exclude honey bees and bumble bees, the number of flowers/plant, seeds/pod and the weight of seed/plant were reduced by 20, 33 and 50% respectively, compared with surrounding plants.

Forster, I. W. and W. V. Hadfield (1958). "Effectiveness of honey bees and bumble bees in the pollination of Montgomery red clover." New Zealand Journal of Agricultural Research 1(5): 607-619.

In February 1954 and 1955, 35 hives of honey bees were placed immediately adjacent to 10 ac. of Montgomery red clover (*Trifolium pratense*) growing in an area considered to be favourable to bumble bees. Insect activity was noted, and it was computed that honey bees constituted 77% of the effective pollinating insects in 1954 and 89% in 1955. Spot checks made at several different points showed this to be a fair cross-section of insect activity on red-clover crops in South Canterbury.

Forsyth, M. (1982). "Proceedings of kiwifruit pollination seminars, Hamilton & Tauranga, 1982." Proceedings of kiwifruit pollination seminars, Hamilton & Tauranga, 1982.: ii-pp.

The Proceedings contain the following papers on pages: 2-10 Stephens, I.; Forsyth, M.: Pollination, fertilisation and fruit development; 11-20 Hawes, L.; Lupton, T.: Setting out a kiwifruit orchard; 21-25 Jay, S.C.: Honey bees as pollinators : a summary; 26-29 Clinch, P.: Some factors influencing the pollination of kiwifruit by honey bees; 30-37 Finlay, N.: The problem and rewards of providing a pollination service; 38-43 Reid, M.: Protecting everyone's interests; 44-52 Berry, R.: Kiwifruit pollination as we see it; 53-56 Alexander, P.: Current state of the kiwifruit industry; 57-64 Bryant, T.: Can the beekeeping industry cope? The 6 Appendixes are: Kiwifruit Aglinks (New Zealand Ministry of Agriculture publications); a pollination agreement (contract); Arataki letter to kiwifruit growers (about sprays); useful contacts; spray pollination of kiwifruit; kiwifruit statistics. There is a short reading list.

Fussell, M. (1992). "Diurnal patterns of bee activity, flowering, and nectar reward per flower in tetraploid red clover." New Zealand Journal of Agricultural Research 35(2): 151-156.

Patterns in the activity of insect visitors to 'Grasslands Pawera' red clover were investigated in 2 dawn-to-dusk studies. Long-tongued bumble bees, mainly *Bombus* hortorum, were the most abundant positive flower visitors on both days. *B. terrestris* was a frequent visitor but usually visited negatively, robbing nectar through holes bitten at the base of flowers. Honey bees were less frequent visitors, despite the proximity of hives, and most robbed the flowers. Bumble bees foraged for a longer period each day than honey bees and visited flowers most frequently in the evening. A peak in the number of newly opened flowers occurred around midday on 7 February and the amount of sugar per red clover flower was higher in the afternoon when investigated in detail on 18 January. Foragers from a boxed B. hortorum colony nearly all worked red clover.

G, W. (1936). "Pollination of fruit trees. Bees in the plantation." Fruitgrower 81: 963-964.

Hive bees in the fruit plantation have proved infinitely more useful in pollinating plums, cherries and bush fruits than they have in pollinating apples. Bees, contrary to the statements of professional beekeepers, are not fond of apple trees for the collection of nectar. This fact is not considered by the author as a reason for not keeping bees in the orchards, but as a reason for keeping more bees than ever, and in order to induce them to leave the hives and get on to the apples in bad weather populations of the hives must be particularly strong. The hives, too, must be in close proximity to the apple trees because a bee will not change from one kind of plant to another in the course of a journey and it is, therefore, necessary for the apple blossoms to be the first to be encountered when the bee leaves the hive. The author attributes bad crops following dull springs to lack of pollination by bees and other insects, the latter being so largely destroyed by spraying operations and, in the case of wild bees, by the clearing of ditches and hedgerows, that there are not sufficient left to carry out the work effectively. He considers, apart from cultural deficiencies, that small apples are due to bad pollination and attributes the lopsided shape often seen in Early Victoria fruit to the same cause. Fruit that has been properly pollinated is more resistant to spring frosts. Instances of this are given. The poisoning of bees by spray materials has never been known in the author's 15 years of beekeeping and fruit growing, but hives have often been greatly diminished by starvation following the disappearance of fruit blossom.

Gaffney, A., et al. (2011). "Insect visitation to flowering hybrid carrot seed crops." New Zealand journal of crop and horticultural science. 39(2): 79-93.

Although there is some literature published on insect visitation to open pollinated carrot seed crops in several regions around the world, there is none in Australasia and none on insect visitation to hybrid carrot seed

crops worldwide. With a growing hybrid carrot seed crop industry in southern Australia and New Zealand, a survey of insect visitation to carrot seed crops is timely as the first step in elucidating which insects may be pollinators. Surveys of insect visitation were thus undertaken over two consecutive seasons in the south of Tasmania in order to identify potential pollinators in carrot seed crops. Sticky traps, water traps and observations were conducted within five carrot crops at three geographically independent sites to determine the variety and quantity of insects present in carrot crops. Nearly 42,000 insects were counted from observations, sticky traps and water traps. More than 100 morphological groupings were discerned. Small insects (<5 mm), most of which were thrips, made up 78% of the catch on sticky traps. Among the insects observed visiting umbels, nectar scarabs (Phyllotocus spp.) were the most abundant taxa but honey bees (*Apis mellifera*), muscoid flies and ladybirds were more often observed but at lower numbers. Nectar scarabs, soldier beetles and muscoid flies warrant further investigation of their role as pollinators of carrot flowers.

Gaffney, A., et al. (2018). "Frequent insect visitors are not always pollen carriers in hybrid carrot pollination." Insects 9(2).

Insect crop visitations do not necessarily translate to carriage or transfer of pollen. To evaluate the potential of the various insects visiting hybrid carrot flowers to facilitate pollen transfer, this study examines insect visitation rates to hybrid carrot seed crops in relation to weather, time of day and season, pollen carrying capacity, inter-row movement, and visitation frequency to male-fertile and male-sterile umbels. The highest pollen loads were carried by nectar scarabs, honey bees, and the hover fly Eristalis tenax (Linnaeus). Honey bees and muscoid flies were observed to forage mostly within the male fertile carrot row while nectar scarabs and E. tenax foraged across rows, carrying equal pollen loads regardless of their distance from the pollen source. All observed insect taxa were more frequently seen visiting male-fertile than male-sterile umbels. In contrast to other visiting insects, honey bees were abundant and frequent visitors and were observed carrying high pollen loads. Consequently, we suggest both optimizing honey bee management and improving the attraction of carrot lines to honey bees to improve pollination rates for hybrid carrot seed crops.

Gaffney, A., et al. (2020). "It is not all about being sweet: differences in floral traits and insect visitation among hybrid carrot cultivars." Insects 11(7).

Cytoplasmically male-sterile (CMS) carrot cultivars suffer from low pollination rates. In this study, insect visitation varied more than eightfold between 17 CMS carrot cultivars in a field-based cultivar evaluation trial. The visitation rates of honey bees, nectar scarabs, muscoid flies, and wasps each significantly differed among these cultivars. No significant difference in visitation rates was observed among cultivars of different CMS type (brown-anther or petaloid) or flower colour, but cultivars of Berlicumer root type had significantly higher insect visitation rates than Nantes. Six cultivars were further compared in regard to selected umbel traits: as umbel diameter increased, so did the visitation of soldier beetles, while that of honey bees decreased. Finally, nectar of these six cultivars was analysed for sugar content, which revealed monosaccharides to be the most common sugars in all. There was high variation in the levels of sugars from individual umbellets but no significant difference in nectar sugar composition among cultivars, suggesting that nectar sugar composition is of minor importance regarding pollinator attraction to hybrid CMS carrot umbels.

George, A. P., et al. (1993). "Effects of pollination and irradiance on fruiting of persimmon (*Diospyros kaki* L.) in subtropical Australia." Journal of Horticultural Science 68(3): 447-454.

Three experiments evaluated the effects of pollination and irradiance on fruit set, fruit drop, and fruit size and weight of 'Fuyu' the most highly planted non-astringent persimmon cultivar in subtropical Australia (Lat. 27-degree S). At irradiances of 13.8 and 5.9 vs. 19.8 MJ m-2 day-1, fruit set of open pollinated flowers was reduced by 53 and 100%, respectively. In contrast, fruit set of hand pollinated flowers was reduced by only 21 and 40%, respectively. Fruit weight of open pollinated or non-pollinated fruit was between 5-20% lower than hand pollinated fruit. Whole tree or calyx shading slightly reduced fruit size of hand pollinated fruit. The planting of adequate numbers of polliniser trees and the provision of hives of European honeybees might be essential for adequate set and fruit size in coastal regions of Australia which experience cloudy conditions (irradiance 10 MJ m-2 day -1).

Gill, R. A. (1989). "Pollination services: an overview." Australasian beekeeper 91(4): 168-187.

From a literature survey, over 60 tropical and temperate-zone crops are rated according to their degree of dependence on pollinating insects and to the effect of removing bees from them. The use of pollination services is illustrated by examples from the USA and New Zealand. The market in Australia is not as fully developed but could be profitable for many commercial beekeepers.

Gill, R. A. (1989). "The value of pollination services in Australia." Australasian beekeeper 91(6): 256-275.

Gilpin, A. M., et al. (2019). "Do mass flowering agricultural species affect the pollination of Australian native plants through localised depletion of pollinators or pollinator spill over effects?" Agriculture, Ecosystems & Environment 277: 83-94.

Australian agricultural landscapes are dominated by northern-hemisphere mass flowering species, with the potential to disrupt pollination of adjacent co-flowering plants. In northern-hemisphere systems, mass flowering plants can act as 'pollinator magnets'. Magnets can reduce the pollination success of adjacent co-flowering neighbours by drawing pollinators from these plants. However, magnets can also produce pollination 'spill over-effects' through increased pollinator movements to adjacent co-flowering taxa, potentially either increasing pollination or impacting it through transfer of mixed-species pollen. The impact of agricultural species on co-flowering plants in Australia is unknown. Native Australian plants evolved with unique pollinators and yet agricultural pollination is dominated by the exotic honeybee *Apis mellifera*. We tested how distance (to 250 m) from each of two populations of Lavender (*Lavandula* spp.) (2 years), Nectarines (*Prunus persica* var. *nucipersica* or var. *nectarina*) (1 year) and the pasture weed Paterson's Curse (*Echium plantagineum*) (2 years) affected pollinator diversity and abundance within experimental arrays of native and northern-hemisphere plants. For Paterson's Curse, we tested whether visitation varied when honeybee abundance was experimentally increased. As expected, we found magnets attracted significantly more honeybee visits in all possible comparisons across combinations of species, sites and years. However, contrary to expectation, in 10 of 18 comparisons, co-flowering species supported a slightly higher diversity of pollinators than magnets, with honeybees comprising a significantly lower proportion of flower visitors in 14 comparisons. The exceptions, which included populations of all three magnet species, were cases where honeybees were the only visitor (6 comparisons) or the magnet and co-flowering species were each visited by a single but different pollinator (2 comparisons). Most strikingly, our data provided no evidence of pollinator spill over. More than 95% of all pollinators on co-flowering species carried only their pollen and overall pollinator abundance didn't vary significantly with distance from magnets at any site or time. Honeybee abundance did not vary significantly with distance from magnets. For Paterson's Curse, the addition of managed hives increased honeybee abundance on co-flowering species in two of eight cases, but pollinator abundance didn't vary with distance from the magnet. Overall, we found few direct effects of mass flowering agricultural species on the pollination of either Australian native or exotic neighbours. The lack of spill over-effects may largely reflect the unusually high species fidelity of foraging *A. mellifera*. However, the numerical dominance of honeybees within Australian agricultural systems may impact pollination at the regional level.

Glare, T. R., et al. (2005). "Measuring environmental impacts of genetically modified crops in New Zealand." Aspects of Applied Biology (74): 91-99.

This paper reviews some of the research examining the effects of transgenic crops on beneficial species (including pollinator honey bees, predatory insects and parasitoids), as well as soil fauna (including nematodes) and flora (bacteria and fungi), in New Zealand.

Goodman, R., et al. (2001). "Honeybee pollination of buckwheat (*Fagopyrum esculentum* Moench) cv. Manor." Australian Journal of Experimental Agriculture 41(8): 1217-1221.

The role of honeybees (*Apis mellifera*) in the pollination of buckwheat cv. Manor was studied in a commercial planting at Smeaton, Victoria. Honeybees comprised 80% of all insect visitors to this crop. Other insects included ladybirds (*Coccinella transversalis* and *C. undecimpunctata*), hoverflies (*Meangyna viridiceps*), drone flies

(*Eristalis* sp.), blowflies (Calliphoridae), cabbage white butterflies (*Pieris rapae*), small bush flies and native bees. The activity of honeybees and other insects increased seed production from 91.5 g/plot (plots closed to insects) to 180.4 g/plot (plots open to insects).

Goodman, R. D. and K. A. Clayton-Greene (1988). "Honeybee pollination of highbush blueberries (*Vaccinium corymbosum*)." Australian Journal of Experimental Agriculture 28: 287-290.

In southern Victoria, Australia, observations on experimental plots showed that honeybees comprised 95.4% of all insect visitors to *V. corymbosum* and they appeared to be efficient pollinators. They were dusted with pollen as they withdrew their heads from the tubular flowers and were observed to pack pollen into their corbiculae. Plants visited by honeybees had a greater percentage fruit set (61% against 18%), higher fruit numbers (1156 against 144) and more fruit by weight (1.6 kg against 0.2 kg) than did plants caged to prevent access by bees and other large insects. Netting against birds did not impede pollination. Flowers inside a bird-proof cage had a greater frequency of bee visitations (8.25 bees per 14 plants) than did those outside (1.5 per 14 plants).

Goodman, R. D. and B. P. Oldroyd (1988). "Honeybee pollination of strawberries (Fragaria X ananassa Duchesne)." Australian Journal of Experimental Agriculture 28: 435-438.

In southern Victoria, Australia, plots of strawberries which were accessible to honeybees yielded 20.8% marketable berries (well-shaped, >10 g fresh weight), whereas plots which were caged and not accessible had only 4.5% marketable berries. The total numbers of fruits were not significantly affected by the presence or absence of pollinating insects. Honeybees comprised 58.9% of insect visitors and were considered to be the main pollinators. Hoverflies (Syrphidae) also visited strawberry flowers frequently and were observed to extend their proboscis into flowers, but they did not appear to be dusted with pollen.

Goodman, R. D. and A. E. Williams (1994). "Honeybee pollination of white clover (*Trifolium repens* L.) cv. Haifa." Australian Journal of Experimental Agriculture 34(8): 1121-1123.

The role of honeybees (*Apis mellifera*) in the pollination of white clover cv. Haifa was studied in a commercial planting at Mount Mercer, Victoria. Honeybees comprised 88% of all insect visitors to this crop. The activity of honeybees and native bees (*Lasioglossum* sp.) increased seed yield from 1.3 g/plot (plots closed to bees) to 403 g/plot (plots open to bees). The caging of plots for part of the flowering period to simulate the non-availability of bees for pollination resulted in lower seed yields than those from uncaged plots.

Goodwin, M. (1991). "Staminate vine distributions." Proceedings, Kiwifruit Pollination Field Days, 26-28 August 1991.: 4-11.

The effects on kiwifruit [*Actinidia deliciosa*] production of different ratios of male to female vines were studied in 54 orchards in South Auckland and the Bay of Plenty, New Zealand. The 5 ratios (male : female) in use were 1 : 3, 1 : 5, 1 : 6, 1 : 7 and 1 : 8. There were no significant differences between these orchards in seed numbers or fruit weights, indicating that the male vine distribution did not have a major effect on pollination. However, in orchards using strip and overhead male vines, with larger distances between male vines, there was a strong correlation between seed number and distance between male vines; seed numbers dropped by about 30% with an increase in distance from 3 m to 16 m. Subsequent trials confirmed this effect on pollination [usually carried out by honey bees]; a 90% reduction in flower numbers resulted in only a 4-9% reduction in fruit size. Further, more extensive, trials are needed.

Goodwin, M., et al. (1992). "A comparison of pollinators." New Zealand Kiwifruit (September): 12-12.

Various kiwifruit pollination devices were tested in 2 orchards in New Zealand which were also stocked with honey bees [*Apis mellifera*] (8 hives/ha). Measurements of fruit set, percentage of undersized fruit, mean fruit weight and average value of fruit, showed that there was little difference between vines receiving only honey bee pollination and those receiving supplementary artificial pollination.

Goodwin, R. M. (1986). "Increased kiwifruit pollen collection after feeding sugar syrup to honey bees within their hive." New Zealand journal of experimental agriculture. 14(1): 57-61.

Goodwin, R. M. (1986). "Kiwifruit flowers: anther dehiscence and daily collection of pollen by honey bees." New Zealand journal of experimental agriculture. 14(4): 449-452.

Goodwin, R. M. (1987). Ecology of honey bee (*Apis mellifera* L.) pollination of kiwifruit (*Actinida deliciosa* (A. Chev.)). ProQuest Dissertations and Theses. Ann Arbor, The University of Auckland (New Zealand): 196-196.
Available from Centre for Research Libraries http://www.crl.edu/content/DissLinkPQDD.asp

Goodwin, R. M. (1995). "Afternoon decline in kiwifruit pollen collection." New Zealand Journal of Crop and Horticultural Science 23(2): 163-171.
The afternoon decline in the collection of kiwifruit pollen by honey bees (*Apis mellifera*) was investigated. Most staminate and pistillate flowers opened before the time of anther dehiscence. Flowers of both sexes partially closed again in the late afternoon of the day that they first opened and made more pollen available after anther dehiscence. Staminate flowers made most of their pollen available in the morning and early afternoon. Most of the bees that stopped collecting kiwifruit pollen in the early afternoon remained in the hive without being recruited to other food sources. Pollen availability from staminate flowers in an orchard with normal numbers of foraging bees reached a peak between 10.00 and 11.00 h, and then dropped sharply until 13.00 h, after which it remained constant. The availability of pollen from staminate flowers in an orchard with few foraging bees continued to increase from the time of anther dehiscence until the late afternoon. This suggests that the decline in pollen collection is the result of the pollen supply becoming depleted and not because it becomes dry and difficult to collect.

Goodwin, R. M. and N. M. Congdon (2018). "Recognition and attractiveness of staminate and pistillate kiwifruit flowers (*Actinidia deliciosa* var. deliciosa) by honey bees (*Apis mellifera* L.)." New Zealand Journal of Crop and Horticultural Science 46(1): 72-80.
Our aim was to determine whether honey bees use pollen to distinguish between staminate and pistillate kiwifruit flowers, and, if so, why they find pistillate flowers more attractive. Bees differentiated between staminate and pistillate flowers when the petals and stigma were removed. In trials using artificially collected staminate and pistillate pollen, bees responded by extending their proboscis to pistillate pollen at significantly higher rates in one out of two trials. Bees were trained to increase their response to staminate pollen, indicating their ability to differentiate the two pollens. There was no difference in the amount of sugar in staminate versus pistillate kiwifruit pollen pellets, suggesting that bees treat them the same during collection. Pistillate pollen grains were significantly lighter than staminate grains, which may influence honey bees' preference for foraging on pistillate flowers. The proboscis extension response to pollen could be used to select staminate vines in breeding programmes.

Goodwin, R. M., et al. (2011). "Number of honey bee visits required to fully pollinate white clover (*Trifolium repens*) seed crops in Canterbury, New Zealand." New Zealand journal of crop and horticultural science. 39(1): 7-19.
White clover (*Trifolium repens* L.) is grown throughout New Zealand in pasture and as a seed crop in the South Island. This investigation was conducted to determine the number of honey bee visits necessary to fully pollinate white clover flowers; the number of foraging honey bees per hectare required to reach the maximum seed number per floret; and to assess the level of white clover pollination in Canterbury. The theoretical maximum number of seeds that can be produced per white clover floret is six, based on the number of ovules present. Based on the number of seeds resulting from a single bee visit (mean = 1.24), it is calculated that in an 8 h foraging day, 19,420 bees would be required per hectare to reach maximum seed number per floret, assuming that no floret received more visits than required. Bee activity was assessed at two clover sites with an estimated 20,124 foraging bees per hectare. This number should have been enough to reach maximum seed number per floret. However, seed set in these fields was approximately half of its theoretical potential.

Goodwin, R. M., et al. (1991). "Effect of variations in sugar presentation to honey bees (*Apis mellifera*) on their collection of kiwifruits (*Actinidia deliciosa*) pollen." New Zealand Journal of Crop and Horticultural Science 19(3): 259-262.

Trials were conducted in 3 commercial orchards to establish appropriate parameters for feeding sugar syrup to honey bee colonies to increase kiwifruit pollen collection. All the groups of colonies fed sugar syrup collected significantly more kiwifruit pollen pellets than the control colonies for at least part of each trial. The type of feeder (top or division-board feeders) and the concentration of syrup (1M or 2M) had no effect on the amount of kiwifruit pollen collected. The grade of sugar (white or industrial raw) had no effect on the total amount of pollen collected. Feeding dry sugar did not increase the number of kiwifruit pollen pellets collected.

Goodwin, R. M., et al. (1991). "Feeding sugar syrup to honey bee colonies to improve kiwifruit pollen collection: a review." Acta horticulturae.: 265-274.

Goodwin, R. M., et al. (1994). "Effect of feeding pollen substitutes to honey bee colonies used for kiwifruit pollination and honey production." New Zealand Journal of Crop and Horticultural Science 22(4): 459-462.

Feeding pollen substitutes to honey bee colonies in kiwifruit orchards had no significant effect on the amount of kiwifruit pollen collected but caused a decline in the amount of pollen collected from other sources. Pollen substitutes had no significant effect on honey production from colonies used for kiwifruit pollination or colonies managed solely for honey production.

Goodwin, R. M., et al. (2013). "Wind and honey bee pollination of kiwifruit (*Actinidia chinensis* 'HORT16A')." Special Issue: Recent advances in pollination biology in New Zealand. 51(3): 229-240.

The aim of this study was to determine the factors required to pollinate 'Hort16A' (*Actinidia chinensis* Planch. var. chinensis) kiwifruit. Pistillate flowers (88%) opened between 0500 and 1200 h. There was no indication of nectar production or viable pollen on pistillate flowers. Stigma receptivity peaked on the second day after anthesis and then declined. Excluding honey bees (*Apis mellifera* L.) significantly ($p<0.05$) reduced fruit set and seed number. Flowers exposed to wind pollination for 5 days produced fruit with an average of 110 seeds. When equal numbers of staminate and pistillate flowers were presented on a tray, only 2.8% of visits were to staminate 'Sparkler' flowers and 2.2% to staminate 'Meteor' flowers. Single bee visits to pistillate flowers produced averages of 51-61.7 seeds. The percentage of staminate pollen carried by honey bees significantly decreased with increasing distance from staminate vines (0.8%/m). Average seed number decreased by 0.75%/m.

Goodwin, R. M. and J. H. Perry (1992). "Use of pollen traps to investigate the foraging behaviour of honey bee colonies in kiwifruit orchards." New Zealand Journal of Crop and Horticultural Science 20(1): 23-26.

A weak honey bee colony (c. 6 frames) in a Langstroth hive fitted with an OAC pollen trap was placed in a kiwifruit orchard at peak flowering. The efficiency of the trap was calculated by dividing the total of trapped pollen pellets by the total number of pellets entering the hive within a given period. The trap had an average daily efficiency of 16.5% and 16.7% on 2 consecutive days. Hourly efficiencies varied between 0 and 25% with the highest efficiency in the middle of the day, which coincided with periods of maximum honey bee foraging activity. The proportions of staminate and pistillate pollen in a foraging bee's corbiculae and on its body were determined by using Alexander's stain [Stain Technology (1980) 55, 13-18], which stains staminate pollen red and pistillate pollen green. The amount of staminate pollen in a forager's corbiculae was closely related to the proportion of staminate pollen on its body indicating that pellets can be used as a measure of pollination efficiency, but there was wide variation between bees in the proportion of staminate pollen carried. ADDITIONAL ABSTRACT: The efficiency of a pollen trap in trapping *Actinidia deliciosa* pollen pellets was investigated. The trap, which was fitted to a hive placed in a commercial orchard at peak flowering, had an average daily efficiency of 16.5 and 16.7% on 2 consecutive days. Hourly efficiencies varied between 0 and 25%, with the highest efficiency in the middle of the day which coincided with periods of maximum honeybee (*Apis mellifera*) foraging activity. The amount of staminate pollen in foragers' corbiculae was closely related to the proportion of staminate pollen on their body, indicating that pellets can be used as a measure of pollination efficiency.

Goodwin, R. M. and D. Steven (1993). "Behaviour of honey bees visiting kiwifruit flowers." New Zealand Journal of Crop and Horticultural Science 21(1): 17-24.

Honey bees (*Apis mellifera* L.) were shown to be able to discriminate between staminate (male) and pistillate (female) kiwifruit (*Actinidia deliciosa*) flowers. They exhibited floral sex constancy and showed an overall preference for pistillate flowers when visiting flowers on a tray. This indicates that honey bee pollination of kiwifruit is not a case of mistake pollination. Foragers also exhibited flower sex constancy between trips when foraging freely in a kiwifruit orchard. A number of foragers also had foraging areas that they returned to during consecutive foraging trips. Honey bees visited staminate flowers between 1 and 3 days old, and pistillate flowers between 1 and 5 days old in a season when pistillate anther dehiscence took 5 days. When pistillate anther dehiscence took only 3 days, foragers only visited flowers between 1 and 3 days old. This suggests that foragers are able to determine whether a kiwifruit flower contains pollen without having to land on it. © 1993 The Royal Society of New Zealand.

Granger, A. R. (1997). "Pollen gene flow in South Australian cherry (*Prunus avium* L.) orchards." Australian Journal of Experimental Agriculture 37(5): 583-589.

Isozyme analysis of sweet cherry embryos from 3 different South Australian orchards has proven to be an invaluable diagnostic tool. It has shown that in comparison with almond orchards, pollen gene flow occurs over much greater distances. Furthermore, pollen genes are being donated by more than one polliniser cultivar. For example, Sam planted at Lenswood Horticultural Centre was pollinated by both Vista and Merton Glory. Protective netting was used to exclude birds from the cherry orchard at Lenswood and only 0.003% of the apparent net pollen gene flow came from cultivars planted outside of the net to those within. The presence of bird netting discouraged the movement of honeybees. Cross-compatible pollen rather than self-pollen contributed most to embryo formation in the self-fertile cultivar Stella. Seventy-one percent of embryos produced by Stella at Lenswood were as a result of outcrossing. This work has culminated in some important recommendations for the cherry industry. Namely that where bird enclosures are used bee hives and polliniser cultivars should be placed inside the netted area, and when planting self-fertile cultivars, such as Stella, polliniser cultivars should be included in the orchard plan.

Gurr, L. (1961). "The pollination of red clover and lucerne in New Zealand." Proceedings of the New Zealand Society of Animal Production 21: 166-173.

Of the 4 species of bumble bees successfully introduced into New Zealand, *Bombus terrestris* is the most efficient pollinator of lucerne and B. ruderatus of red clover. The foraging behaviour of these and honeybees is discussed in relation to seed yields. -J.G.G.

Hadfield, J. W. and R. A. Calder (1936). "Lucerne (*Medicago sativa*). Investigations relative to pollination and seed-production in New Zealand." New Zealand Journal of Science and Technology 17: 577-594.

Tripping is shown to be a pre-requisite to seed-production. Artificial tripping has aided seed-production under open pollination in the ratio of 1: 1.5 and under cages in the ratio of 1: 2.8. Trials are described by which the efficacy of different species of bees as pollinating agents has been determined on a basis of seed production. *Bombus terrestris* is proved to be very effective as a tripping and pollinating agent. Italian, hybrid, black and Caucasian bees are shown to be relatively inefficient, and rarely trip the flowers. Their inefficiency, however, can be counterbalanced by the concentration of their numbers. Wind and bees are shown to be agents in the distribution of pollen, which can be found adhering to the standards of untripped flowers, thus indirectly assisting cross-pollination. In this district under natural open pollination about 25 per cent of the available florets set pods. Of the fertilization effected, approximately 44 per cent results from cross-fertilization and 56 per cent from self-fertilization. Self-fertilization results in a marked decrease in seed production, and to a lesser degree in vegetative vigour. Cross-fertilization results in a marked increase in seed production and in a measure of heterosis. The practical application of the findings to New Zealand conditions is discussed. -Authors' summary.

Hall, M. A., et al. (2020). "Bee visitation and fruit quality in Berries Under Protected Cropping Vary Along the Length of Polytunnels." Journal of Economic Entomology 113(3): 1337-1346.

Wild and managed bees provide effective crop pollination services worldwide. Protected cropping conditions are thought to alter the ambient environmental conditions in which pollinators forage for flowers, yet few studies have compared conditions at the edges and centre of growing tunnels. We measured environmental variables (temperature, relative humidity, wind speed, white light, and UV light) and surveyed activity of the managed honey bee, *Apis mellifera* L.; wild stingless bee, *Tetragonula carbonaria* Smith; and wild sweat bee, *Homalictus urbanus* Smith, along the length of 32 multiple open-ended polyethylene growing tunnels. These were spaced across 12 blocks at two commercial berry farms, in Coffs Harbour, New South Wales and Walkamin, North Queensland, Australia. Berry yield, fresh weight, and other quality metrics were recorded at discrete increments along the length of the tunnels. We found a higher abundance and greater number of flower visits by stingless bees and honey bees at the end of tunnels, and less frequent visits to flowers toward the middle of tunnels. The centre of tunnels experienced higher temperatures and reduced wind speed. In raspberry, fruit shape was improved with greater pollinator abundance and was susceptible to higher temperatures. In blueberry, per plant yield and mean berry weight were positively associated with pollinator abundance and were lower at the centre of tunnels than at the edge. Fruit quality (crumbliness) in raspberries was improved with a greater number of visits by sweat bees, who were not as susceptible to climatic conditions within tunnels. Understanding bee foraging behaviour and changes to yield under protected cropping conditions is critical to inform the appropriate design of polytunnels, aid pollinator management within them, and increase economic gains in commercial berry crops.

Harden, J. and G. Kleinschmidt (1978). "The value of plant pollen in honeybee nutrition. I. pollen sources and pollen collection by bees foraging in agricultural areas." Australasian beekeeper: 155-158.

Hawkeswood, T. J. (1983). "Pollination and fruit production of *Cupaniopsis anacardioides* (A. Rich.) Radlkf. (Sapindaceae) at Townsville, North Queensland. 1. Pollination and floral biology." Victorian Naturalist 100(1): 12-20.

Of 6 insect species identified during one day on the strongly scented flowers of this hardy tree, only 2 were common visitors: *Trigona carbonaria* and a calliphorid fly *Stomorhina discolor*. Only 2 honeybees were observed on the tree. *T. carbonaria* appeared to be the main pollinator, effecting mainly self-pollination and only a small amount of cross-pollination. The pollen grain is described and illustrated.

Heard, T. (1987). "Preliminary studies on the role of *Trigona* bees in the pollination of macadamia." Proceedings of the Second Australian Macadamia Research Workshop, Bangalow Palms Resort, Bangalow, NSW, 15-19 September 1987.: 192-197.

Bees of the genus *Trigona* and honeybees, *Apis mellifera*, were together responsible for 94% of visits to Macadamia flowers in 10 orchards in Queensland and New South Wales, Australia. *Trigona* bees were particularly abundant where natural vegetation abutted the orchard. All *Trigona* bees collected pollen and came into direct contact with the stigma. Most honeybees collected nectar and made only perfunctory contact with the stigma. Trials aimed at testing the relative pollinator efficiency of *Trigona* and honeybees were inconclusive. Attempts at hiving *Trigona* and propagating these colonies were largely successful. All *Trigona* bees and 24% of honeybees sampled returning to hives placed in an orchard had Macadamia pollen on their bodies.

Heard, T. A. (1988). "The requirement for insect pollination by macadamia and the pollinator efficiency of *Trigona* bees." Proceedings of the Fourth Australasian Conference on Tree and Nut Crops, Lismore, NSW, Australia, 14-20 August 1988.: 219-223.

The requirement of *Macadamia integrifolia* for insect pollination was examined by bagging immature racemes and removing the bags for varying periods when the racemes matured. A positive correlation existed between bee (*Apis mellifera* and *Trigona* spp.) visitation and initial nut set. More abortion occurred at the highest rate of bee visitation so that there was no difference in final yield between the high and medium levels of bee visitation. These results suggest that pollination was not a limiting factor at the 2 experimental sites near Brisbane, Australia. Racemes enclosed in cages which excluded *A. mellifera*, but which allowed access to the smaller *Trigona* bees showed high nut set, indicating that these bees are efficient pollinators of Macadamia in this area.

Heard, T. A. (1993). "Pollinator requirements and flowering patterns of *Macadamia integrifolia*." Australian journal of botany. 41(4-5): 491-497.

Heard, T. A. and E. M. Exley (1994). "Diversity, abundance, and distribution of insect visitors to macadamia flowers." Environmental entomology. 23(1): 91-100.

Fifty-five species of insects visited macadamia flowers in orchards in eastern Australia. Only two species, the social bees *Apis mellifera* L. and *Trigona carbonaria* Smith, were common. Abundance of *T. carbonaria*, but not *A. mellifera*, was significantly positively correlated with extent of surrounding eucalypt vegetation. *A. mellifera* and *T. carbonaria* showed no preference for heavily versus lightly flowering trees. Both bee species, but especially *T. carbonaria*, preferred outer racemes to shaded racemes, possibly reducing the effectiveness of these species as pollinators. Both bee species were present for the major period of macadamia flowering. *T. carbonaria* foraged for a mean of 7 h a day compared with 10 h for *A. mellifera*. Both species showed moderate annual variation in abundance at some sites. Four bird species were also observed feeding on macadamia flowers, they may play a role in pollination.

Heard, T. A., et al. (1990). "Pollination biology of cashew in the Northern Territory of Australia." Australian journal of agricultural research. 41(6): 1014-1101.

Hely, F. W. and M. Zorin (1977). "Influence of temperature and humidity on tripping of lucerne flowers." Australian Journal of Agricultural Research 28(6): 1015-1027.

Flowering lucerne plants cv. (a) Hunter River, (b) Dry Area, (c) Siro Peruvian, (d) Lahontan, (e) Totana, (f) Urgel, (g) Saladina, (h) Nemasin, (i) Uruguay clone 10, (j) Rambler, (k) Deniliquin and (l) Krawarree were transferred from cool overnight conditions to glasshouses at 25 deg C and 40% RH. Automatic flower tripping ranged between 1 and 14% of available flowers (values for (j) and (b), resp.). In a 2nd experiment, flowering stems of (a), (b), (f), (g), (h), (j), and (l) were cut, and stood in water in covered beakers in glasshouses at 20, 25, 30 or 40 deg C with 50, 40, 33 and 28% RH, resp. Increased temp. generally resulted in increased tripping, except with (j), and at 40 deg C (a), (b) and (h) had approx. 25, 50 and 35%, resp., flowers tripped. Using the same temp. but reduced RH, automatic tripping increased in (a) and (b) to approx. 70 and 87%, resp., whereas (f), (j) and (l) showed no response, and (g) and (h) gave significant increases at 30 deg C. In field trials using (a), (c) and (d) at Deniliquin, New South Wales, where temp. reached only 24-26 deg C during warmer parts of the day, approx. 75% flowers of each cv. produced pods; mean seed number/pod was 5.1, 6.3 and 5.9 in (a), (c) and (d), resp. At 25 deg C induced tripping, simulating actions of pollen-collecting bees, showed differences in resistance to tripping between lucerne cv. similar to those in automatic tripping.

Hermansen, T. D., et al. (2014). "Identifying the real pollinators? Exotic honeybees are the dominant flower visitors and only effective pollinators of *Avicennia marina* in Australian temperate mangroves." Estuaries and Coasts 37(3): 621-635.

The literature suggests that, in the tropics, mangroves are typically pollinated by a range of generalist pollinators, whereas in temperate populations, pollination biology is largely unstudied. We predicted that, for the mangrove *Avicennia marina* in temperate southeast Australia, pollinator diversity would be low, and its pollination system modified by the exotic honeybee *Apis mellifera*. Multi-year surveys and experiments were used to test these hypotheses by determining the identity and frequency of flower visitors, quantifying pollinator foraging behaviour, determining the species composition of pollen loads, and demonstrating pollen removal and deposition. We identified 38 species that visited flowers, but only *A. mellifera* was a significant pollinator. It was the only species to carry large amounts of pollen and forage in a manner permitting transfer of pollen to stigmas. Moreover, *A. mellifera* was the numerically dominant flower visitor and was effective in both pollen removal and deposition. This study demonstrates the importance of distinguishing flower visitors from pollinators and emphasises the surprisingly widespread influence of the exotic *A. mellifera*. Finally, our study and a worldwide review of the literature on the pollination of mangroves reveal that the pollination biology of other mangrove systems requires similar scrutiny.

Hill, S. J. (1987). "Pollination of almond (*Prunus dulcis* (Mill.) D. A. Webb)." Pollination of almond (*Prunus dulcis* (Mill.) D. A. Webb). 330-pp.

Variables which are known to affect pollination and nut-set of almonds were investigated by a literature review and by experiments in one orchard at Angle Vale, S. Australia. Examination of the flowers of the cultivars Chellaston and Davey showed that 10-90% of all flowers were female-sterile on any one date, and over the whole 1984 season 22-31% of flowers were female-sterile. Rate of anther dehiscence varied with time but appeared to be independent of flower age. Rate of dehiscence increased with increasing air temperature in the range 8-17 degrees C. Anthers did not dehisce until 6-48 h after anthesis and all anthers within a flower dehisced after a further 2-74 h. Pollen was available for collection by honey bees for 2-6 days after anthesis. Most flowers were not visited by a bee until they were at least 24 h old. Pollen foragers rarely visited flowers that did not contain pollen in dehisced anthers. Honey bees collected pollen from up to 7.5 anthers/s and touched the stigma during 58-100% of flower visits. Wind pollination was negligible and honey bees are considered necessary for pollination. Man-aided methods of pollination can be useful but are expensive compared to the efficient use of honey bees. Three methods for the estimation of the optimum number of honey bee colonies for almond orchards are discussed. Most instances of effective pollination are thought to be due to foragers that visit 2 or more cultivars during a foraging trip. The number of foragers that do this depends on several factors, including distribution of the cultivars, planting pattern, tree size, distance between trees, and whether or not hedgerows have formed. Methods of increasing almond yields in orchards are discussed.

Hill, S. J. (1989). "Almond orchard design with respect to honeybee behaviour." Acta horticulturae.: 201-204.

Holtkamp, R. H., et al. (1992). "Influence of nectar volume and sugar content on seed set in lucerne." Australian Journal of Experimental Agriculture 32(6): 713-716.

Twenty-four commercial *Medicago sativa* cultivars were grown with flood irrigation in NSW, Australia; *Apis mellifera* colonies were present throughout flowering, at a density of 5/ha. In each cultivar, glucose, fructose and sucrose concentrations in nectar were measured by HPLC, and seed set was determined. Seed set was found to be correlated with both nectar volume and sucrose concentration ($r = 0.74$, $P < 0.01$). Differences in seed set between cultivars were not significant. Nectar volume varied from 18.3 to 74.7 micro l/100 florets, and fructose, glucose and sucrose concentrations were 5.4-40, 10.6-26.8 and < 0.01-17.9 g/100 ml, respectively. ADDITIONAL ABSTRACT: Twenty-four *Medicago sativa* cultivars, representing the genetic variation currently grown in Australia, were grown with flood irrigation at the Agricultural Research Centre, Trangie, New South Wales. Soil type was a red-brown earth. Plants were sampled during peak flowering to determine nectar volume per 100 florets. Seed set was determined by hand collection and threshing of 100 racemes of mature pods per cultivar. Glucose, fructose and sucrose concentrations in the nectar were measured using HPLC. No other sugars were found in the nectar. Seed set was correlated with both nectar volume and sucrose concentration.

Hopping, M. E. (1982). "80,000 honeybee hives not needed; spray pollination of kiwifruit possible by 1990." New Zealand Agricultural Science 16(1): 46-48.

Since it is unlikely that the 80 000 honeybee colonies estimated to be required by 1990 for kiwifruit pollination in the Bay of Plenty, New Zealand, will be available, an alternative pollination method has been developed which involves harvesting staminate flowers. Extracted pollen is suspended in an aqueous medium containing calcium nitrate, boric acid and sodium carboxymethyl cellulose (each at 0.01% wt./vol) plus gum-acacia (0.005% wt./vol) or pentaerythritol (0.5% wt./vol), which maintains pollen viability for up to 3 h. The suspension is applied to pistillate flowers with hand-operated sprayers. In trials using concentrations of 0.5 g pollen per litre of spray there was a significant increase in number of seeds per fruit and fruit weight compared with unsprayed controls open to pollination by insects and wind. Trials with a boom sprayer were less successful because pollen viability decreased rapidly during suspension pumping and insufficient pollen was deposited on the stigmas.

Hopping, M. E. M. J. A. K. G. M. B. T. G. (1986). "Kiwifruit pollination seminar proceedings." Kiwifruit pollination seminar proceedings.

The 7 main contributions to this volume deal with: payment for kiwifruit [*Actinidia deliciosa*] by count, factors which influence fruit size, growing export kiwifruit, male vine selection, spray pollination, and honeybee pollination. M.E Hopping and J.A.K. Martyn describe recent research on spray pollination which showed that fruit set from either honeybee or hand pollination was similar, but that the overall success of bee pollination depended on the weather; in some years the percentage of fruit reaching export weight averaged 31% less than those from hand pollination. Spray pollination is recommended as a supplement to normal bee pollination. M. Goodwin describes research which emphasizes that it is important for the grower to determine if there are enough bees in the orchard to ensure that each flower receives the maximum number of visits each day. If there is a pollen surplus, introducing extra bees should improve pollination. Feeding sugar syrup inside the hives is recommended as a way of changing the foraging behaviour of bees, so that more kiwifruit pollen is collected. T.G. Bryant discusses the relationships between kiwifruit flowers and honeybees and describes management techniques for ensuring adequate pollination. There are 3 Appendixes, comprising a suggested pollination contract, a list of useful contacts for growers in New Zealand, and the MAF Aglink leaflet 'Honey bees - pollination of crops: economic significance and management'.

Hornitzky, M. and A. Ghalayini (2006). "Honey produced from genetically modified canola (*Brassica napus*) nectar will not need to be labelled as a GM food under current Australian guidelines." Australian Journal of Experimental Agriculture 46(8): 1101-1104.

Food or ingredients labelled as genetically modified (GM) contain either new genetic material or protein as a result of genetic modification. In Australia, a 1% threshold, below which labelling is not required, exists for the unintended presence of GM material in non- GM foods. The canola pollen content by dry weight in a range of canola honey samples from diverse geographical areas in Australia was determined to be 0.2 +/- 0.12%, well below the 1% threshold. Two GM canola honey samples sourced from Canada contained 0.19 and 0.24% of canola pollen. This work indicates honey derived from GM canola crops will not need to be labelled as a GM food.

Howlett, B. G., et al. (2015). "Native and introduced bee abundances on carrot seed crops in New Zealand." New Zealand Plant Protection 68: 373-379.

In New Zealand, unmanaged bees' species can be important crop pollinators, but their abundance and distribution are poorly known within hybrid carrot seed crops. Standardised counts of bees visiting flowering carrot umbels (1350 umbels observed/field) across 19 commercial hybrid fields were conducted between 1000 h and 1500 h. Despite honey bees being observed in all fields, abundance varied greatly between fields (mean=98.1; maximum=330, minimum=1). Other bees observed visiting umbels were *Lasioglossum sordidum* (17 fields; mean=14; maximum=65); *Leioproctus* sp. (12 fields; mean=2.0; maximum=19); *Hylaeus* sp. (one field; maximum= 1) and *Bombus terrestris* (six fields; mean=2.0; maximum=11). The number of individual bees (all species together) counted/umbel on male fertile umbels was significantly higher than on male sterile umbels, a factor that could contribute to sub-optimal pollen flow between umbel lines by bees. Examination of their movements between male fertile and sterile lines is required to verify their efficiency as pollinators.

Howlett, B. G., et al. (2015). "Pollination of macadamia: Review and opportunities for improving yields." Scientia Horticulturae 197: 411-419.

Macadamia nuts are a valuable culinary resource, but yields can vary substantially between varieties, orchards and seasons. The nuts are harvested from commercial varieties derived from two endemic Australian tree species; *Macadamia integrifolia* Maiden & Betche and *Macadamia tetraphylla* L.A.S. Johnson. While some aspects of crop management for this relatively new crop are well known and generally well applied-including variety selection, irrigation and pesticide application-progress towards increasing quantity and reliability of yield has proven elusive. Hand pollination studies indicate that inadequate cross pollination contributes to low nut set and thus low yield. Typically, just 0.3% of flowers develop into harvestable nuts. Lack of nut development after flowering and early abscission are indicators of poor fertilisation of the ovule. Honey bees (*Apis mellifera* Linnaeus, 1758) are routinely reported as the most common insect visitor to macadamia flowers and are widely regarded as the most important agent for transferring pollen between flowers. Stingless bees, beetles, flies and birds also visit flowers and have been considered as pollinators. In this review, we aim to collate what is currently known about the pollination of

macadamia varieties, assess the factors that may hinder effective pollination and subsequent yield, and identify opportunities to improve both pollination and yield in commercial macadamia orchards. © 2015 Elsevier B.V.

Howlett, B. G., et al. (2017). "Diurnal insect visitation patterns to 'Hayward' kiwifruit flowers in New Zealand." New Zealand Plant Protection 70: 52-57.

Different pollinators may vary in their temporal flower-visitation patterns within crops, potentially extending the period pollination may occur. To assess whether this could be the case in kiwifruit, we conducted standardised observational surveys of insects visiting kiwifruit flowers within 31 orchards at three times: 10:00-11:00, 12:00-13:00 and 14:00-15:00 hr. Honey bees (*Apis mellifera*) represented 92% of visitations (n=5474), but temporal abundances were uneven (predicted abundances were lower at 14:00-15:00 hr). Predatory hover flies (Melangyna, Melonostoma, *Allograpta* spp.) also showed an uneven temporal pattern. There were no significant differences in the temporal abundances for buff-tailed bumble bees (*Bombus terrestris*), rat-tailed hover flies (Eristalis, *Helophilus* spp.), March flies (*Dilophis nigrostigma*), flower longhorn beetles (*Zorion guttigerum*) or the native bees (*Leioproctus* and *Lasioglossum* spp.) although, in some cases, low numbers may have masked potential unevenness trends. Variation in diurnal flower-visitation patterns among insects suggests the potential for complementarity between different pollinators.

Howpage, D. (1999). Pollination biology of kiwifruit: Influence of honey bees, *Apis mellifera* L, pollen parents and pistil structure. PQDT - Global. Ann Arbor, University of Western Sydney, Hawkesbury (Australia): 278-278.

The importance of European honey bees in improving fruit set, yield and fruit weight of kiwifruit on the central east coast of Australia was investigated. Field investigations were carried out using different bee saturations and different types of male pollen parents. These investigations confirmed the importance of honey bees in kiwifruit fruit set, yield and fruit weight. However, the results suggested that increasing bee activity alone may not increase pollination of kiwifruit by honey bees. Many factors need to be understood before introducing bees into the orchard. Bees were more effective during the early part of the flowering period, and bee activity varied according to the sex of the vine, planting design and the time of day. The type of male pollen parents also influenced fruit size and quality. Flowers pollinated by different pollen parents were assessed for pollen tube growth and histochemical changes. The resulting fruit were also examined for weight and seed numbers. Honey bees play the major role in the size and yield of kiwifruit, but the design of male vines, their age and type of male pollen may also contribute. The kiwifruit pistil also possesses important features that can be considered as adaptations to insect pollination.

Howpage, D., et al. (2001). "Influence of honey bee (*Apis mellifera*) on kiwifruit pollination and fruit quality under Australian conditions." New Zealand Journal of Crop and Horticultural Science 29(1): 51-59.

The influence of honey bee (*Apis mellifera* L.) pollination of kiwifruit (*Actinidia deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson) under different pollination regimes (viz. honey bee supplementation, honey bee saturation in a cage with a single male cultivar, and honey bee exclusion) was investigated under Australian conditions during 1993/94 and 1995/96 seasons. Vines that had no access to honey bees had significantly ($P \leq 0.01$) lower fruit set (24%) compared to honey bee supplementation (91%) and bee saturation (89%). The mean yield (kg/vine) and the mean number of fruit/vines in bee-supplemented and bee-saturated treatments did not differ significantly, although vines that were excluded from honey bees produced significantly ($P \leq 0.01$) lower yields. However, individual fruit weight in the bee-saturated treatments was affected. There was significantly more small fruit in bee-saturated vines than in vines that were supplementary pollinated by honey bees. Bee activity as assessed by the number of bee visits on flowers (bees/vine per min) was significantly higher on male vines than female vines during the first 2 weeks of the flowering period. Honey bees were the main contributor to pollination and fruit set, although low numbers of other potential insect pollinators such as ladybird beetles and hover flies were also observed. The mean seed numbers in comparable fruit from higher weight groupings (i.e., 70-89, 90-109, and ≥110 g) in bee-supplemented and bee-saturated vines did not differ significantly, suggesting adequate pollination and fertilisation of ovules in these two treatments. Vines that were caged with a single male cultivar produced fruit with significantly higher ($P \leq 0.01$) total soluble solids concentration than did those that were honey bee supplemented. Possible reasons for the reduced mean fruit weight under honey bee saturation is discussed.

Ironside, D. A. (1970). "Biology of Macadamia flower caterpillar (Homoeosoma vagella Zell.)." Queensland Journal of Agricultural and Animal Sciences 27(3): 301-309.

Much of the information in this account of investigations on the life-history, habits and seasonal incidence of *Homoeosoma vagella* Zell. on *Macadamia* spp. in Queensland has already been noticed [cf. RAE A 59 3315]. All stages of the Pyrah'd are described, and its known parasites and predators are listed. The most important are the *Braconid Agathis rufithorax* (Turner), which parasitized 61% of the larvae during March-April 1966, and a Mirid predator of the genus *Psallus*, which attacked the larvae. These reduced *H. vagella* so much that Macadamia trees flowering in May were free from infestation and only light infestations that did not affect the nut set developed on those flowering during June-August. In the spring of 1969, large numbers of *Psallus* sp. were present and infestations of *H. vagella* were considerably lighter than in previous springs. In experiments on control, sprays of 0.05% trichlor-phon killed the eggs and larvae in all stages. For flowers that open between late August and mid-September in south-eastern Queensland, a single application just before full-bloom gives effective control, but later flowerings may need an application when 80% of the racemes are infested with eggs and another just prior to full-bloom. Honey bees are important pollinators of Macadamia, and applications just before full bloom should minimize losses among them; the applications should be made at the time of day when the bees are least active.

Jay, D. and C. Jay (1983). "Honeybee dispersal studies in kiwi fruit orchards." New Zealand beekeeper.: 23-23.

Jay, D. and C. Jay (1984). "Observations of honeybees on Chinese gooseberries ('kiwifruit') in New Zealand." Bee world. 65(4): 155-166.

Jones, W. (1983). "Specific crops for pollination." Apiculture Workshop Papers: Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 104-122.

Jones, W. (1992). "Lucerne pollination research in New South Wales." Australasian beekeeper 93(11): 468-474.

Improvements in seed yields from *Medicago sativa* in New South Wales, Australia, have been limited by lack of information on the effects of different irrigation regimes, pest insects and bee pollination. A field study (1983-1984) showed that all 3 factors were important and, if all were well managed, yields of up to 1100 kg/ha were obtained (compared with the average commercial yield of 250 kg/ha). Numbers of racemes and flowers were higher on plots with more frequent irrigation. The following are among the recommendations made: honey bee colonies should be introduced before 10% of flowers open, at a stocking density of 10 hives/ha; when introduced, a colony should have a minimum brood area of 6000 cm^2, and adult bees should have at least 50% body weight of protein (supplementary feeding of isoleucine may be beneficial when bees are working lucerne); management should be aimed at increasing colony pollen demand, thus stimulating pollen collection; honey should be removed regularly from hives so that nectar collection is also stimulated. Advice is also given on crop management and pest control.

Jones, W. A. (1988). "A pollination study into relative self-compatibility levels of 25 sunflower oilseed cultivars." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 131-134.

The seed yields (g/head) of (A) unbagged and (B) bagged heads of 25 sunflower cultivars were determined in trials in NSW, Australia, in 1984-85 and 1986-87. The relative self-compatibility (A / B x 100) of cultivars varied from 37.5 to 105.2 g, while the percentage of yield increase produced by honeybee pollination varied from -4.89 to 167%. With the exception of 2 cultivars that gave decreases of 4.77% and 4.89% in the 1986-87 trial, all cultivars showed a significant increase in yield in the presence of bees.

Keshlaf, M. M. (2008). An assessment of Honeybee foraging activity and pollination efficacy in Australian Bt Cotton. PQDT - Global. Ann Arbor, University of Western Sydney (Australia): 259-259.

Cotton is a high-value commercial crop in Australia. Although cotton is largely self-pollinating, previous researchers have reported that honeybees, *Apis mellifera*, can assist in cross-pollination and contribute to improved yield. Until recently, use of bees in cotton had, however, been greatly limited by excessive use of pesticides to control arthropod pests. With the widespread use of transgenic (Bt) cotton varieties and the associated reduction in pesticide use, I decided to investigate the role and importance of honeybees in Bt cotton, under Australian conditions. I conducted two major field trials at Narrabri, in the centre of one of Australia's major cotton-growing areas, in the 2005–6 and 2006–7 seasons. In the first trial, I particularly assessed methods of manipulating honeybee colonies by feeding pollen supplements of pollen/soybean patties, and by restricting pollen influx by the fitting of 30% efficient pollen traps. I aimed to test whether either of these strategies increased honeybee flight activity and, thus, increased foraging on cotton flowers. In the second trial, I spent more time investigating honeybee behaviour in cotton as well as assessing the effect of providing flowering cotton plants with access to honeybees for different time periods (e.g. 25 d, 15 d, 0 d). In this year, I used double the hive stocking rate of (16 colonies / ha) than in the previous year, because in 2005-6 I observed few bees in cotton flowers. I also conducted a preliminary investigation to assess whether there was any gene flow over a 16 m distance from Bt cotton to conventional cotton, in the presence of a relatively high honeybee population. Both of my field experiments showed that honeybees significantly increased cotton yield via increased boll set, mean weight of bolls, number of seeds / bolls, and weight of lint / boll. It was obvious that cotton flowers, and particularly cotton pollen, were not attractive to honeybees, and this was also reflected in the low proportion (5.3% w/w) of pollen from cotton collected in the pollen traps. However, flower visitation rate was generally above the 0.5% level regarded as optimal for cross-pollination in cotton, and this was reflected in increased yield parameters. Because the insecticide fipronil was commonly used in Australian cotton at flowering time, and because I had some experience of its toxic effects against honeybees in my field investigations, I conducted a series of laboratory and potted plant bioassays, using young worker bees. The studies confirmed its highly toxic nature. I recorded an acute dermal LD50 of 1.9 ng / bee, and an acute oral LC50 of 0.62 ppm. Fipronil's residual toxicity also remained high for an extended period in both laboratory and potted plant trials. For example, when applied to cotton leaves in weather-exposed potted cotton plants, it took 25 d and 20 d for full and half recommended rates of fipronil, respectively, to become non- toxic to honeybees. I had previously investigated whether a shorter period of exposure of cotton plants to honeybees would contribute adequately to increased yield, and concluded that a 10 d window within a 25 d flowering period would contribute 55% of the increase in total weight of bolls contributable to honeybee pollination, but only 36% of the increase in weight of lint. Given the highly residual activity of fipronil I recorded, the only opportunity for an insecticide-free period during flowering would be at its commencement. I concluded that, while there is evidence that honeybees can contribute to increased cotton yield in Bt cotton in Australia, this is unlikely with the continued use of fipronil at flowering. (Abstract shortened by ProQuest.)

Kleinschmidt, G. J. (1986). "Graham J. Kleinschmidt research papers.".

The research described in these papers was carried out at the Queensland Agricultural College in the period 1967-85. Much of it was financed by the honey and/or oil seed industries, and it was conducted in commercial situations under normal production conditions so that the findings would be directly applicable to industry. The individual papers, which are producer-management oriented, have been presented at conferences and workshops, and a number have appeared in Australasian Beekeeper. They are gathered together here in a loose-leaf ring binder, and it is intended that future papers will be issued in the same format. The papers are grouped under 9 main headings - population management, nutrition, pollen, queen bees, diseases, hive equipment, honey processing and storage, pollination, and pesticides. Where applicable, a summary combining results from several projects is presented. The individual research topics include aspects such as colony management for maximum populations, advantages and disadvantages of supplementary feeding, pollen sources in agricultural areas, evaluation of honeybee breeding stock, influence of management on the effects of *Nosema* disease, influence of hive design on honey production, temperature darkening of honey, management of honeybees for pollination, and toxicity of insecticides to honeybees in major entomophilous crops in Australia. The management methods described and discussed in the book are especially applicable to Australian conditions, but the research and basic principles they are based on should be of interest to anyone concerned with managing honeybee colonies. D.G. Lowe.

Lacey, F. (1983). "Pollination contracts." Apiculture Workshop Papers: Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 132-137.

Langridge, D. F. (1972). "Honeybee pollination in Australia." Apiacta: 153-156.

Langridge, D. F. (1975). "Pollination of fruit crops." Victorian Horticulture Digest (66): 14-16.
From pollination studies on deciduous fruit trees the following facts were ascertained: (a) bees were essential to obtain a reasonable crop from apple cvs Jonathan or Yates, and from cherries; (b) pear cvs Winter Nelis also needed bees to set a good crop but cv. Packham's Triumph set parthenocarpic fruit readily; (c) peach cv. Crawford was not self-fertile and needed bees for pollination; (d) apricots were self-fertile; (e) in a mixed fruit orchard pear blossoms, which produce nectar with a low sugar content, did not attract bees as readily as those of other fruit trees.

Langridge, D. F. (1983). "An overview of pollination." Australasian beekeeper 84(8): 157-161.
Particularly in relation to fruit and seed crops in Victoria, Australia, and the use of pesticides.

Langridge, D. F. and R. D. Goodman (1973). "The role of honeybees in pollination of cherries." Australian Journal of Experimental Agriculture and Animal Husbandry 13(61): 193-195.
Laboratory and orchard studies were made of the effects of temperature and humidity on the ripening and dehiscence of anthers of Moss' Early cherry flowers and on concentrations of airborne pollen and its dispersal by wind and honeybees. Ripening and dehiscence of anthers was promoted by higher temperatures and lower relative humidity. Airborne pollen concentrations were greatest between 10.00 a.m. and 4.00 p.m. The flight activity of bees was related to ambient temperatures, with virtually no activity below 13 deg C, and a marked rise between 13 and 20 deg. The average number of bees/trees was 7.3 and the maximum was 21. Of over 2000 insect visitors recorded, 97% were honeybees. Fruit set of trees enclosed in bee-proof cages was only 2%, compared with 36% for trees in the open, and yield differences were equally marked.

Langridge, D. F. and R. D. Goodman (1974). "A study on pollination of sunflowers (*Helianthus annuus*)." Australian Journal of Experimental Agriculture and Animal Husbandry 14: 201-204.
In studies on 18 pairs of adjacent plots, each 2m X 2m, one of each pair was caged just before flowering. There were 40 colonies of honeybees less than 1 km south-east of the trial area, and 26 colonies 100 m to the north. Of all insect visitors to the open plots, 98.7% were honeybees; 97.3% of bees were nectar collectors and only 2.7% pollen collectors. Airborne pollen counts showed a mean of 117 grains of sunflower pollen/m3 of air in the open, and 226 grains/m3 in the cages. The yield of open plots was over 60% greater than that of caged plots. The number of seeds set/cm2 of flower head, percentage germination, and oil content of seed, were also significantly greater from open plots. Individual seeds were heavier in caged plots.

Langridge, D. F. and R. D. Goodman (1975). "A study on pollination of oilseed rape (*Brassica campestris*)." Australian Journal of Experimental Agriculture and Animal Husbandry 15(73): 285-288.
In a trial in 1973 in N.E. Victoria with a rain-fed crop of oilseed rape (*B. campestris* var. *oleifera*) cv. Arlo, plots to which bees and larger insects had access produced 58% more seeds/plant and 46% greater weight of seed/plant than plots from which these insects had been excluded. The 1000-seed weight was significantly greater in the enclosed plots than in the open ones, but seed oil content or germination did not differ significantly. Although hoverflies appeared to play some role in pollination of rape, honeybees were considered the more efficient pollinator. Oilseed rape provided pollen and nectar for bees although no useable surplus of the latter was produced.

Langridge, D. F. and R. D. Goodman (1977). "A study on pollination of lupins (*Lupinus angustifolius*)." Australian Journal of Experimental Agriculture and Animal Husbandry 17: 319-322.

Mean seed yields were significantly greater on plots to which honeybees and other large insects had access (579 g) than on plots from which these insects were excluded (472 g). There was no difference in the mean germination rate and weight of 1000 seeds from open and closed plots. Honeybees collected appreciable quantities of pollen from lupin flowers, and the nectar gathered allowed colonies to build up to swarming point and store surplus honey. Lupins are strongly self-pollinating, but wind pollination seems to be negligible. Bee activity on lupins makes them important agents of cross-pollination. Seed price and cost of hire are factors in determining the feasibility of using bees for pollination. Author

Langridge, D. F. and R. D. Goodman (1979). "Pollination of canning peaches cv. Golden Queen." Australian Journal of Experimental Agriculture and Animal Husbandry 19(99): 510-512.

Pollination requirements of Golden Queen peaches were studied in an orchard in the Goulburn Valley, Victoria. There was virtually no airborne pollen in the open orchard nor inside a cage placed around a peach tree. Flight activity of bees was related to ambient temperatures and honeybees accounted for 99.4% of insect visitors to the peach flowers. On trees to which bees had access there was 1.2 times increase in the percentage of flowers that set fruit, but the weight of fruit harvested was not significantly different. Self-fertilization supplemented by honeybee pollination appeared to be the normal mode of fruit set in this cv.

Langridge, D. F. and R. D. Goodman (1980). "A study on pollination of safflower (*Carthamus tinctorius*) cv. Gila." Australian Journal of Experimental Agriculture and Animal Husbandry 20: 105-107.

In a trial on safflower cv. Gila grown without irrigation in northern Victoria, Australia, there was no significant difference in seed yield/plant, oil content, or % germination, between plants grown on plots to which bees and other large insects had access and those grown inside 2.5-mm mesh cages; nor was there any difference in weight of 1000 seeds. Honeybees (75%) and Lasioglossum spp. (21%) were the predominant insects foraging on the flowers for nectar and pollen. It is concluded that cv. Gila is essentially self-pollinated or pollinated by airborne pollen, and that no benefit in terms of yield would accrue through the introduction of honeybee colonies into crops. Most honeybees (99%) were nectar gatherers; and the average yield of surplus honey for 5 colonies was 4.7 kg/colony. The mean yield of pollen from 5 hives fitted with pollen traps was 343 g/trap. The pollen obtained was chiefly safflower, with a little clover. D. G. Lowe

Langridge, D. F. and R. D. Goodman (1980). "A study on pollination of safflower *Carthamus tinctorius* cultivar Gila." Australian Journal of Experimental Agriculture & Animal Husbandry 20(102): 105-107.

In a trial on *C. tinctorius* 'Gila' grown without irrigation in northern Victoria [Australia], there was no increase in yield of seed per plant, oil content or percentage germination obtained from plots to which bees and larger insects had access and plots enclosed in cages of 2.5 mm mesh to exclude these insects; nor was there any difference in 1000-seed weight. Honeybees and native bees were the predominant insects working the flowers for nectar and pollen. 'Gila' is essentially self-pollinated or pollinated by airborne pollen.

Langridge, D. F. and R. D. Goodman (1981). "Honey bee pollination of sunflower *Helianthus annuus* cultivars Hysun-30 and Sunfola." Australian Journal of Experimental Agriculture & Animal Husbandry 21(111): 435-438.

In trials on an irrigated crop of hybrid sunflowers, (H. annus), cv. Hysun 30, in northern Victoria [Australia], plots where bees had access produced 11% more seed than plots where bees and larger insects were excluded. Although some seed was set in cages by airborne pollination and self-pollination, honeybees increased seed set significantly. There was a slightly greater oil content in seed from open plots but no difference in weight of 1000 seeds or percentage germination. There was a 20% increase in the percentage of flowers that set seed in the open compared with enclosed plots. There was a 1362% increase in open-pollinated flowers that set seed compared with self-pollinated but there was no difference between open-pollinated and open-pollinated supplemented by hand-pollination. The yield of seed from open plots of the so-called open-pollinated cv. Sunfola was directly related to the honeybee density on the crop, expressed as ratio of bees to inflorescences. Honeybees were effective cross-pollinators of the sunflowers. 'Hysun 30' pollen was not attractive to bees and they tended to discard it. Colony

strength declined while the bees worked the crop. A rate of 1 honeybee/plant during anthesis could optimize yields of set seed.

Langridge, D. F. and R. D. Goodman (1981). "Honeybee pollination of sunflower cultivars Hysun 30 and Sunfola." Australian journal of experimental agriculture and animal husbandry. 21(111): 435-438.

Langridge, D. F. and R. D. Goodman (1981). "Honeybee pollination of the apricot cv. Trevatt." Australian Journal of Experimental Agriculture and Animal Husbandry 21(109): 241-244.

The role of honeybees in the pollination of apricots, cv. Trevatt, was examined in a 2-year study. When trees were enclosed in cages the percentage of flowers that set fruit, the weight of fruit harvested/tree and the number of fruit/trees were reduced by 43, 32 and 50%, respectively. Honeybees comprised 97.6% of insects visiting the flowers, and 84% of the bees counted were pollen gatherers visiting newly opened flowers; they were thus more important than nectar-collecting bees. Optimum conditions for opening and dehiscence of anthers were found to occur at temperatures of 20 deg C or higher and at 70% RH or less. Parthenocarpy was not a significant factor in fruit set and while self-pollination and possibly some airborne pollen accounted for some fruit set, the cv. Trevatt clearly benefitted from pollination by honeybees.

Langridge, D. F. and R. D. Goodman (1982). "Honeybee pollination of oilseed rape, cultivar Midas *Brassica napus*, Australia." Australian journal of experimental agriculture and animal husbandry. 22(114-115): 124-126.

Langridge, D. F. and R. D. Goodman (1985). "Honeybee pollination of Japanese plums (*Prunus salicina* Lindl. cv. Satsuma) in the Goulburn Valley, Victoria." Australian journal of experimental agriculture. 25(1): 227-230.

Langridge, D. F. and R. D. Goodman (1985). "Honeybee pollination of loganberries (*Rubus loganobaccus* L.H. Bailey)." Australian Journal of Experimental Agriculture 25: 224-226.

On experimental plots in Victoria, Australia, some plants were caged to exclude bees and larger insects. There were 55 honeybee colonies within about 100 m of the plants. Total number and weight of fruits from caged plants were comparable with the total number and weight of fruits obtained from uncaged plants. However, half the fruits from caged plants were rejected because of their poor quality, compared with only 88% from open-pollinated plants. Of the 1206 insect visitors counted on the flowers, 98.6% were honeybees; in spot checks the mean number of honeybees on a plant was 4.64. In observations of 376 bees, 79% were collecting nectar and the rest pollen. The density of airborne pollen was much higher inside cages than in the open. The use of honeybee colonies at 5/ha is recommended.

Langridge, D. F. and R. D. Goodman (1985). "Honeybee pollination of lupins (*Lupinus albus* cv. Hamburg)." Australian Journal of Experimental Agriculture 25(1): 220-223.

Mean yields of seed, percentage germination of seed, and mass of 1000 seeds of Lupinus albus cv. Hamburg were significantly greater from plots to which honeybees (*Apis mellifera*) and larger insects had access than from plots which excluded these insects. No airborne lupin pollen was detected, and wind pollination of this species seems to be negligible; but some self-pollination does occur. Bee activity on this species makes bees important agent of pollination of L. albus.

Langridge, D. F. and P. T. Jenkins (1970). "The role of honeybees in pollination of apples." Australian Journal of Experimental Agriculture and Animal Husbandry 10: 366-368.

In an experiment to determine the relative roles of airborne and insect-borne pollen in the pollination of apples, Yates apple trees, each grafted with a limb of Jonathan, were enclosed in bee-proof cages. There were significant reductions in the number of fruits set, the weight of fruit harvested and the number of seeds per fruit as compared with uncaged trees, although airborne apple pollen concentrations were 4.07 times higher inside the

cages than outside. The concentrations of air-borne apple pollen were greatest in the late morning and early afternoon. The flight activity of the bees was related to ambient conditions, temperature having a major effect. There appeared to be a threshold of flight activity at about 13 degrees C. Ripening and dehiscence of the anthers of Yates apple were promoted by higher temperatures and lower humidity. [See also H.A., 40: 2824.]-Apic. Res. Unit, Ferntree Gully, Vict.

Langridge, D. F. and P. T. Jenkins (1972). "A study on pollination of Packham's Triumph pears." Australian Journal of Experimental Agriculture and Animal Husbandry 12: 328-330.

The method was described in an earlier study of apple pollination [AA 241/72]. During favourable weather, concentrations of airborne pollen were 4 times as great during the day as at night and 3 times as great in cages as outside. The maximum in the open was 225 grains/m^3 air. However, results indicated that the presence of airborne pollen was of little importance in pollination of Packham's Triumph pears. Caging had little effect on yields, which were poor on all trees. In spite of high honey bee activity, a maximum of 400 per min leaving the hive, a mean of only 4.5 bees/tree was recorded, the maximum being 13. These values are much lower than those found for apple trees. Pear blossom nectar is not as attractive to bees as that of many other flowers.

Langridge, D. F. and P. T. Jenkins (1975). "A study of pollination of Winter Nelis pears." Australian Journal of Experimental Agriculture & Animal Husbandry 15(72): 105-107.

Langridge, D. R. and R. D. Goodman (1985). "Honeybee Pollination of Japanese Plums (*Prunus Salicina* Lindl. cv. Satsuma) in the Goulburn Valley, Victoria." Australian Journal of Experimental Agriculture 25(1): 227-230.

The pollination requirements of Japanese plums (*Prunus salicina* Lindl. cv. Satsuma) were examined in an orchard in the Goulburn Valley area of Victoria. Trees which were accessible to honeybees (*Apis mellifera*) had a higher percentage pollination rate (3.2 times) greater weight of fruit (2.6 times) and more fruit (3.3 times) than did the trees that were enclosed to exclude bees and large insects. Honeybees comprised 88.5% of all insect visitors to the flowers. The behaviour patterns of other insects were such that they would affect little or no pollination. Pollen gathering bees are considered the main pollinators of this species because of their activity early in flowering. No native bees (*Trigona* spp.) were seen to visit the flowers. While parthenocarpy and wind pollination may produce some fruit on Satsuma, the presence of an adequate population of honeybees is necessary to set a satisfactory crop.

Lawrence, L. and M. Dillon (2004). "Using honey bees to plug a gap in Bt in cotton plants." Outlooks on Pest Management 15(2): 83-84.

This paper describes the use of honey bees to deliver baculoviruses (*Heliothis nuclear polyhedrosis* viruses or HNPV) to genetically modified (GM) cotton crops to protect flowers from attack by *Helicoverpa armigera* larvae. By making simple modifications of the hive, bees are forced to pick up a load of HNPV dust and carry it with them when they visit the cotton flowers, thereby protecting the plants from larval attack. Results of trials on the efficacy of this approach in cotton under Australian conditions are presented.

Leach, G. J. (1972). "Variation in lucerne seed yields in relation to genotype and intensity of pollination." Australian Journal of Experimental Agriculture and Animal Husbandry 12(57): 420-427.

Variation in the seed yields of 12 lucerne cv. was studied at (a) Adelaide and (b) Tintinara in 1967-70. Irrigation was given in early summer at (a). Seed yields were highest in cv. Hunter River, African and Spanish, and with irrigation. 9 plants with the most consistent seed yields, representing a range from low to high yields, were selected from cv. Hunter River and Spanish in the Adelaide experiment, were clonally multiplied and exposed to different intensities of pollination. Seed yields were negligible when bees were excluded, increased with exposure to casual visits by bees and increased further with exposure to bees in pollination cages. There were large genotypic differences in seed production, the pathways to seed production and in potential seed production, but these were not correlated with actual seed production. Even in the most efficient genotypes at the highest pollination intensity, only 25% of the potential seed yield was realized.

Lentini, P. E., et al. (2012). "Supporting wild pollinators in a temperate agricultural landscape: Maintaining mosaics of natural features and production." Biological conservation. 149(1): 84-92.

Pollination has received attention recently due to reported sharp declines of *Apis mellifera* in several locations, and it has been proposed that diverse native bee communities may be key for continued pollination of economically important crops. However, there is some inconsistency in the literature as to how these communities should best be managed. To address this issue, we collected bees from an intensively managed agricultural region in eastern Australia using blue vane traps. Both linear remnants of vegetation, which form part of a larger corridor network, and adjacent fields of native and exotic pastures, wheat, canola, and lucerne were sampled. A total of 3249 individual bees, representing four families and 36 species were collected. Highly modified environments of nectar-bearing crop supported the most species-rich bee assemblages, and the highest abundance of individual bee species. Distance from the remnants did not limit the body size of species occupying fields (up to 400m). However, richness of bee assemblages also responded positively to the presence of conservation land in nearby areas, or the number of remnant native trees surrounding traps. Linear remnants of native vegetation contributed to assemblage heterogeneity by adding unique species to the regional pool. Our findings indicate that agricultural industries that currently rely on pollination by *A. mellifera* should ensure that intensive land use is complemented by untilled areas in the form of conservation land, or farm dams and scattered trees in fields, to support wild pollinators that may act as insurance against further future losses of managed hives.

Low, A. (1983). "Plant breeding as it relates to crop pollination--a review." Apiculture Workshop Papers: Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 138-158.

Macfarlane, R. P. (1976). "Bees and pollination: general pollination." New Zealand Insect Pests.: 221-229.

Macfarlane, R. P. and B. J. Donovan (1976). "Bees and pollination." New Zealand insect pests, editor D.N. Ferro.: 221-240.

The significance of native and introduced bees in the pollination of crops in New Zealand is outlined. The introduction, present distribution, biology and management of bumble bees (*Bombus terrestris*, *B. ruderatus, B. hortorum, B. subterraneus*), and of *Nomia melanderi* and *Megachile pacifica*, are described. [See also Donovan, AA 708L/76.] D. G. Lowe

Macfarlane, R. P., et al. (1991). "Pollination needs of 'Grasslands Pawera' red clover." Acta horticulturae.: 399-404.

Macfarlane, R. P. and A. M. Ferguson (1983). "Horticultural pollination a New-Zealand perspective with emphasis on kiwi-fruit." Pacific Science Congress Proceedings 15(1-2): 153-153.

Macfarlane, R. P. and A. M. Ferguson (1984). "Kiwifruit pollination: a survey of the insect pollinators in New Zealand." Proceedings of the 5th International Symposium on Pollination, Versailles, 1983: 367-373.

Insects were collected from flowers in 54 *Actinidia chinensis* orchards; of the 150 species identified *Apis mellifera* was by far the most abundant (hives were present). Of wild bees, bumble bees (mainly *Bombus terrestris*) were the most common, followed by species of *Leioproctus*. Most of the flies, thrips, beetles and moths observed moved slowly, if at all, from flower to flower. *Bombus* queens spent an average of 7.7 s on each flower, thus it is estimated that they can visit about 2600 female flowers per day; *Bombus* workers spent 13.7 s and honeybees 20.3 s on a flower. Only these species and *Leioproctus* moved between male and female flowers. These bees also made the greatest contact with the stigmas. The number of pollen grains on the bodies of bees collected from female flowers varied from 20 to 90 x 10superscript 3. Honeybees tended to visit some other flower species in bloom at the same time as *A. chinensis*, but *B. terrestris* and *Leioproctus* visited few other species.

Macfarlane, R. P. and R. P. Griffin (1985). "An assessment of bumble bees and honey bees as pollinators of red clover." Proceedings, 4th Australasian Conference on Grassland Invertebrate Ecology, Lincoln College, Canterbury, 13-17 May 1985: 114-120.

The relative importance of the pollinators of red clover (*Trifolium pratense*) was assessed in Marlborough and South Canterbury, New Zealand, from 1983 to 1985. The major pollinators were the long-tongued bumble bees *Bombus ruderatus* and *B. hortorum*, and pollen-collecting honeybees. The effectiveness of honeybees as pollinators on red clover declined markedly as the season progressed. It was estimated that a single bumble bee pollinated enough flowers to produce 0.3-0.6 kg harvestable seed in reasonable growing conditions. Crops of the tetraploid 'Grasslands Pawera' stocked with 2-7 and 12 colonies/ha of B. ruderatus and B. hortorum yielded 250-340 and 528 kg/ha of seed compared to the previous average yield of 90 kg/ha when no extra bees were introduced. Mustard, lotus and white clover were attractive to pollen-collecting honeybees but other common flowers such as thistles attracted relatively few pollen-collecting honeybees or long-tongued bumble bees.

Malone, L., et al. (2010). "Observations on bee species visiting white clover in New Zealand pastures." Journal of Apicultural Research 49(3): 284-286.

Manning, R. (1995). "Honeybee pollination: technical data for potential honeybee-pollinated crops and orchards in Western Australia." Bulletin - Western Australia Department of Agriculture (4298).

Section 1 of this Bulletin discusses several aspects of honey bee pollination of crops, such as pollination costs and contracts, hive requirements and siting, honey bee requirements, feeding, bee attractants, the Code of Practice for Western Australia, disposable pollination units, and greenhouse pollination. Section 2 gives information for specific crops - vegetables, crops [field crops], fruits, nuts and other crops. The crops are listed in alphabetical order of common name within each category, and each has an entry giving the following information (where known): common name, botanical name, area of production, flowering period, hives/ha requirements, pollination fee, nectar production, honey production, review of bee pollination benefits. A sample pollination contract is given in appendix 1, whilst Appendix 2 lists beekeepers in Western Australia who provide pollination services.

Manning, R. (2018). "Artificial feeding of honeybees based on an understanding of nutritional principles." Animal production science 58(4): 689-703.

Artificial pollen substitutes were developed to improve productivity from honeybees during periods of nutrient scarcity. The history of pollen-substitute development is outlined. Although many attempts have been made, no substitute has the same nutritional value as bee-collected pollen. Following a review of honeybee nutrition, Black (2006) described the ingredient and nutrient specifications for a pollen substitute, including the need for attractiveness to honeybees. Protein isolates were recommended to avoid toxicity from carbohydrates found in many ingredients used in previous studies. Twenty-seven plant-and animal-derived oils and a rum supplement, mixed at 2% with a low-lipid irradiated pollen, were evaluated for attractiveness by measuring consumption and bee congregation when placed in dishes within beehives. Coconut, linseed oil and rum were preferred significantly ($P < 0.05$) to the pollen, whereas pollen was preferred to lavender and sage oils. Almond and evening primrose oils were also highly, but not significantly, preferred compared with pollen and were used in combinations with coconut and linseed oils in subsequent experiments. Eleven predominantly pure protein sources, either singly or in combination, were mixed with 2% or 5% attractive oils and evaluated for attractiveness. Soybean protein isolate was selected, because attractiveness was not significantly different from bee-collected pollen. It was then used with oils in an experiment to evaluate either powdered cellulose or milled oat hulls as a fibre source. There were no significant differences in attractiveness of substitutes with the two fibre sources or pollen, and powdered cellulose was selected for further use on the basis of availability. An experiment with similar to 1000 newly hatched bees with a fertile queen in cages was undertaken to evaluate the diets when given as the sole nutrient source. Consumption, bee longevity and estimated hypopharyngeal gland development using head weight were measured One artificial diet (PI-5) contained 30% soybean protein isolate, 10% cellulose, 42% icing sugar, 12.5% water, 4.5% mixed oils and 1.3% minerals and vitamin plus cholesterol. Diet (PI-10) was similar but contained twice as much oil replacing icing sugar. Other treatments were redgum pollen (P), a commercial pollen substitute, Feedbee (R) and defatted soybean meal.

Diet consumption, lifespan and head weights were significantly less for the PI diets than for P, while Feedbee (R) and defatted soybean-meal diets were generally intermediate. The PI diets were discovered to contain excess sodium, due to the manufacturing process. Bees consuming the PI diets had lower concentrations of magnesium, copper, iron, manganese and zinc in their bodies than did those offered P. The fatty acid content of bee bodies also varied with diet. A revised formulation is recommended with reduced sodium and modified mineral and fatty acid composition.

Manning, R. and A. Agriculture Western (1998). "Honey bee pollination of canola in Western Australia."

Manning, R. and J. Boland (2000). "A preliminary investigation into honey bee (*Apis mellifera*) pollination of canola *(Brassica napus* cv. Karoo) in Western Australia." Australian Journal of Experimental Agriculture 40(3): 439-442.

The aim of this preliminary experiment was to evaluate the effect of distance from the apiary on pod yield in canola. Beehives were used at a density of 1.28 hives/ha. The results showed that the number of pods/plants decreased as distance from the apiary increased, when plant height and branch number were used as explanatory variables. Multiple linear regression indicated a predicted pod loss of 15.3 pods/plant over a distance of 1000 m from an apiary. This was equivalent to a 16% loss based on an average of 59 plants/m2 and average pod production of 5666 pods/m2 from his experiment. For a 2 t/ha crop this would be equivalent to about 320 kg/ha. The results are only indicative because of the variation in the crop studied and lack of replication, but may, in fact, be a conservative estimate.

Manning, R., et al. (2010). "Methods and modifications to enhance the abundance of pollen on forager honey bees (*Apis mellifera* L.) exiting from beehives: implications for contract pollination services." Australian Journal of Entomology 49(3): 278-285.

Langstroth hives fitted with a modified lid with an entrance lined with soft felt or steel or plastic pollen traps or hives fitted with plastic pollen traps and sugar-fed significantly increased the pollen count on the bodies of exiting honey bees. In terms of utilising the research findings in contract pollination service where costs can determine profitability, the recommendation is for a trial in a commercial orchard (e.g. almond, apple, avocado, plum) of sugar-fed single hives fitted with plastic pollen traps. Despite the bees' destruction of the felts lining the modified lid entrances, the soft felt liner might be a worthwhile inclusion into any field trial.

Manning, R. and I. R. Wallis (2005). "Seed yields in canola (*Brassica napus* cv. Karoo) depend on the distance of plants from honeybee apiaries." Australian journal of experimental agriculture. 45(10): 1307-1313.

Matheson, A. (1982). "Pollinating blackcurrants with the honeybee Colony management, New Zealand." New Zealand farmer. 103(21): 96-96.

Matheson, A. (1984). "Practical beekeeping in New Zealand." Practical beekeeping in New Zealand.

This is a comprehensive, well-illustrated book, written to replace the New Zealand Ministry of Agriculture & Fisheries Bulletin 267 [last edition was AA 506L/77]. It gives a general picture of beekeeping in this country, as well as much practical advice for the beekeeper. The topics covered include: New Zealand's beekeeping industry and its history; bee biology; nectar and pollen sources; hive design and construction; starting beekeeping; management, including queen rearing; hive products; pests and diseases; using honeybees for pollination. Chapter 20 covers laws affecting beekeepers in New Zealand, and Chapter 21 lists selected sources of further information. The book has both a glossary and a subject index.

Matheson, A. (1986). "Colony standards for kiwifruit pollination." New Zealand beekeeper (189): 20-22.

In New Zealand demand is rapidly increasing for honeybee colonies to be used for pollinating kiwifruit (*Actinidia deliciosa*, previously known as *A. chinensis*). Over 50 000 colonies were rented out to growers in 1985.

Until now there has not been agreement on the best type of colony to use for pollinating kiwifruit. The author reviews general pollination research and New Zealand studies on kiwifruit pollination, and proposes the following criteria for pollination colonies for this crop: at least 7000 cm^2 of brood; at least a quarter of the brood unsealed; most of the brood in the lower box; a young queen; at least 12 full-depth frames of bees; empty combs for the queen to continue laying; at least 3 frames of honey; no AFB.A. Matheson.

Matheson, A. (1986). "Survey of kiwifruit pollination hives in Nelson." New Zealand beekeeper (189): 23-24.

A survey was conducted of honeybee colonies used for pollination of kiwifruit (*Actinidia deliciosa*) in Nelson, New Zealand. In November 1985, 172 hives in 38 orchards were examined in detail. Average colony strength was 13.2 full-depth frames, and average brood area was 8178 cm^2. The survey indicated that most beekeepers supplying colonies for pollination were meeting the minimum standards guaranteed by the local beekeepers' association. Recommendations for improving pollination management are given.

Matheson, A. (1991). "Beekeeping: leading agricultural change in New Zealand." Bee world. 72(2): 60-73.

Matheson, A. (1991). "Beekeeping: leading agricultural change in New Zealand. 2." Bee world. 72(3): 117-130.

Matheson, A. G. (1982). "Nectar and pollen sources - summer/autumn/early winter." Farm Production and Practice, Ministry of Agriculture and Fisheries, New Zealand (529): 4-pp.

Matheson, A. G. (1991). "Managing honey bee pollination of kiwifruit (*Actinidia deliciosa*) in New Zealand - a review." Acta Horticulturae (288): 213-219.

Wind pollination of kiwifruit is insufficient for a commercial crop of export-size fruits, which need to weigh >72 g and which contain over 800 seeds, requiring the transfer of 1000-3000 pollen grains. The use of honey bees for pollination has increased greatly in recent years, and there are presently 80 000 hives in kiwifruit orchards in New Zealand. Recommendations for hives include: 8 hives of disease-free honey bees per ha, a young prolific queen, 25% of the brood unsealed and most of the brood in the lower box of the hive, sufficient empty combs for colony expansion, and sufficient honey stores or sugar syrup to sustain the colony, since the flowers produce no nectar.

McLaren, G. F., et al. (1992). "Pollination of apricots." Orchardist of New Zealand 65(8): 20-23.

The cultivar Sundrop is grown in New Zealand for apricot exports, but fruit set varies widely. In a survey in 2 districts the average number of fruits was 2-28 per 30 cm of branch. The cultivar is self-incompatible; in hand-pollination trials in the field, selfing produced 9.1% fruit set, and cross-pollination with pollen of 14 other cultivars 17-90% set. A comparison of flowering dates of 40 cultivars showed that only 25 of them synchronized with the flowering of Sundrop, and only 2 of these were commercial cultivars (CluthaGold and CluthaStar). The frequency of honey bee visits required for satisfactory pollination was studied for 3 years; the results suggest that the minimum needed in a 30-s search is 2 bees/tree (tree spacing 5 x 2 m). Bee Scent, a bee attractant, failed to increase the number of bee visits to a tree, or fruit set.

McLaren, G. F., et al. (1996). "Some factors influencing fruit set in 'Sundrop' apricot." New Zealand Journal of Crop and Horticultural Science 24(1): 55-63.

Two apricot cultivars, Sundrop and Moorpark, were found to be cross-compatible with pollen of 32 genetically diverse cultivars. The flowers of Valleygold, CluthaGold and Moorpark remained receptive to pollination for up to 8 days after emasculation at the balloon stage. Floral receptivity declined in Moorpark, Sundrop and CluthaGold (but not Valleygold) over the 8 days. Sundrop had the lowest receptivity and Moorpark the highest. Fruit set of Sundrop flowers varied between sites and years in central Otago, New Zealand, with significantly lower sets being recorded in 1992 and 1993 than in 1991. In these 3 seasons, a 2-ha block of Sundrop, with no pollinisers within it, showed a decrease in fruit set as the distance from the nearest polliniser on the edge of the block increased; fruit

set was unacceptably low beyond the first 4 or 5 rows. Bee density did not decline across the block in the same manner. The fruits were smaller on trees adjacent to the polliniser but were generally of similar storage quality to those from 10 rows away. The addition of extra beehives in 1992 and 1993 increased the bee numbers per tree throughout the block, but not fruit set. In comparison, a 1.7-ha block of Sundrop on the same property, in which 3% of the trees were cv. Trevatt planted at random, produced a better set in each of the 3 years. Over 8 years, correlations were found between percentage fruit set and (1) the mean temperature between 5 and 90% bloom, (2) the number of days when the maximum temperature exceeded 18 degrees C between 5 and 90% bloom and (3) the mean temperature over the 3 weeks after 90% bloom. The roles of in-hive pollen exchange and self-pollination in Sundrop are discussed. Planting of pollinisers within the block remains the most reliable method of increasing fruit set in large blocks of Sundrop. ADDITIONAL ABSTRACT: A trial in 1991-1993 in Otago, New Zealand, to study the fruit set of apricot (Prunus armeniaca) cv. Sundrop, showed that this cultivar was cross-compatible with 32 others, genetically diverse, cultivars. Fruit set showed a decrease as the distance from the nearest polliniser tree increased. The population density of honey bees [*Apis mellifera*] did not decline across the block in the same manner. The addition of extra hives increased bee numbers throughout the block, but not fruit set. The planting of pollinisers within large blocks of Sundrop is the most reliable method of ensuring adequate fruit set, and in the presence of an adequate supply of compatible pollen an average of 4 bees/30 s per tree per day throughout flowering produces a satisfactory crop. The role of in-hive pollen exchange is discussed.

Merry, A. M., et al. (2017). "Increasing seed yield in Papaver somniferum L. with the use of honey bees (*Apis mellifera* L.)." "Doing More with Less", Proceedings of the 18th Australian Agronomy Conference 2017, Ballarat, Victoria, Australia, 24-28 September 2017: 1-4.

Honeybees (*Apis mellifera* L.) are known to play a role in pollination of poppy (Papaver somniferum L.) and could be used in seed crops to increase yield. Experiments were conducted on commercial poppy crops in northern Tasmania to establish the relationship between a gradient of honeybees and seed yield of poppy. Three beehives were grouped in the centre of three commercial poppy fields and an additional three fields were chosen that had no hives as controls. Plots were established in a spiral design every 5 m from 10 m to 140 m radius from the centre, thus having plots ranging over distance from a higher density to a lower density of bees pollinating the flowers at treatment sites. There were significantly more seeds per capsule for all capsule size classes, at the sites with beehives compared to the control. In addition, for the large capsules there was a significant radial effect at the bee sites, with more seeds per capsule closer to the hive than further away. There was no radial effect for the control. Insect pollinations were also monitored using pan traps at set distances from the centre of the crop at each site. There were significantly more native pollinators captured at the edge of the crop than at any other distance from the centre of the field. Honeybees have been shown to increase yield in commercial poppy crops and can be used to increase yield in crops were the yield of genetic superior seed is important.

Miller, J. A. C., et al. (2005). "Pollination biology of oilseed poppy, *Papaver somniferum* L." Australian journal of agricultural research. 56(5): 483-490.

Moar, N. T. (1985). "Pollen analysis of New Zealand honey." New Zealand journal of agricultural research. 28(1): 39-70.

Morley, F. H. W. (1963). "The mode of pollination in strawberry clover (*Trifolium fragiferum*)." Australian Journal of Experimental Agriculture and Animal Husbandry 3(8): 5-8.

Contrary to reports in the literature, *T. fragiferum* was shown to be predominantly self-incompatible and cross-pollinated. The ratio of seeds to flowers where bees were plentiful was higher than where they were scarce. It was concluded that seed yields would be improved if high populations of active honeybees were provided at flowering time.

Morrison, L. (1961). "Pollination and seed-setting of red clover in scrim-covered cages." New Zealand Journal of Agricultural Research 4(5-6): 560-565.

Honey bees (*Apis mellifera*} and introduced species of bumble bee (*Bombus ruderatus* and *B. terrestris*) were put into cages over red clover and other forage plants during Feb.-Mar. for each of 5 yr. and the seeds were harvested in May. There was large variation in pollination between years. In general B. ruderatus was the most efficient pollinator of red clover. *A. mellifera* and *B. terrestris* also effectively pollinated red clover despite the presence of other plants that they preferred. The seed set in 1 year when the butterfly Pieris rapae was used as pollinator was almost nil. [See also H.A. 32: 842.]-J.G.G.

Morthorpe, K. J. (1983). "Design of pollination field trials." Apiculture Workshop Papers: Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 248-251.

Newstrom, L. and A. Robertson (2005). "Progress in understanding pollination systems in New Zealand." New Zealand Journal of Botany 43(1): 1-59.

Pollination in New Zealand, an isolated oceanic archipelago in the Southern Hemisphere, has previously been characterised as having low rates of self-incompatibility and a lack of specialised pollination, as well as little pollinator dependence. These features have been interpreted as supportive of "Baker's Rule", which suggests that long-distance colonisation selects for breeding systems that do not require biparental mating. However, we show that recent studies of the angiosperm flora reveal sexual systems (sexual dimorphism, self-incompatibility, monoecy, dichogamy, and herkogamy) that usually involve a dependence on pollen vectors. The level of self-incompatibility in the flora, though still poorly known, should be regarded as moderate rather than unusually low (about 36% of hermaphrodite populations tested are strongly or partially self-incompatible), though many more species remain to be tested. As found elsewhere, incompatibility is higher in the trees and shrubs (around 80%) compared with herbs (21%), Moreover, high rates of autonomous selfing have been demonstrated empirically in only 21% of the self-compatible species, demonstrating that they are not regular selfers. The pollinator dependence that these features impose makes much of the flora vulnerable to declines in pollinator service.

Newstrom-Lloyd, L. E. (2013). Pollination in New Zealand. Lincoln, Manaaki Whenua Press, Landcare Research.

Pollination by animals is a crucial ecosystem service. It underpins New Zealand's agriculture-dependent economy yet has hitherto received little attention from a commercial perspective except where pollination clearly limits crop yield. In part this has been because background pollination by feral honey bees (*Apis mellifera*) and other unmanaged non-Apis pollinators has been adequate. However, as pollinators decline throughout the world, the consequences for food production and national economies have led to increasing research on how to prevent further declines and restore pollination services. In New Zealand, managed honey bees are the most important pollinators of most commercial crops including pasture legumes but introduced bumble bees can be more important in some crops and are increasingly being used as managed colonies. In addition, New Zealand has several other introduced bees and a range of solitary native bees, some of which offer prospects for development as managed colonies. Diverse other insects and some vertebrates also contribute to background pollination in both natural and agricultural ecosystems. However, New Zealand's dependence on managed honey bees makes it vulnerable to four major threats facing these bees: diseases, pesticides, a limited genetic base for breeding varroa-resistant bees, and declining floral resources. To address the fourth threat, a preliminary list of bee forage plants has been developed and published online. This lists species suitable for planting to provide abundant nectar and high-quality pollen during critical seasons. Providing high-quality nutrition will help bee colonies resist diseases, pests and exposure to pesticides and improve pollinator security in New Zealand.

Palmer-Jones, T. (1959). "Organization of pollination service for farm seed industry." New Zealand Journal of Agriculture 98(1): 17-24.

The white-clover seed industry of New Zealand depends almost entirely on honey bees for pollination. Though the seed-growing areas are well stocked with hives for honey production, hive numbers are inadequate for intensive seed production. The organization of a pollination service by beekeepers and projected research into white-clover pollination are discussed. The pollination of mixed clovers recently sown for the first time in the

Mackenzie Country is examined and the role played by bumble bees as pollinators there and in other hill-country areas assessed. F. s.-M.H.

Palmer-Jones, T. (1968). "Lucerne pollination in New Zealand." New Zealand Agricultural Science 3(1): 19-21.

The honey bee was the main pollinator and in some areas the short-tongued bumble bee (*Bombus terrestris*). Only about 10% pollination was observed and methods for improvement are discussed.

Palmer-Jones, T. and P. G. Clinch (1966). "Observations on the pollination of apple trees (Malus sylvestris Mill.). I. Variety Cox's Orange Pippin." New Zealand Journal of Agricultural Research 9: 191-196.

Insect visitation on Cox's Orange Pippin apple trees was studied during the blossoming period. The only insects of any importance as pollinators were honey bees and bumble bees (*Bombus terrestris*), nearly all of which were nectar collectors. Honey bees were about 18 times as numerous on the flowers as bumble bees. At most, only a trace of fruit set occurred on trees caged to exclude bees. It was concluded that fruit set depended almost entirely upon insect visitation to the flowers, and that honey bees were by far the most important pollinators. Supplementary observations, confined to insect visitation, were also made on the apple varieties Dunn's Favourite and Granny Smith. [A.S.]-Wallaceville Animal Res. Cent., Dep. Agric., Wellington.

Palmer-Jones, T. and P. G. Clinch (1967). "Observations on the pollination of apple trees (Malus sylvestris Mill.) II. Varieties Granny Smith, Sturmer, Jonathan, and Cox's Orange Pippin." New Zealand Journal of Agricultural Research 10: 143-149.

In studies during the blossoming period in the Nelson district the only pollinating insects observed on the trees were honey bees and negligible numbers of *Bombus terrestris*. Fruit-set was very low on Jonathan apple trees caged to exclude bees. A density of about 40 honey bees per 30, 000 flowers, estimated per minute, appears adequate, or more than adequate, for pollination of the varieties studied. [For part I see H.A., 36: 6137.]-Wallaceville Animal Res. Cent., Dep. Aeric. Wellington.

Palmer-Jones, T. and P. G. Clinch (1968). "Honey bees essential for pollination of apple trees." New Zealand Journal of Agriculture 116(5): 32-33.

Investigations in 2 districts of New Zealand over 3 seasons showed that the honey bee was overwhelmingly the major agent in apple pollination. The only other pollinating insect, the short-tongued bumble bee, occurred in very small numbers. [See also H.A., 37: 4430 and 38: 5033.]-Wallaceville Animal Res. Cent.

Palmer-Jones, T. and P. G. Clinch (1968). "Observations on the pollination of apple trees (Malus sylvestris Mill.). III. Varieties Granny Smith, Kidd's Orange Red, and Golden Delicious." New Zealand Journal of Agricultural Research 11(1): 149-154.

The only pollinating insects observed on the trees were honey bees, a few *Bombus terrestris* and long-tongued bumble bees. Fruit set was very low on Granny Smith trees caged to exclude bees. [Cf. XXXVII, 6804].

Palmer-Jones, T. and P. G. Clinch (1974). "Observations on the pollination of Chinese gooseberries variety "Hayward"." New Zealand journal of experimental agriculture 2: 455-458.

In 4 orchards of chinese gooseberries (*Actinidia chinensis*) with 2.5-8.0 hives/ha, pollination was due almost entirely to honeybees. During the period of observation, neither male nor female flowers secreted nectar, but bees gathered pollen from both, mainly in the morning. Virtually all female flowers developed fruit even when covered to exclude bees. However, the weight of individual fruit formed from covered flowers was significantly lower. Seed production in covered fruit was significantly lower than in exposed fruit.

Palmer-Jones, T. and I. W. Forster (1965). "Observations on the pollination of lucerne (*Medicago sativa* Linn.)." New Zealand Journal of Agricultural Research 8: 340-349.

Although the honey bee appeared to be the most important pollinator in the populations studied in the various localities, no suggestions, other than the introduction of new pollinating species, could be made for increasing the amount of pollination of the crop, which averaged only 10%.

Palmer-Jones, T. and I. W. Forster (1972). "Measures to increase the pollination of lucerne (*Medicago sativa* Linn.)." New Zealand Journal of Agricultural Research 15(1): 186-193.

The effect of excluding pollen sources other than lucerne from honey bees was studied by enclosing areas of a lucerne seed crop with cages containing hives and comparing pollination in these with that in the surrounding crop. Greatly increased pollination was obtained from 'Wairau' lucerne grown under such conditions and worked solely by typical commercial strains of bee. The elimination of competing pollen sources is uneconomic. Hence the effect of moving successive waves of hives, with a maximum population of young bees, to lucerne crops to promote tripping, and so increase lucerne seed yields, was studied. This measure proved of no practical value under New Zealand conditions. A hive concentration of less than one per acre cannot be guaranteed to give adequate pollination under all conditions. An investigation of honey bee visitation to the flowers of lucerne crops showed bee coverage was apparently sufficient to give adequate seed set if bees could be induced to gather pollen rather than collect nectar. Improvement in lucerne pollination appears possible only by the introduction of new species of pollinators. © 1972 Taylor & Francis Group, LLC.

Palmer-Jones, T. and I. W. Forster (1975). "Observations on the pollination of sunflowers." New Zealand journal of experimental agriculture 3(1): 95-97.

In trials with sunflowers cv. Peredovic, an average of about 1 honeybee/sunflower head provided adequate pollination, as measured by the number of seeds produced per head. This density was achieved when about 20 hives/ha of crop were present within 3 km of the crop. Bumble bees played no effective part in sunflower pollination. An average of 400 filled seeds/head with a germination of 99% were produced by plants grown in cages which excluded bees. Crops with a low bee density also yielded good quality seed but the yield was lower than when bee densities were high. The number of filled seeds/heads was considered to provide a reasonably accurate measure of the degree of pollination.

Palmer-Jones, T., et al. (1966). "Observations on the pollination of Montgomery red clover (*Trifolium pratense* L.)." New Zealand Journal of Agricultural Research 9(3): 738-747.

From investigations with red clover cv. Montgomery it was concluded that: honey bees and bumble bees were the only insects of importance for pollination and, of these, honey bees were the more important, with 1-89 bees/10, 000 flowers, compared with 0-15, for each of long- and short-tongued bumble bees. Low bee densities were associated with competition from other nectar- and pollen-producing plants; usually the bee population was considerably higher on red clover with >69% pollination than with less well-pollinated plants. High concentrations of honey bees and long-tongued bumble bees in cages gave similar pollination values; these were much higher than with short-tongued bumble bees (*B. terrestris*), which frequently collected nectar through holes they made in the sides of the corolla tubes. Florets were available for pollination for 20-30 days.

Palmer-Jones, T., et al. (1962). "Observations on the role of the honey bee and bumble bee as pollinators of white clover (*Trifolium repens* Linn.) in the Timaru district and Mackenzie Country New Zealand." New Zealand Journal of Agricultural Research 5(3-4): 318-325.

In the honey-producing area at Timaru where there were few bumble bees, pollination of New Zealand white clover by honey bees was 89-98%. In Mackenzie Country, where there were few honey bees, bumble bees were effective, although their population varied with area and season. Increasing the honey-bee population above approx. 4000/ac or 75 per 10, 000 flowers did not increase pollination. It was thought that adequate pollination was achieved by existing populations, i.e. approx. 2000 bees/ac or 25 per 10, 000 flowers. -J.G.G.

Parish, J. B., et al. (2020). "Collection of conidia of *Podosphaera xanthii* by honey bee workers." Australasian Plant Pathology: AAP 49(3): 245-247.

Honey bees, *Apis mellifera*, actively collect a range of materials including pollen and fungal spores. However, the interaction between honey bees and fungal spores is largely unexplored. Therefore, this study aimed to assess the corbicular contents of workers foraging on zucchini leaves severely affected by powdery mildew. The dimensions (length and width) of conidia removed from the corbiculae of honey bee workers and from the zucchini leaves were similar and conidia matched the description of *Podosphaera xanthii*, the causal agent of powdery mildew of cucurbits. Our findings that corbicular loads comprised only conidia of *P. xanthii* confirm that honey bees exhibited constancy, just as they almost always forage on a single species of flower per foraging trip, and highlight the importance of understanding the behaviour of honey bee workers in regards to the collection of fungal spores.

Pattemore, D. E. (2013). "Recent advances in pollination biology in New Zealand." New Zealand Journal of Botany 51(3, Sp. Iss. SI): 147-154.

Pattemore, D. E., et al. (2014). "Evidence of the role of honey bees (*Apis mellifera*) as vectors of the bacterial plant pathogen *Pseudomonas syringae*." Australasian Plant Pathology 43(5): 571-575.

Honey bees (*Apis mellifera*) have been implicated in the spread of the fire blight pathogen (Erwinia amylovora) and may transmit other bacterial plant pathogens in the process of pollinating crops. Furthermore, the movement of hives from one orchard to another could spread plant diseases over large distances. We investigated whether honey bees might play a role in the transmission of different pathovars of *Pseudomonas syringae*. We detected live *P. syringae* pv. actinidiae (Psa), a pathogen of kiwifruit (Actinidia spp.), on caged bees in hives 6 days after the bees were inoculated with Psa and recorded up to 1.8x104 colony forming units of Psa on honey bees foraging naturally on flowers of Psa-infected vines. P. syringae pv. syringae (PssSmr), a pathogen with a wide host range, was spread to untreated bees in a hive within 24 h following the introduction of foragers doused in PssSmr-contaminated pollen and was still detected on bees 9 days later. PssSmr was found on caged bees in hives 6 d after they were inoculated and PssSmr survived in hives for at least 14 days. These results demonstrate that P. syringae can survive in beehives and spread within a hive, which broadens the applicability of results from studies of E. amylovora and supports recommendations for a stand down period before moving beehives from a contaminated to a non-contaminated orchard.

Pistillo, G. and A. Low (1977). "The role of honey bees in the pollination of sunflowers (*Helianthus annuus*)." Proceedings of the XXVIth International Apicultural Congress, Adelaide: 420-424.

Low seed yields sometimes obtained in Australia are partly due to inadequate pollination. In greenhouse and field trials, the presence of honeybees has increased yields by up to 60%. Other factors affecting seed set were plant spacings and date of sowing. P. Walker

Priestley, G. (1954). "Use of honey bees as pollinators in unheated glasshouses." New Zealand Journal of Science and Technology 36: 232-236.

At the Crop Research Division, Lincoln, pollination of Savoy cabbage plants for stock-seed production was affected by the use of a strain of Italian honey bee in insect-proof glasshouse units. Each unit held about 40 plants and when flowering commenced two hives, each consisting of six frames, were introduced. As a result of the high temperatures reached during warm weather, bee mortality was high; seed setting was, however, satisfactory, 2.69 Ib. clean seed being obtained from 80 plants.

Rader, R., et al. (2013). "Diurnal effectiveness of pollination by bees and flies in agricultural *Brassica rapa*: Implications for ecosystem resilience." Basic & Applied Ecology 14(1): 20-27.

Bees are known to provide pollination services to a wide range of crops, yet flies are rarely included in estimates of function. As bees and flies differ markedly in their life history characteristics and resource needs, they may be active and hence provide pollination services at different times of the day. Here, we explore the differences in bee and fly diurnal activity patterns and how this may impact upon pollination services provided to *Brassica rapa*, a mass-flowering crop. We observed pollinators at two-hourly intervals from 6:00 to 20:00 h in twelve fields in New

Zealand in 2004-2005. Overall, bees were most active in the middle of the day and were more effective pollinators than flies, driven primarily by the high pollinator efficiency of *Apis mellifera* and *Bombus terrestris*. Some fly taxa however, visited flowers early and late in the day when there were few bees. The results of this study demonstrate that fine-scale temporal dynamics and the spatial distribution of crop pollinators may directly affect the quantity of pollination services. The maintenance of biodiversity in agro ecosystems may therefore be critical to ensure pollinator taxa are available under a range of environmental conditions.

Radford, B. J., et al. (1979). "Agents of pollination in sunflower crops on the central Darling Downs, Queensland." Australian Journal of Experimental Agriculture and Animal Husbandry 19(100): 565-569.

Honeybees were the most frequent insect visitors to flowering sunflower heads on the central Darling Downs. Populations in 42 crops during mid-morning in fine weather averaged 65.3 bees/100 flowering heads. A range of moth sp. was observed at night but total moth population in 33 crops between 7 p.m. and 8 p.m. averaged only 3.9 moths/100 flowering heads. Although Heliothis armigera moths and wind can pollinate sunflowers, insects other than honeybees, and wind, played an insignificant role in crop pollination.

Radford, B. J. and J. W. Rhodes (1978). "Effect of honeybee activity on the pollination of sunflowers." Queensland Journal of Agricultural and Animal Sciences 35(2): 149-155.

In field trials sown on 15th Jan., 1974 on the Darling Downs at a site expected to lack honeybees, Sunflower cv. Sunfola 68-1 was sown in N./S. rows at a density of 40 000 plants/ha and row spacing of 100 cm. Honeybee hives were placed at the S. end of the row and pollinator activity was observed and seed set determined. Honeybees were the only insects playing a significant role in pollination. Hourly number of visits/head declined with distance from the colony. The visits to flowerheads were short, 61% lasting <1 min. Only 10.7% of the florets in bagged heads set seed compared with 100% in open heads even in florets 2000 m from the colonies.

Radford, B. J., et al. (1979). "Populations of honeybees pollinating sunflower crops on the Central Darling Downs, Queensland." Australian journal of experimental agriculture and animal husbandry. 19(101): 716-718.

Radford, B. J., et al. (1979). "Seed set in sunflower crops on the central Darling Downs, Queensland." Queensland Journal of Agricultural and Animal Sciences 36(2): 133-139.

In generally fine weather in 1974-75, seed set in heads open to pollination (79-97%) was positively correlated with seed set in bagged heads at the same site (0-48%). Seed set in the open heads was not significantly correlated with percentage commercially usable achenes (40-84%). Seed set in open heads was independent of number of beehives within 3 km and area of crop, indicating that pollinators were adequate. In 1975-6, heads which flowered during 5 wet days had lower seed set than heads which flowered in fine weather. Achene yield/head was also lower. This is attributed to reduced honeybee activity during the wet weather and low self-compatibility in the cv. studied.

Read, S. F. J., et al. (2017). "Insect visitors to avocado flowers in the Bay of Plenty, New Zealand." New Zealand Plant Protection 70: 38-44.

Insect pollination is key to ensuring adequate fruit yields within avocado orchards. Various bee and non-bee insect species have been considered as potential pollinators of avocado worldwide, but in New Zealand there has been little research into which insect species visit avocado flowers. In the Bay of Plenty, an important avocado production area, flower visitor abundance and diversity data were obtained by conducting observational surveys in four orchards in November 2015. Honey bees were the dominant flower visitors in all orchards surveyed, representing 92.9% of all insects recorded, but there was high variation in numbers among sites. Other common insects observed included the beetle, Zorion guttigerum (3.4%), and bumblebees *Bombus* spp. (1.6%). A better understanding of the interaction between honey bee stocking rates and flower visitor abundances within orchards could assist in improving pollination recommendations.

Reid, P. and G. Innes (1996). "Fruit tree pollination under nets." Australasian beekeeper 98(6): 229-231.
Hail netting is being used increasingly in apple and pear orchards in South Queensland, Australia, and yields decrease unless honey bee colonies are introduced at the right time. One grower who uses 2 hives/ha has reported great improvements. Advice is given for beekeepers preparing and hiring colonies for netted orchards.

Rhodes, J. (1985). "Crop pollination." Australasian beekeeper 87(6): 121-125.
Discusses economic aspects of hiring honeybees for pollination, and colony management whilst bees are on a crop.

Rhodes, J. (1985). "Kiwi fruit pollination." Australasian beekeeper 87(4): 69-71.
In New Zealand it is recommended that 8 hives/ha should be placed in large, mature orchards.

Rhodes, J. (2002). "Cotton pollination by honey bees." Australian journal of experimental agriculture. 42(4): 513-518.

Rhodes, J., et al. (1977). "Seed set in sunflower (*Helianthus annuus* L.) crops on the central Darling Downs." Proceedings of the XXVIth International Apicultural Congress, Adelaide.: 425-428.
In studies in Queensland, Australia, mean percentage seed set (MS) in bagged heads (8.9%) was correlated positively with MS in open heads (89.2%). Significant differences were found between some cultivars. MS was not significantly different between plots within 2 km of an apiary and those not near an apiary, indicating that the population of pollinators was sufficient without apiaries being present. Five days of wet weather during flowering reduced seed set on some plots, due to reduced honeybee activity on highly self-incompatible cultivars. P. Walker

Rhodes, J. W. (1979). "Honey bee (*Apis mellifera* L.) activity on sunflowers (*Helianthus annuus* L.)." Queensland Journal of Agricultural and Animal Sciences 36(1): 21-24.
Nectar was available in sunflowers throughout the day (06.00 to 18.00 h), and honeybees collected nectar for almost all of this period. Peak activities were mid-morning and mid-afternoon. Pollen was present on sunflower heads from 06.00 to 11.00 h and from 15.30 to 16.00 h; maximum availability was from 07.00 to 09.00 h. Pollen which stuck to the bodies of nectar foragers was taken to the hive. Only 1 of 2465 foragers on sunflowers was observed to be an active pollen collector. P. Walker

Roberts, D. (1952). "Honey bees and pollination of orchard fruits." New Zealand Journal of Agriculture 84: 465-466.
The requirements necessary for maximum pollination by honey bees are outlined. It is shown that some varieties of plum, apricot, peach and pear may be affected detrimentally by the presence of competing plants, which, having a higher sugar concentration of nectar, are more attractive to bees.

Roberts, D. (1956). "Sugar sprays aid fertilisation of plums by bees." New Zealand Journal of Agriculture 93: 206-211.
Observations during 1951-55 showed that 99% of the insect visitors to plum trees were honey bees. These are not normally interested in flowers in which the nectar has a sugar concentration of less than 25 %, and plum nectar, varying from 1 % to 32 % sugar, is normally low until it is increased by evaporation. In many plum orchards other competitive sources of nectar nearby have been responsible for poor fruit set, and trials in 1954-55 have shown that plum blossoms can be made more attractive to bees by spraying them with a 20-30 % sugar solution in the late morning and early afternoon each day. The number of bees per tree was increased from 6 to 300 by the first spray and to 500 after the second. -Dep. Agric., Auckland. [See also H.A., 26: 1426 and 27: 118.] J.R.L.

Roberts, J. M. K., et al. (2018). "Honey bee-assisted surveillance for early plant virus detection." Annals of Applied Biology 173(3): 285-293.

Incursions of plant viral pathogens are a primary concern for horticulture as they can significantly impact crop yields and require expensive management. Early detection of plant viruses is critical for effective plant biosecurity because it enables growers to respond quickly and limit their spread. However, current surveillance methods relying on enzyme-linked immunosorbent assay and PCR testing of plant material can only operate at a limited scale. It quickly becomes unfeasible to test a large number of samples for area-wide surveillance of multiple viruses and ineffective in novel virus discovery. Advances in high-throughput sequencing (HTS) platforms have greatly improved our surveillance capability and its value demonstrated for screening plant material for viral pathogens. However, while HTS can improve detection, it does not necessarily address the issue of sampling effort needed to achieve early detection. The solution is to couple HTS with a method of constant surveillance and sampling from potentially infected plants. We propose that when managed honey bee (*Apis mellifera*) hives are brought to flowering crops to deliver essential pollination services, they can also provide valuable surveillance by effectively "sampling" entire crops as they collect pollen and nectar. Combining the ability of honey bees to create a representative sample from a large number of plants with the sensitivity of HTS offers a powerful system for early detection of plant viruses. We describe a novel approach to plant biosecurity where HTS virus detection in honey bees was found to provide earlier detection of plant virus incursions in Australia than current surveillance programmes. In 2013-2014, a national virus survey of honey bees was conducted, which used HIS screening of pooled honey bee samples across Australia. This HTS data simultaneously identified multiple plant viruses in these samples and showed the presence of cucumber green mottle mosaic virus in several states of Australia before its subsequent detection from diseased plant material.

Sandhu, H., et al. (2016). "Scarcity of ecosystem services: an experimental manipulation of declining pollination rates and its economic consequences for agriculture." PeerJ 4: e2099-e2099.

Ecosystem services (ES) such as pollination are vital for the continuous supply of food to a growing human population, but the decline in populations of insect pollinators worldwide poses a threat to food and nutritional security. Using a pollinator (honeybee) exclusion approach, we evaluated the impact of pollinator scarcity on production in four brassica fields, two producing hybrid seeds and two producing open-pollinated ones. There was a clear reduction in seed yield as pollination rates declined. Open-pollinated crops produced significantly higher yields than did the hybrid ones at all pollination rates. The hybrid crops required at least 0.50 of background pollination rates to achieve maximum yield, whereas in open-pollinated crops, 0.25 pollination rates were necessary for maximum yield. The total estimated economic value of pollination services provided by honeybees to the agricultural industry in New Zealand is NZD $1.96 billion annually. This study indicates that loss of pollination services can result in significant declines in production and have serious implications for the market economy in New Zealand. Depending on the extent of honeybee population decline, and assuming that results in declining pollination services, the estimated economic loss to New Zealand agriculture could be in the range of NZD $295728 million annually.

Saunders, M. E. and G. W. Luck (2014). "Spatial and temporal variation in pollinator community structure relative to a woodland-almond plantation edge." Agricultural and Forest Entomology 16(4): 369-381.

Agricultural landscape elements, such as field edges, are not always a barrier to insects but can influence their distribution and dispersal behaviour. The present study investigated spatial and temporal patterns in wild pollinator (fly, wasp and non-Apis bee) distribution across an edge between natural mallee woodland and monoculture almond plantations in southern Australia, during the critical almond flowering period. This is the first study of variation in pollinator community distribution on both sides of an edge between natural vegetation and flowering tree crop plantations. Species richness, diversity and evenness (SHE) analysis was also used to identify changes in pollinator community structure relative to the edge. It is shown that the spatial distribution and structure of pollinator communities can vary across a habitat edge with an abrupt temporal change in resources. Our results suggest that the plantation edge did not prevent wild pollinators spilling over from woodlands, although vegetation homogeneity and phenological changes in resources most likely influenced the dispersal of pollinators into plantation interiors. The findings of the present study contribute to our knowledge of edge responses by insects in managed landscapes and could motivate growers to adopt ecological management practices in commercial plantations. Future studies of insects near farmland edges should include samples on both sides of the edge and should also consider the landscape context.

Shaw, D. E. and D. F. Robertson (1981). "Collection of fungus spores by bees." Australasian beekeeper. 82(8): 185-187.

Smith, A. W., et al. (1973). "Raspberry pollination in Canterbury [New Zealand]." New Zealand Journal of Agriculture 127(4): 50-51.

Somerville, D. (1994). "Honey bees in faba bean pollination." Bee Briefs 11(1): 13-15.

In a trial in a *Vicia faba* field in NSW, Australia, yields from plots caged with honey bees averaged 24% higher than those from plots caged without honey bees. V. faba pollen (crude protein content 22-24%) is useful for building up colonies, but the crop provides little, if any, nectar so colonies must be given honey stores or sugar syrup. Advice on placement of hives, time of introduction to the crop, condition of colonies and stocking rates is also given.

Somerville, D. (1999). "Honey bees on canola." Agnote - NSW Agriculture (DAI/82): 4-pp.

Somerville, D. C. (1999). "Honeybees (*Apis mellifera* L.) increase yields of faba beans (*Vicia faba* L.) in New South Wales while maintaining adequate protein requirements from faba bean pollen." Australian Journal of Experimental Agriculture 39(8): 1001-1005.

A trial was conducted to measure the impact of honeybees (*Apis mellifera* L.) on faba bean (*Vicia faba* L.) yields and to determine the value of the crop to honeybees. The seed yield in cages with bees was 25% higher than in those without bees. The pollen harvested by honey bees from the faba beans met their nutritional requirements for protein and amino acids but there was no detectable nectar crop gathered from the faba beans. Thus, there seems to be a strong case for using managed honey bees to improve pollination and hence yields of Australian faba beans where feral bee populations may be insufficient.

Stace, P. (1986). "Observations on the behaviour of honey bees in flowering macadamia orchards." Australasian beekeeper 88(2): 36-41.

The foraging behaviour of honeybees on *Macadamia integrifolia* flowers in NSW, Australia, was observed in 1983-85. The bees collected nectar from 07.30 to about 13.00 h, with peak activity at about 08.30 h. Bees foraging before about 10.00 h spent 3.5-4.0 s on a floret, but after that time spent per floret decreased, probably because there was little nectar left (and no more was being secreted). A few bees collected pollen in the afternoon. Foraging bees, especially pollen foragers, appeared to effect cross-pollination (which increases fruit set in macadamia). However, nectar production, and thus the attractiveness of the flowers to honeybees, varied from season to season. Colony development also varied from year to year, but in 1985 it was good, and 5-10 kg honey/hive was collected; it was dense, dark, and with a light burnt sugar flavour. It is suggested that honeybees could be used successfully as cross-pollinators of macadamia. P. Walker.

Stace, P. and E. B. Dettman (1985). "Managed pollination of sunflowers." Australasian beekeeper 87(5): 100-105.

The following information was extracted from 99 replies to a questionnaire sent to commercial sunflower growers in northern New South Wales, Australia. The mean yield obtained by 23 farmers who had brought in bees to pollinate their crops (from 0.2 to 1.5 hives/ha) was 1.03 t/ha, and of those who did not, 0.89 t/ha (although many of the latter group did observe honeybees or wild bees on their crops). The difference was statistically significant. No such difference was found between mean oil contents of the seed from the 2 groups, which were 42.3% and 43.2%, respectively. Nineteen of the farmers who hired bees thought they were beneficial to the crop, but some felt hiring costs were too high; 45 farmers who had not hired bees planned to do so. It is concluded that both grower and beekeeper can benefit if they work together, and that more research is necessary into the economics and application of managed pollination.

Stevenson, M. (1990). "Artificial pollination for kiwifruit." Orchardist of New Zealand 63(8): 24-25.

Honeybees are the major pollinators of kiwifruit (4-8 hives or more/ha being required) but artificial pollination may also be necessary where weather or orchard conditions are not conducive to good bee pollination. Dry and spray methods are discussed. Machines for collecting and transferring dry pollen from male to female flowers include the Airflo, Roll-on and Turbo Bee (all developed by growers). The Ruakura sprayer (suitable for pergola-trained vines) and the air-shear nozzle sprayer (hand-held) apply pollen suspended in a liquid medium; an advantage of spray methods is that they can be used during light rain or while free water is present on the canopy.

Stewart, A. M. and J. L. Craig (1989). "Factors affecting pollinator effectiveness in *Feijoa sellowiana*." New Zealand Journal of Crop and Horticultural Science 17: 145-154.

Feijoa sellowiana was studied under cultivation in New Zealand, California and Japan to determine which floral visitors were the most effective pollinators. A large range of insects and birds visited feijoa flowers to collect pollen or to feed on the fleshy sugary petals, but only large birds deposited sufficient compatible pollen to initiate fruit development. This was confirmed by an exclusion experiment. Bird visits were greater at the edges of blocks and, in large blocks, fruit set was significantly lower in the centre of the block. Honeybees, because of their small size and localized movement on anthers, deposited little pollen. They tended to forage for pollen during the male phase when stigmas were unreceptive. The placing of hives in feijoa orchards is therefore not recommended.

Stoddard, F. L. (1991). "Pollen vectors and pollination of faba beans in southern Australia." Australian journal of agricultural research. 42(7): 1173-1178.

Tanda, A. S. (2019). "Entomofauna enhance the quality and quantity in okra." Indian Journal of Entomology 81(1): 16-17.

The most important insect pollinators of okra (*Abelmoschus esculentus*) (L.) Moench (Malvaceae) at Rosehill NSW Australia were the honey bees *Apis mellifera*. Bee pollination enhanced the quality and quantity of okra vegetable patches. Of a sample of 100 *A. mellifera* foragers in okra, 62 collected nectar, 21 pollen and 17 both nectar and pollen. Corresponding numbers for wild bees were 77, 13 and 10. Insect visitors included honey bees, other bees, butterflies and Scoliid spp. For honey bees the numbers of flowers visited per foraging trip were wild bees 104, *A. mellifera* 97 and others 44. The maximum numbers of flowers visited/min by these bees were 3.1, 5.1 and 2.5, respectively. Fruit retention on flowers known to have been pollinated by honey bees was 37-42%, in the flowers pollinated by other insects it was 25%, and on self-pollinated flowers it was 17%. Fruit quality and fruit length was significantly better in bee-pollinated flowers.

Thorp, R. W. (1983). "Australian pollination reviewed." Australian bee journal 64(4; 5; 7): 16-18.

Recommendations for honeybee pollination services in Australia.

Tobler, P. and L. Jolly (1988). "The outlook for crops [in Australia] suitable for bee pollination." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 253-254.

Twidle, A. M., et al. (2017). "Identification of *in situ* flower volatiles from kiwifruit (*Actinidia chinensis* var. deliciosa) cultivars and their male pollinisers in a New Zealand orchard." Phytochemistry. 141(141): 61-69.

In situ flower volatiles from six kiwifruit cultivars (*Actinidia chinensis* var. deliciosa); -Hayward-, -Chieftain-, -M56-, -Zes007- (Green11), -M36-, and -M43- were collected by dynamic headspace sampling. Forty-five compounds were detected in the headspace of the flowers, with straight chain hydrocarbons and terpenes accounting for >98% of the volatiles emitted quantitatively across the six cultivars. Of these hydrocarbons, (3Z,6Z,9Z)-heptadecatriene is reported for the first time from a floral source while (8Z)-hexadecene and (9Z)-nonadecene are reported for the first time from kiwifruit flowers. All three hydrocarbons were verified by synthesis. Quantitative comparison of the six honey bee perceived compounds from the headspace of the cultivars showed that the males -M36- and -M43- closely matched the female cultivar Green11 that they are used to pollinate. Males -M56- and -Chieftain- were not as closely matched to the female cultivar -Hayward- that they are used to pollinate. The male -M56- in particular differed significantly from the female -Hayward- in four of the six honey bee perceived compounds.

Twidle, A. M., et al. (2018). "Identification of floral volatiles and pollinator responses in Kiwifruit cultivars, *Actinidia chinensis* var. chinensis." Journal of Chemical Ecology 44(4): 406-415.

Volatiles emitted from unpollinated *in situ* flowers were collected from two male cultivars, 'M33', 'M91', and one female cultivar 'Zesy002' (Gold3) of kiwifruit (*Actinidia chinensis* var. chinensis). The samples were found to contain 48 compounds across the three cultivars with terpenes and straight chain alkenes dominating the headspace. Electrophysiological responses of honey bees (*Apis mellifera*) and bumble bees (*Bombus terrestris*) to the headspace of the kiwifruit flowers were recorded. Honey bees consistently responded to 11 floral volatiles from Gold3 pistillate flowers while bumble bees consistently responded to only five compounds from the pistillate flowers. Nonanal, 2-phenylethanol, 4-oxoisophorone and (3E,6E)-α-farnesene from pistillate flowers elicited responses from both bee species. Overall, honey bees were more sensitive to the straight chain hydrocarbons of the kiwifruit flowers than the bumble bees, which represented one of the main differences between the responses of the two bee species. The floral volatiles from staminate flowers of the male cultivars 'M33' and 'M91' varied greatly from those of the pistillate flowers of the female cultivar Gold3, with most of the bee active compounds significantly different from those in the Gold3 flower headspace. The total floral emissions of 'M33' flowers were significantly less than those of the Gold3 flowers, while the total floral emissions of the 'M91' flowers were significantly greater than those of the Gold3 flowers.

Van Eaton, C. (1992). "Kiwifruit: pollination and production." Gleanings in Bee Culture 120(9): 494-497.

This article describes the situation and standards used in New Zealand, which produces 39% of the world's kiwifruit.

Vanneste, J. L., et al. (1999). "Honey bees to distribute beneficial, bacteria to apple and Asian pear flowers." Acta Horticulturae (489): 615-617.

It was shown that beneficial bacteria that prevent the development of fire blight caused by Erwinia amylovora in apples and pears could be distributed by honey bees (*Apis mellifera*) in Waikato, New Zealand. The bees successfully vectored Eh252R, a spontaneous rifampicin resistant derivative of E. herbicola [Pantoea agglomerans] which successfully controlled the disease.

Vithanage, H. I. M. V. (1986). "Insect pollination of avocado and macadamia." Acta Horticulturae 175: 97-101.

Observations were carried out in orchards in NSW, Australia, in 1982-84. Both avocado [*Persea americana*] and Macadamia were visited by many insect species whose relative importance as pollinators was assessed by comparing the quantities of pollen, they carried per unit time (i.e. mean no. pollen grains carried per insect x mean no. flowers visited/h). This 'pollinator index' (PI) showed that the most effective pollinator of both crops was *Apis mellifera*. PI values for avocado were honeybees, 25.6 x 10^3; Calliphora sp., 1.63 x 10^3; other species, below 1.0 x 10^3. PI values for Macadamia were honeybees, 9.6 x 10^5; *Metriorrhynchus rhipidius* (Coleoptera), 2.3 x 10^5; other species, 0.1 x 10^5 or less

Vithanage, V. (1990). "The role of the European honeybee (*Apis mellifera* L.) in avocado pollination." Journal of horticultural science. 65(1): 81-86.

Vithanage, V. and T. J. Douglas (1987). "Honeybee pollination of Macadamia floral rewards and their effect on pollen flow." Journal of apicultural research. 26(4): 261-269.

Vithanage, V. and D. A. Ironside (1986). "The insect pollinators of Macadamia and their relative importance." Journal of the Australian Institute of Agricultural Science. 52(3): 155-160.

Walker, M. K., et al. (2009). "Small arthropods as pollinators in a New Zealand pak choi field trial [part 2]." New Zealand Plant Protection 62: 92-98.

Brassica seed crops are grown throughout New Zealand and worldwide, and inter-crop and crop-weed contamination through gene flow is a major concern. For Brassica, large arthropods (body length > 3 mm), particularly honey bees, are the most important pollinators and are considered key vectors of pollen. Small arthropods (body length < 3 mm) are also abundant in Brassica crops but their role as pollinators is rarely assessed. Numerous small arthropods (particularly Diptera and Thysanoptera) were recorded within cages surrounding pak choi inflorescences that excluded large arthropods. Inflorescences inside these cages set seed, but seed set was significantly reduced compared with inflorescences in cages that were hand pollinated and uncaged inflorescences. Although the presence of large arthropods significantly increased seed set, the role of small arthropods and wind cannot be excluded in pak choi pollination. Further studies are required to fully determine the role of small arthropods in long distance pollen flow.

Wallace, H. M., et al. (1996). "The effect of supplementary pollination on nut set of Macadamia (Proteaceae)." Annals of botany. 78(6): 765-773.

The effects of supplementary pollination on initial and final nut set and nut weight of the Macadamia cultivars, 'Hawaii Agricultural Experiment Station 246' and 'Hidden Valley A4', were assessed over 3 years at an orchard in eastern Australia. The final nut sets of racemes bagged to exclude insect pollinators were low in all 3 years of the study for both cultivars. This demonstrated the importance of exposure to insect visitors to increase nut set of these cultivars. However, the improved initial nut set by supplementary cross pollination of 246 in all 3 years of the study showed that insect pollination is inefficient compared to hand pollination. Furthermore, supplementary cross pollination of 246 increased final nut set by 57-97% in 1989 and increased nut weight by 15.0 % and kernel weight by 20.0% in 1991. Cross pollination of A4 did not result in any consistent pattern of initial nut set and did not improve final nut set, but increased nut weight by 11.6% and kernel weight by 18.4%, with a higher percentage kernel recovery in 1991. In addition, supplementary self-pollination of A4 increased nut sets in both 1989 and 1990. Yield and quality of both cultivars may benefit from increasing pollen transfer in the orchard.

Wallingford, N. (1986). "Artificial pollination of kiwifruit - some history and observations." New Zealand beekeeper (191): 7-9.

The author believes that the case for artificial pollination of kiwifruit [*Actinidia deliciosa*] has been based on incorrect assumptions, e.g. that there are insufficient honeybee colonies available for pollination of this crop in New Zealand. He asserts that publicity for artificial pollination has been misleading and has not been backed up by results. If the costs of the two methods are compared, that of artificial pollination (which is labour-intensive) is 4 times that of hiring the maximum of 8 colonies/ha. Even if more hives have to be brought in to problem areas, the latter method is still more economical, assuming that suitable planting plans for male and female vines have been followed.

Ward, B. A. (1983). "Pollination." Australian bee journal 64(11): 14-23.

Management of honeybee colonies for pollination.

Wheen, G. (1984). "The honeybee as a pest control agent." Bee world. 65(3): 143-143.

White, K. A. (1983). "Pollination of commercial sunflower crops in Australia." Australasian beekeeper 84(11): 224-230.

The effect of bees on the pollination of sunflower hybrids is discussed using published results from Australia and other countries. The likely effect of Australian conditions is taken into account, and the number of bees needed for maximum seed yield is assessed for existing hybrids and for those likely to be grown in future. A summary table predicts the percentage increase in seed yield if honeybees are introduced; for example, on open-pollinated cultivars in a harsh environment with an average feral bee population the increase might be 30%. On future hybrids the increase might be only 5%, and it would only be economic to introduce hives under contract if the feral bee population were low.

Willcox, B. K., et al. (2019). "Evaluating the taxa that provide shared pollination services across multiple crops and regions." Scientific Reports (Nature Publisher Group) 9: 1-10.

Many pollinator species visit multiple crops in multiple regions, yet we know little about their pollination service provisioning at local and regional scales. We investigated the floral visitors (n=13,200), their effectiveness (n=1718 single visits) and response to landscape composition across three crops avocado, mango and macadamia within a single growing region (1 year), a single crop (3 years) and across different growing regions in multiple years. In total, eight wild visitor groups were shared across all three crops. The network was dominated by three pollinators, two bees (*Apis mellifera* and *Tetragonula* spp.) and a fly, *Stomorhina discolor*. The visitation network for the three crops was relatively generalised but with the addition of pollen deposition data, specialisation increased. Sixteen managed and wild taxa were consistently present across three years in avocado, yet their contribution to annual network structure varied. Node specialisation (d') analyses indicated many individual orchard sites across each of the networks were significantly more specialised compared to that predicted by null models, suggesting the presence of site-specific factors driving these patterns. Identifying the taxa shared across multiple crops, regions and years will facilitate the development of specific pollinator management strategies to optimize crop pollination services in horticultural systems.

Wood, G. J. (1975). "Pollination trial on blackcurrants." New Zealand Commercial Grower 30(7): 17-17.

Bushes that had been sprayed against *Botrytis* and that were open to honeybee pollination yielded 4.90 kg/bush; bushes sprayed but caged to exclude bees yielded 0.68 kg/bush; controls (no treatment) gave 4.45 kg/bush. An increase in the honeybee population to 2 hives/acre [4+/ha] increased yields substantially. D.G. Lowe

Woodward, D. (1992). "Lucerne pollination service." Australasian beekeeper 94(5): 208-214.

The South Australian Apiarists Association has been instrumental in developing guidelines for beekeepers providing colonies to pollinate lucerne and for the crop growers. The guidelines are set out and discussed. During the past 7 years the area of seed lucerne in South Australia, and therefore the number of colonies required for pollination, have increased. However, honey yields from lucerne have decreased (possible reasons are discussed), and the numbers of beekeepers and of colonies have also decreased. The effects of pollination hire charges are examined. For the best pollination of lucerne, the colony density should be 10/ha. The potential increase in seed yield is assessed.

BEEKEEPING EQUIPMENT

(2014). "News from Affiliated Societies." Austral Entomology 53(1): 29-31.

The article offers news briefs of Entomological Society of Queensland, Australia. Prof. Mandyam V. Srinivasan of the University of Queensland (UQ) gave a speech on honeybees and robotics. Article also offers photographs of students which includes Federica Turco of Queensland Museum explaining bark fogging methods to the students of UQ and postgraduate students catching insects at the light trap.

(2014). "Sensors put the buzz in Australian bee pollination research." Environmental Engineering 27(1): 7-7.

The article reports on a research project, being led by the Australian Commonwealth Scientific and Industrial Research Organization, that focuses on the use of the swarm sensing technique to monitor honey bees and the environment, and describes the sensors used in the project.

(2015). "HIVE MINDS." Geographical (Geographical Magazine Ltd.) 87(10): 8-9.

The article focuses on a study by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) researchers in Australia which monitors the population of honey bees using trackers to learn the insect's health and productivity.

Baker, G. T., et al. (1978). "The development and operation of the "G.T. 180" honey extractor." Australasian beekeeper 79(10): 201-207.

The horizontal extractor designed by G. T. Baker for handling large numbers of combs in batches has been developed into a commercially viable unit by Pender Bros. Pty Ltd, of NSW, Australia. The following components of the extracting unit are described: power uncapping machine, comb conveyor, GT 180 honey extractor, unloading rack, box conveyor. A team of 3 men can extract up to 1470 kg honey in 65 min. P. Walker

Berkhout, R. v. (1987). "The story of kiwicomb." New Zealand beekeeper (195): 38-38.

The concept of the half-comb originated in the USA and has been developed in New Zealand. A half-comb is a clear polystyrene box, 1 inch [2.5 cm] deep, with a cell pattern moulded in the base; the inside of the box is waxed. The half-comb sections are supplied in rows of 10, taped together; 4 such rows fill a half-depth super and are simply fixed in position. The bases are vertical and the open ends all face in the same direction. Bees readily build cells from the base, filling the box to the edges and corners. When full of sealed honey, a half-comb contains 350 g of honey; a lid is put on and it is ready for sale.

Berry, R. (1987). "Radical new package for long distance transportation of honey bees." Gleanings in Bee Culture 115(9): 542-543.

The author has designed the Arataki tube for transporting package bees. The long narrow tube (dimensions not given; possibly 150 cm long) with a circular cross-section provides a large surface area for the bees to hold on to. The tube is carried vertically, and closures at each end allow cool fresh air to enter at the bottom and warm air to escape at the top. Food is provided by filling a synthetic mesh 'sock' with sugar syrup jelled with agar. A total of 704 Arataki tube packages (each containing 2 lb [0.9 kg] bees) can be fitted into an airline pallet 125 x 88 inches [317 x 223 cm]. A pallet of this size holds 432 conventional 2-lb packages. To hive the bees, the gauze cap is removed, the feed sock (to which the queen is attached) is taken out, the tube is turned upside down and, with the open end in the hive, it is knocked once to empty it of bees. The successful transport of one pallet of bees (704 tubes) from New Zealand to Canada is described.

Clinch, P. G. (1971). "A battery-operated vacuum device for collecting insects unharmed." New Zealand Entomologist 5(1): 28-30.

The suction device described was developed in New Zealand during investigations on honey bees. The bees are drawn through a removable glass collecting tube into a wooden chamber with a wire gauze base (the vacuum inlet) and a galvanised-iron sliding gate on top through which, when opened, they pass into a perforated zinc funnel leading into the collecting cage. Suction is provided by a car vacuum-cleaner operated by a 12-volt car battery or by heavy-duty dry cells. Where bees are numerous, they can be collected at a rate of over 8/minute and mortality is very low. The apparatus has also been used successfully to trap *Bombus* spp., Paracolletes spp. and Pentatomids.

Gollan, J. R., et al. (2011). "Comparison of yellow and white pan traps in surveys of bee fauna in New South Wales, Australia (Hymenoptera: Apoidea: Anthophila)." Australian journal of entomology. 50(2): 174-178.

Pan trapping is a standardised and commonly used method for collecting bees, but characteristics of the trap may influence its effectiveness or bias results. The effect of trap colour on the species and numbers caught has been studied in the Northern Hemisphere, but not in the Australian region. Australia has a unique bee fauna and colour preferences, if any, may differ from those found in other continents. In four separate surveys across a wide area of New South Wales, it was tested whether there was a difference in the abundance or species richness captured by yellow- and white-coloured pan traps. In total, 1267 bees were collected, comprising 66 species, 50 of which are in the family Halictidae. In all surveys, yellow pan traps collected a significantly larger number and greater diversity of bees. Eight of the thirteen most common species were observed significantly more frequently ($P < 0.01$) in yellow pan traps, while the European honey bee (*Apis mellifera*) was found in larger numbers in white traps. Our results demonstrate that differently coloured traps collect different components of the Australian bee fauna. Therefore, a variety of pan colours should be used when sampling overall bee biodiversity, but specific colours may be more effective when targeting certain groups or species.

Guilfoyle, J. L. (1975). "New product development in beekeeping equipment." Proceedings of the XXVth International Apicultural Congress, Grenoble.: 519-526.

Illustrated account of equipment used in Australia.

Harrison, D. L. and R. G. Nairn (1959). "Danger of using arsenic-treated timber for beehives." New Zealand Journal of Agriculture 98(4): 338-339.

Tests with hives treated with Tanalith U and Boliden S 25 showed that preservatives containing as should on no account be used, as they are poisonous to bees [cf. F.A. 18 No. 2201. KEYWORDS: Bees toxicity \ wood preservatives \ wood preservation \ Preservative treated wood toxicity \ bees \ wood preservatives \ arsenical \ wood preservatives \ toxicity \ bees

Johnson, L. H. (1954). "Timber preservation for Pinus radiata hives." New Zealand Journal of Agriculture 88(2): 105-109.

Describes suitable preservatives (i.e. water-soluble inorganic salts and oil-soluble preservatives) and methods of treatment, including home treatment by dipping. KEYWORDS: Pinus radiata wood preservation \ Preservation \ bee hives \ wood preservation

Jones, W. A. (1986). "New bee blower developed." Australasian beekeeper 88(1): 7-9.

A lightweight 4-stroke motor close-coupled to a fan has been successfully used for operating a rabbit fumigator. It has now been used, with some modifications, to power a bee-blower made by Ag-Murf Engineering, Australia. Supers to be cleared are set up on top of an adjacent hive and air is blown in from the bottom of the frames. The lower-pressure air flow from this blower upsets and damages the bees less than the high-pressure flow produced by a 2-stroke motor. The blower is also quieter and produces fewer fumes.

Kleinschmidt, G. (1993). "Influence of hive design & hive position on pallet on honey production on the Atherton Tableland." Australasian beekeeper 95(3): 111-115.

In Queensland, Australia, 56 honey bee (*Apis mellifera*) colonies were housed in hives of 8 different designs, varying in colour, ventilation, and type of hive body. Hives were mounted on pallets in groups of 4. Monthly checks were made of brood area and bee numbers, and samples of honey taken. The temperature and RH of the hive interior and environment were recorded. Hives were weighed weekly. Hive design had no effect on honey production, honey sugar content, bee numbers or brood area. There were significant differences in honey production, honey sugar content, bee numbers and brood area during different months: it is suggested that the major determinant of colony strength is availability of food resources. Honey sugar content was highest when ambient humidity was lowest. Bee numbers, brood area and hive weight were correlated during the first 3 months of the trial as colonies expanded. Drifting of bees between adjacent hives on pallets with entrances facing in the same direction was minimized by placing a metal sheet between the hives: honey production was not influenced by position on the pallet.

Levot, G. W. and D. Somerville (2012). "Efficacy and safety of the insecticidal small hive beetle refuge trap APITHORTM in bee hives." Australian Journal of Entomology 51(3): 198-204.

Research into the insecticidal control of adult small hive beetle culminated in the development of an insecticidal refuge trap for deployment inside commercial bee colonies. The device (APITHORTM) is comprised of a two-piece rigid plastic shell encasing a fipronil-treated corrugated cardboard insert. Comparison of key hive health parameters (frames of bees, area of brood and weight of honey produced) between 'control' and APITHORTM-treated hives demonstrated no significant differences over a 6-week trial conducted during a spring honey flow. Mean fiprole (fipronil plus its toxic metabolites) residues in honey ripened while the devices were in place did not exceed the limit of quantification (1 micro g/kg). In a 36-day field trial conducted in a beetle-infested apiary, all live adult beetles were eliminated from hives containing APITHORTM, while beetle numbers increased by approximately 20% in co-located control hives.

Manning, R. (2002). "The Beetube - a new honey bee pollination device in Western Australia." Australian Journal of Experimental Agriculture 42(5): 643-647.

The development of a simple, durable, lightweight and disposable beehive for high-density (and netted) orchards and crops distant from beekeeping areas provides a useful product and a further diversification for beekeepers involved in professional pollination services. The total weight of a fully developed Beetube ranged from 2.23 to 3.64 kg, contained about 9101 bees, 3038 cm2 of comb, and had a morning and afternoon flight activity of 19-43 and 11-34 honey bees per minute, respectively.

Price, D. (2000). "Honeybees to UAVs: doing the waggle walk." IEEE Intelligent Systems & Their Applications 15(2): 6-6.

Presents a study on the presence of a kind of visual odometer in honeybees at the Australian National University in Canberra, Australian Capital Territory. Aid in directing hive mates to food sources; Performance of varying dances; Examination of insect landing strategies.

Rhodes, J. (1989). "Bee hives, bees, bee products and apiary equipment introduced into Queensland - legislation requirements." Australasian beekeeper 91(1): 47-47.

Roberti, M. (2014). "A simple tagging procedure could help solve a global problem." RFID Journal: 1-2.

The article discusses the study regarding the Radio-frequency identification (RFID) tagging of Bees to identify the factors contributing to declining pollination rates and colony collapse disorder (CCD). It presents the views of Paulo de Souza, head of the research team of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia regarding the role played by honeybees. It mentions the tracking of bees by using RFID readers placed around hives with pollen.

Stace, P. and T. Bond (1985). "Honey houses: a guide to their design." Honey houses: a guide to their design.: 32-pp.

The layout of honey houses is described, with advice on working methods and desirable features. Topics covered include drainage, hot water systems, dimensions of common extracting equipment and storage areas needed, and loading and unloading. Annotated drawings are used to describe: the loading dock; work flow systems for 250, 500, 750 and 1000 hives; the extracting room - equipment layout and plumbing; an automatic drum filler. Legislation which is applicable to honey houses is reprinted from the New South Wales Pure Foods Act Section 77.D.G. Lowe.

Sundareswaran, K. and V. T. Sreedevi (2009). "Inverter harmonic elimination using honey bee intelligence." Australian Journal of Electrical and Electronics Engineering 6(2): 153-164.

This paper discusses selective harmonic elimination (SHE) in a pulse width modulated (PWM) inverter using two novel algorithms developed by the authors. The task of harmonic elimination together with output voltage regulation is framed as an optimisation problem, and then solution of switching instances are computed through the newly developed algorithms. The two optimisation algorithms are derived based on a colony of honey bees. Computed and measured results on a prototype PWM inverter shows that the SHE is successfully achieved at different steady-state values of reference output voltages. Further, the optimisation schemes are compared with traditional Newton-Raphson (NR) method and genetic algorithms (GA). It is shown that the proposed schemes are on a par with existing methods. © 2009 Institution of Engineers Australia.

Weatherhead, T. (1984). "Preservation of bee hive components." Australasian beekeeper 86(3): 52-53.

This is a brief discussion of work by M. Kalnins and B. Detroy (USA) who compared the effects on bees and their products of 7 different hive preservatives. Honey, bees and wax were periodically sampled and analysed for the presence of the chemicals. Results are not discussed for 2 chemicals not available in Australia (acid copper chromate and copper 8-quinolate), and one that is not recommended by the Queensland Forestry Department (tributyl tin oxide). In hives treated with pentachlorophenol elevated levels of the chemical were found in bees and in wax. In hives treated with chromated copper arsenate (CCA) there were increased levels of arsenic, and some bees were killed. However, Queensland beekeepers have not noticed these adverse effects. In the tests, copper naphthenate was applied at a concentration 30 times as high as that recommended in Queensland. Honey samples contained 0.43 ppm copper, compared with 0.3 ppm in untreated hives; the maximum permitted in Queensland is 10 ppm. Thus, the chemical seems safe for preserving hives, but formulations which in addition contain aldrin must not be used. [See also Weatherhead & Kennedy, AA 193/82.]

BEHAVIOUR AND PHYSIOLOGY

Dyer, A. G. (1998). "The colour of flowers in spectrally variable illumination and insect pollinator vision." Journal of Comparative Physiology 183(2): 203-212.

The spectral reflectance of differently coloured Australian native plant flowers and foliage was measured and plotted in a colour triangle to represent the colour space of the honeybee. Spectral variations in illumination are shown to significantly change plant colours for bee vision without colour constancy. A model of chromatic adaptation based upon the von Kries coefficient law shows a reduction in plant colour shift, with the degree of correction depending upon position in colour space. A set of artificial reflectance's is used to map relative colour shift caused by spectrally variable illumination for the entire colour space of the honeybee. The rarity of some flower colours in nature shows a correlation to a larger colour shift for these colours when illuminated by spectrally variable radiation. The model of chromatic adaptation is applied to illuminations used in a behavioural study on honeybee colour constancy by Neumeyer 1981. Surface colours used by Neumeyer are plotted in colour space for the various illuminations. The results show that an illumination-dependent colour shift correlates to a decrease in the frequency of bees correctly choosing a colour to which it was trained.

Dyer, A. G., et al. (2015). "Seeing in colour: A hundred years of studies on bee vision since the work of the Nobel Laureate Karl Von Frisch." Proceedings of the Royal Society of Victoria 127(1): 66-72.

One hundred years ago it was often assumed that the capacity to perceive colour required a human brain. Then in 1914 a young Austrian researcher working at Munich University in Germany published evidence that honeybees could be trained to collect sugar water from a 'blue' coloured card and find the colour among a number of different shades of achromatic grey. Von Frisch thus established honeybees as an important model of sensory processing in animals, and for work including his demonstration that bees used a symbolic dance language, won a Nobel Prize in 1973. This work led to the establishment of several research groups in Germany that developed a rich understanding of how bee vision has shaped flower colour evolution in the Northern Hemisphere. Applying these insights to Australian native bees offers great insights due to the long-term geological isolation of the continent. Australian bees have a phylogenetically ancient colour visual system and similar colour perception to honeybees. In Australia similar patterns of flower colour evolution have resulted and provide important evidence of parallel evolution, thanks to the pioneering work of Karl von Frisch 100 years ago.

Howard, S. R., et al. (2017). "Perception of contextual size illusions by honeybees in restricted and unrestricted viewing conditions." Proceedings of the Royal Society. Biological Sciences 284(1867): 20172278-20172278.

How different visual systems process images and make perceptual errors can inform us about cognitive and visual processes. One of the strongest geometric errors in perception is a misperception of size depending on the size of surrounding objects, known as the Ebbinghaus or Titchener illusion. The ability to perceive the Ebbinghaus illusion appears to vary dramatically among vertebrate species, and even populations, but this may depend on whether the viewing distance is restricted. We tested whether honeybees perceive contextual size illusions, and whether errors in perception of size differed under restricted and unrestricted viewing conditions. When the viewing distance was unrestricted, there was an effect of context on size perception and thus, similar to humans, honeybees perceived contrast size illusions. However, when the viewing distance was restricted, bees were able to judge absolute size accurately and did not succumb to visual illusions, despite differing contextual information. Our results show that accurate size perception depends on viewing conditions, and thus may explain the wide variation in previously reported findings across species. These results provide insight into the evolution of visual mechanisms across vertebrate and invertebrate taxa and suggest convergent evolution of a visual processing solution.

Howard, S. R., et al. (2019). "Honeybees prefer novel insect-pollinated flower shapes over bird-pollinated flower shapes." Current Zoology 65(4): 457-465.

Plant-pollinator interactions have a fundamental influence on flower evolution. Flower colour signals are frequently tuned to the visual capabilities of important pollinators such as either bees or birds, but far less is known about whether flower shape influences the choices of pollinators. We tested European honeybee *Apis mellifera* preferences using novel achromatic (greyscale) images of 12 insect-pollinated and 12 bird-pollinated native

Australian flowers in Germany; thus, avoiding influences of colour, odour, or prior experience. Independent bees were tested with a number of parameterized images specifically designed to assess preferences for size, shape, brightness, or the number of flower-like shapes present in an image. We show that honeybees have a preference for visiting images of insect-pollinated flowers and such a preference is most-likely mediated by holistic information rather than by individual image parameters. Our results indicate angiosperms have evolved flower shapes which influence the choice behaviour of important pollinators, and thus suggest spatial achromatic flower properties are an important part of visual signalling for plant pollinator interactions.

Hung, Y.-S. and M. R. Ibbotson (2014). "Ocellar structure and neural innervation in the honeybee." Frontiers in Neuroanatomy.

Honeybees have a visual system composed of three ocelli (simple eyes) located on the top of the head, in addition to two large compound eyes. Although experiments have been conducted to investigate the role of the ocelli within the visual system, their optical characteristics, and function remain controversial. In this study, we created three-dimensional (3-D) reconstructions of the honeybee ocelli, conducted optical measurements and filled ocellar descending neurons to assist in determining the role of ocelli in honeybees. In both the median and lateral ocelli, the ocellar retinas can be divided into dorsal and ventral parts. Using the 3-D model we were able to assess the viewing angles of the retinas. The dorsal retinas view the horizon while the ventral retinas view the sky, suggesting quite different roles in attitude control. We used the hanging drop technique to assess the spatial resolution of each retina. The lateral ocelli have considerably higher spatial resolution compared to the median ocellus. Moreover, in both types of ocellus the dorsal retina has a higher spatial resolution than the ventral retina. In addition, we established which ocellar retinas provide the input to five pairs of large ocellar descending neurons. We found that four of the neuron pairs had their dendritic fields in the dorsal retinas of the lateral ocelli, while the fifth had fine dendrites in the ventral retina. One of the neuron pairs also sent very fine dendrites into the border region between the dorsal and ventral retinas of the median ocellus.

Ibbotson, M. R., et al. (2017). "Neural basis of forward flight control and landing in honeybees." Scientific Reports (Nature Publisher Group) 7: 1-15.

The impressive repertoire of honeybee visually guided behaviours, and their ability to learn has made them an important tool for elucidating the visual basis of behaviour. Like other insects, bees perform optomotor course correction to optic flow, a response that is dependent on the spatial structure of the visual environment. However, bees can also distinguish the speed of image motion during forward flight and landing, as well as estimate flight distances (odometry), irrespective of the visual scene. The neural pathways underlying these abilities are unknown. Here we report on a cluster of descending neurons (DNIIIs) that are shown to have the directional tuning properties necessary for detecting image motion during forward flight and landing on vertical surfaces. They have stable firing rates during prolonged periods of stimulation and respond to a wide range of image speeds, making them suitable to detect image flow during flight behaviours. While their responses are not strictly speed tuned, the shape and amplitudes of their speed tuning functions are resistant to large changes in spatial frequency. These cells are prime candidates not only for the control of flight speed and landing, but also the basis of a neural 'front end' of the honeybee's visual odometer.

Iwasaki, J. M., et al. (2020). "Honey bees do not displace foraging bumble bees on nectar-rich artificial flowers." Apidologie 51(1): 137-146.

In an enclosed glasshouse with sucrose provisioned artificial flowers, we observed nectar-foraging bumble bees and honey bees under several resource conditions to determine potential for displacement. Different responses were displayed for varying resource treatments. Overall, bumble bees did not show reduced foraging in the presence of honey bees. When resources were reduced, bumble bees did not change their foraging behaviour, whereas honey bees responded by decreasing their visitation rate. When a food resource of higher quality was introduced, bumble bee foragers shifted their foraging effort to the high-quality resources, whereas honey bees continued to forage on the lower quality resources they had been foraging on. We discuss these results by considering how the individual strategy of bumble bees compared with the colony-based strategy of honey bees may explain observed differences and highlight the potential advantages of each strategy in the natural environment.

Jarriault, D., et al. (2018). "Dopamine release in mushroom bodies of the honey bee (*Apis mellifera* L.) in response to aversive stimulation." Scientific Reports (Nature Publisher Group) 8: 1-12.

In *Drosophila melanogaster*, aversive (electric shock) stimuli have been shown to activate subpopulations of dopaminergic neurons with terminals in the mushroom bodies (MBs) of the brain. While there is compelling evidence that dopamine (DA)-induced synaptic plasticity underpins the formation of aversive memories in insects, the mechanisms involved have yet to be fully resolved. Here we take advantage of the accessibility of MBs in the brain of the honey bee to examine, using fast scan cyclic voltammetry, the kinetics of DA release and reuptake in vivo in response to electric shock, and to investigate factors that modulate the release of this amine. DA increased transiently in the MBs in response to electric shock stimuli. The magnitude of release varied depending on stimulus duration and intensity, and a strong correlation was identified between DA release and the intensity of behavioural responses to shock. With repeated stimulation, peak DA levels increased. However, the amount of DA released on the first stimulation pulse typically exceeded that evoked by subsequent pulses. No signal was detected in response to odour alone. Interestingly, however, if odour presentation was paired with electric shock, DA release was enhanced. These results set the stage for analysing the mechanisms that modulate DA release in the MBs of the bee.

Jay, S. C. (1984). "Sun Position as a Possible Factor in the Disorientation of Honeybees in the Southern Hemisphere." Journal of Apicultural Research 23(3): 143-147.

Rows of honeybee (*Apis mellifera*) hives were arranged in squares, 5 to a side with their entrances facing outwards (N, S, E, W), in the south temperate zone (at Tauranga, New Zealand, 37° 40′S, 176° 12′E). A significant number of marked bees of various ages moved (drifted) westward from the central hives of north-and south-facing rows during January and February 1983 when the zenith angles of the sun were 17°10′N,21° 49′N at solar noon. Marked bees in hives facing east showed a significant tendency to drift northward along the rows by the time they were 17-18 days old. This movement of marked bees was not evident in rows that faced west. These data are compared with those obtained in the north temperate zone (at 49° 38′N, 97° 09′W) and in the tropical zone (at 18° 00′N, 76° 45′W). It appears that the sun's position, and its apparent movement, influence the direction that most bees drift from their parent hives. © 1984 International Bee Research Association.

Jones, J. C., et al. (2004). "Honey bee nest thermoregulation: Diversity promotes stability." Science (Washington D C) 305(5682): 402-404.

A honey bee colony is characterized by high genetic diversity among its workers, generated by high levels of multiple mating by its queen. Few clear benefits of this genetic diversity are known. Here we show that brood nest temperatures in genetically diverse colonies (i.e., those sired by several males) tend to be more stable than in genetically uniform ones (i.e., those sired by one male). One reason this increased stability arises is because genetically determined diversity in workers' temperature response thresholds modulates the hive-ventilating behaviour of individual workers, preventing excessive colony-level responses to temperature fluctuations.

Klein, S., et al. (2019). "Honey bees increase their foraging performance and frequency of pollen trips through experience." Scientific Reports (Nature Publisher Group) 9(1).

Honey bee foragers must supply their colony with a balance of pollen and nectar to sustain optimal colony development. Inter-individual behavioural variability among foragers is observed in terms of activity levels and nectar vs. pollen collection, however the causes of such variation are still open questions. Here we explored the relationship between foraging activity and foraging performance in honey bees (*Apis mellifera*) by using an automated behaviour monitoring system to record mass on departing the hive, trip duration, presence of pollen on the hind legs and mass upon return to the hive, during the lifelong foraging career of individual bees. In our colonies, only a subset of foragers collected pollen, and no bee exclusively foraged for pollen. A minority of very active bees (19% of the foragers) performed 50% of the colony's total foraging trips, contributing to both pollen and nectar collection. Foraging performance (amount and rate of food collection) depended on bees' individual experience (number of foraging trips completed). We argue that this reveals an important vulnerability for these social bees

since environmental stressors that alter the activity and reduce the lifespan of foragers may prevent bees ever achieving maximal performance, thereby seriously compromising the effectiveness of the colony foraging force.

Knight, K. (2020). "Enzyme helps honeybees cope in cold." Journal of Experimental Biology 223(18): jeb234310-jeb234310.

Kokay, I. C. and A. R. Mercer (1997). "Age-related changes in dopamine receptor densities in the brain of the honey bee, *Apis mellifera*." Journal of Comparative Physiology 181(4): 415-423.

Changes in the levels of binding of 3H-SCH-23390, a vertebrate D1 dopamine receptor ligand, and 3H-spiperone, a vertebrate D2 dopamine receptor ligand were investigated in the brain of the worker honey bee during metamorphic adult development and during the lifetime of the adult bee. Age-related fluctuations in binding levels were markedly different for these two ligands. 3H-SCH-23390 and 3H-spiperone binding sites were present at low levels during metamorphic adult development. After adult emergence, however, 3H-SCH-23390 binding levels, in contrast to those of 3H-spiperone, increased significantly. Within the first 48 h of adult life 3H-SCH-23390 binding reached a level not significantly different from that detected in forager bees. No significant fluctuations in the levels of 3H-spiperone binding were observed during the adult lifetime of the bee. Measurements of dopamine levels in the brains of pupal and adult bees revealed no direct correlation between fluctuations in endogenous amine levels and the amount of binding of either 3H-SCH-23390 or 3H-spiperone. These results provide evidence for subtype-specific patterns of expression of dopamine receptors in the insect brain and show that D1- and D2-like receptors are expressed not only in the adult CNS, but also in the developing brain of the bee.

Ledgard, N. J. and W. Simes (1984). "High country beekeeping." New Zealand beekeeper (184): 27-29.

In the 1982-83 (third) season of this study, 4 hives were weighed weekly and 1 daily. From early December to the end of April the mean weight gain was only 48 kg/hive; the cool wet season was probably responsible for this low yield compared with previous seasons. The relationship between hive weight gain and temperature was confirmed, and 19 degrees C was again the threshold. It is recommended that hives should be sited in a warm position, especially at high altitudes where night temperatures are low.

Ludin, N. M., et al. (2012). "A honey bee (*Apis mellifera*) light phase response curve." Chronobiology International 29(4): 523-526.

The authors report a phase response curve (PRC) for individual honey bees (*Apis mellifera*) to single 1-h light pulses (1000 lux) using an Aschoff Type 1 protocol (n=134). The bee PRC is a weak (Type 1) PRC with a maximum advance of 1.5h between circadian time (CT) 18 and 3 and a maximum delay of 1.5h between CT 12 and 18. This is the first published honey bee light PRC and provides an important resource for chronobiologists and honey bee researchers. It may also have practical applications for what is an economically important species frequently transported across different time zones. (Author correspondence: G.warman@auckland.ac.nz) © 2011 Informa Healthcare USA, Inc.

Mahadeeswara, M. Y. and M. V. Srinivasan (2018). "Coordinated turning behaviour of loitering honeybees." Scientific Reports (Nature Publisher Group) 8: 1-14.

Turning during flight is a complex behaviour that requires coordination to ensure that the resulting centrifugal force is never large enough to disrupt the intended turning trajectory. The centrifugal force during a turn increases with the curvature (sharpness) of the turn, as well as the speed of flight. Consequently, sharp turns would require lower flight speeds, in order to limit the centrifugal force to a manageable level and prevent unwanted sideslips. We have video-filmed honeybees flying near a hive entrance when the entrance is temporarily blocked. A 3D reconstruction and analysis of the flight trajectories executed during this loitering behaviour reveals that sharper turns are indeed executed at lower speeds. During a turn, the flight speed is matched to the curvature, moment to moment, in such a way as to maintain the centrifugal force at an approximately constant, low level of about 30% of the body weight, irrespective of the instantaneous speed or curvature of the turn. This ensures that turns are well coordinated, with few or no sideslips - as it is evident from analysis of other properties of the flight trajectories.

Mahadeeswara, M. Y. and M. V. Srinivasan (2019). "Author Correction: Coordinated Turning Behaviour of Loitering Honeybees." Scientific Reports (Nature Publisher Group) 9(1).

A correction to this article has been published and is linked from the HTML and PDF versions of this paper. The error has not been fixed in the paper.

Manning, R. J. G. (2002). "Body nutrient changes to honey bees when fed pollen or supplementary feedstuffs in the field in Western Australia."

Mas, F., et al. (2020). "The Scent of Individual Foraging Bees." Journal of Chemical Ecology 46(5-6): 524-533.

Honey bees (*Apis mellifera*) forage by using their sense of smell and returning to floral odours that they have previously learned to associate with high-quality food rewards. Foraging bees communicate with other bees in the hive about food sources by exchanging chemical and locational information. It is well established that bees transfer non-volatile information regarding taste and quality of nectar via trophallaxis and communicate location information via directional dances. But to our knowledge, volatiles carried by returning forager bees on their bodies has not been explored as another source of chemical information. We investigated the cuticular-adsorbed odours of bees when foraging on three different crops and compared their odours with the crops' flower headspace. We found that cuticular extracts were in majority correlated with the flower headspace where bees were foraging, specific to the crop and field. Our results support the hypothesis that the scent of returning forager bees can be communicated to hive mates and is associated with information about current floral resources. Some of the floral volatiles that we identified in bee extracts had been previously found to be key compounds learned from the crop, thus supporting a mechanism for the selection of decisive compounds.

Mas, F. A., et al. (2014). "Can bees eavesdrop on biosecurity targets?" New Zealand Plant Protection 67: 323-323.

Surveillance of unwanted organisms without lures is one of the greatest challenges in biosecurity. Previous work in the USA has shown that honey bees (*Apis mellifera*) can be trained to detect land mines. Based on this successfully proven method, the possibility of detecting key species of agricultural and biosecurity interest in a field environment was examined. Application examples presented here include detection of a weed in a crop, such as rosemary (*Rosmarinus officinalis*) in wheat, and detection of the Argentine ant (*Linepithema humile*) in a field. Bees were trained at the colony level on the specific odours of each target, and their ability to locate these odours in the field was measured with video cameras. Bees were able to detect rosemary hidden in a wheat crop and the cluster of four plants attracted significantly more bees than the positive and negative controls. Similarly, bees were shown to learn to detect the Argentine ant (*Linepithema humile*) trail pheromone, z-9-hexadecenal, and their response ranged down to parts-per-trillion (ppt, 10 supers (-12)). However, there was a clear preference for higher concentrations that may be associated with higher expected rewards. Detection thresholds and the sensitivity of bees are discussed.

Moreno, A. M., et al. (2012). "A comparative study of relational learning capacity in honeybees (*Apis mellifera*) and Stingless Bees (*Melipona rufiventris*)." PLoS One 7(12).

Background Learning of arbitrary relations is the capacity to acquire knowledge about associations between events or stimuli that do not share any similarities and use this knowledge to make behavioural choices. This capacity is well documented in humans and vertebrates, and there is some evidence it exists in the honeybee (*Apis mellifera*). However, little is known about whether the ability for relational learning extends to other invertebrates, although many insects have been shown to possess excellent learning capacities in spite of their small brains. Methodology/Principal Findings Using a symbolic matching-to-sample procedure, we show that the honeybee *Apis mellifera* rapidly learns arbitrary relations between colours and patterns, reaching 68.2% correct choice for pattern-colour relations and 73.3% for colour-pattern relations. However, *Apis mellifera* does not transfer this knowledge to the symmetrical relations when the stimulus order is reversed. A second bee species, the stingless bee *Melipona rufiventris* from Brazil, seems unable to learn the same arbitrary relations between colours and patterns, although it exhibits excellent discrimination learning. Conclusions/Significance Our results confirm that the capacity for learning arbitrary relations is not limited to vertebrates, but even insects with small brains can perform this learning task. Interestingly, it seems to be a species-specific ability. The disparity in relational learning performance between the

two bee species we tested may be linked to their specific foraging and recruitment strategies, which evolved in adaptation to different environments.

Nouvian, M., et al. (2018). "Cooperative defence operates by social modulation of biogenic amine levels in the honey bee brain." Proceedings of the Royal Society. Biological Sciences 285(1871): 20172653-20172653.

The defence of a society often requires that some specialized members coordinate to repel a threat at personal risk. This is especially true for honey bee guards, which defend the hive and may sacrifice their lives upon stinging. Central to this cooperative defensive response is the sting alarm pheromone, which has isoamyl acetate (IAA) as its main component. Although this defensive behaviour has been well described, the neural mechanisms triggered by IAA to coordinate stinging have long remained unknown. Here we show that IAA upregulates brain levels of serotonin and dopamine, thereby increasing the likelihood of an individual bee to attack and sting. Pharmacological enhancement of the levels of both amines induces higher defensive responsiveness, while decreasing them via antagonists decreases stinging. Our results thus uncover the neural mechanism by which an alarm pheromone recruits individuals to attack and repel a threat, and suggest that the alarm pheromone of honey bees acts on their response threshold rather than as a direct trigger.

Pahl, M., et al. (2011). "Large Scale Homing in Honeybees." PLoS One 6(5).

Honeybee foragers frequently fly several kilometres to and from vital resources and communicate those locations to their nest mates by a symbolic dance language. Research has shown that they achieve this feat by memorizing landmarks and the skyline panorama, using the sun and polarized skylight as compasses and by integrating their outbound flight paths. In order to investigate the capacity of the honeybees' homing abilities, we artificially displaced foragers to novel release spots at various distances up to 13 km in the four cardinal directions. Returning bees were individually registered by a radio frequency identification (RFID) system at the hive entrance. We found that homing rate, homing speed and the maximum homing distance depend on the release direction. Bees released in the east were more likely to find their way back home and returned faster than bees released in any other direction, due to the familiarity of global landmarks seen from the hive. Our findings suggest that such large-scale homing is facilitated by global landmarks acting as beacons, and possibly the entire skyline panorama.

Shrestha, M., et al. (2018). "Pollination in a new climate: assessing the potential influence of flower temperature variation on insect pollinator behaviour." PLoS One 13(8): e0200549-e0200549.

Climate change has the potential to enhance or disrupt biological systems, but currently, little is known about how organism plasticity may facilitate adaptation to localised climate variation. The bee-flower relationship is an exemplar signal-receiver system that may provide important insights into the complexity of ecological interactions in situations like this. For example, several studies on bee temperature preferences show that bees prefer to collect warm nectar from flowers at low ambient temperatures, but switch their preferences to cooler flowers at ambient temperatures above about 30 degrees C. We used temperature sensor thermal probes to measure the temperature of outdoor flowers of 30 plant species in the Southern regions of the Australian mainland, to understand how different species could modulate petal temperature in response to changes in ambient temperature and, potentially, influence the decision-making of bees in the flowering plant's favour. We found that flower petal temperatures respond in different ways to changing ambient temperature: linearly increasing or decreasing relative to the ambient temperature, dynamically changing in a non-linear manner, or varying their temperature along with the ambient conditions. For example, our investigation of the difference between ambient temperature and petal temperature (Delta T), and ambient temperature, revealed a non-linear relationship for Erysimum linifolium and Polygala grandiflora that seems suited to bee temperature preferences. The temperature profiles of species like Hibertia vestita and H. obtusifolia appear to indicate that they do not have a cooling mechanism. These species may therefore be less attractive to bee pollinators in changing climatic conditions with ambient temperatures increasingly above 30 degrees C. This may be to the species' detriment when insect-pollinator mediated selection is considered. However, we found no evidence that flower visual characteristics used by bees to identify flowers at close range, such as colour or shape, were straightforward modulators of floral temperature. We could not identify any clear link to phylogenetic history and temperature modulation either. Mapping our test flower distribution on the Australian continent, however, indicates a potential clustering that suggests different flower responses may constitute

adaptations to local conditions. Our study proposes a framework for modelling the potential effects of climate change and floral temperature on flower pollination dynamics at local and global scales.

Watts, M. E., et al. (2018). "Hypoxia-Induced MicroRNA-210 Targets Neurodegenerative Pathways." Non-Coding RNA 4(2).

Hypoxia-regulated microRNA-210 (miR-210) is a highly conserved microRNA, known to regulate various processes under hypoxic conditions. Previously we found that miR-210 is also involved in honeybee learning and memory, raising the questions of how neural activity may induce hypoxia-regulated genes and how miR-210 may regulate plasticity in more complex mammalian systems. Using a pull-down approach, we identified 620 unique target genes of miR-210 in humans, among which there was a significant enrichment of age-related neurodegenerative pathways, including Huntington's, Alzheimer's, and Parkinson's diseases. We have also validated that miR-210 directly regulates various identified target genes of interest involved with neuronal plasticity, neurodegenerative diseases, and miR-210-associated cancers. This data suggests a potentially novel mechanism for how metabolic changes may couple plasticity to neuronal activity through hypoxia-regulated genes such as miR-210.

Zhang, S. W., et al. (1998). "Eye-specific learning of routes and "signposts" by walking honeybees." Journal of Comparative Physiology 182(6): 747-754.

This study investigates the honeybee's ability to learn routes based on visual stimuli presented to a single eye, and to then navigate these routes using the other (naive) eye. Bees were trained to walk through a narrow tunnel carrying visual stimuli on the two walls. At the end of the tunnel the bees had to choose between two arms, one of which led to a feeder. In a first experiment, bees had to learn to choose the left arm to get a reward when the right wall carried a yellow grating, but the right arm when the left wall carried a blue grating. The bees learned this task well, indicating that stimuli encountered by different eyes could be associated with different routes. In a second experiment, bees had to turn left when the right eye saw a blue grating, but to the right when the same eye saw a yellow grating. They also learned this task well. In subsequent tests, they chose the correct arm even when these gratings were presented to the untrained eye. These results suggest that there is interocular transfer of route-specific learning with respect to visual stimuli that function as navigational "signposts".

ECOLOGY

(1983). "Introduced bees in conservation parks." Australasian beekeeper 84(11): 213-214.

Interactions between honeybees and native Australian bees.

Aitken, J. (1973). "Notes from west of Streaky Bay." South Australian Naturalist 48(2): 26-27.

Aitken, J. (1973). "Notes on animal life from Port Lincoln." South Australian Naturalist 48(2): 28-29.

Arundel, J., et al. (2014). "Remarkable uniformity in the densities of feral honey bee *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae) colonies in South Eastern Australia." Austral Entomology 53(3): 328-336.

It is often assumed that the density of feral honey bee colonies in Australia is sufficient to provide adequate pollination services to the many agricultural crops that require pollination. In contrast, there is concern that the density of feral colonies is sufficiently high to have inimical effects on Australian biota. For both these reasons, it is desirable to have robust estimates of the density of feral honey bee colonies in Australian landscapes. In this study, we mated four to five queens with wild drones at disturbed and undisturbed sites in three of the major ecosystems in Victoria Australia and examined the paternities of worker offspring to estimate the density of feral colonies within mating range of the test queens. We show that the density of feral colonies differs little with land use (cleared or uncleared) and is similar across the state. Our data suggest that the density of feral colonies is probably insufficient to provide adequate pollination of agricultural crops and that neither land use nor local climate variation is a major factor determining density. Finally, our data suggest that the mating range sampled by test queens is significantly greater than previously assumed.

Barbour, R. C., et al. (2005). "Pollen dispersal from exotic eucalypt plantations." Conservation Genetics 6(2): 253-257.

The introgression of genes from exotic species or populations into gene pools of native species is a widespread concern in agricultural systems. This is also an issue of increasing importance in forest systems as there has been a dramatic expansion of tree plantations, which have now reached 180 million ha globally. This has recently occurred in Australia with eucalypts. To help assess the risk of genetic pollution, we assess the pattern of realised pollen dispersal from exotic *Eucalyptus nitens* plantations into native *E. ovata* forest in Tasmania. We assessed the frequency of F-1 hybrids in open-pollinated seed collected from native *E. ovata* trees located at varying distance from three exotic *E. nitens* plantations in Tasmania. Over 119,000 seedlings were screened for morphological markers diagnostic of each species and the F-1 hybrid. F-1 hybridisation averaged 7.2% within 100 m of the exotic *E. nitens*, with one native tree reaching 56%, but diminished to 0.7% by 200 - 300 m and continued at this low level to the limits of the sampling at 1.6 km. The decay in the percentage of interspecific F-1 hybridisation with distance followed a power function with a negative exponent (% F-1 = 91.435distance(-0.789); R-2 = 0.84). *Eucalyptus nitens* is exclusively pollinated by small insects (smaller than honeybees), which the study shows can disperse pollen over 1.6 km. However, the restriction of most exotic F-1 hybridisation to within 200 m of exotic plantations presents clear opportunities to manage the genetic impacts of plantations on native forests.

Bartareau, T. (1995). "Pollination and breeding systems in varieties of *Dendrobium canaliculatum* and their implications on the taxonomic status of the group." Orchadian 11(8): 380-387.

The pollination and breeding system of *D. canaliculatum* were studied in NE Queensland, Australia, in 1990-1992. The flowers were nectarless, but they attracted insect visitors with a colourful, fragrant display. Honey bees, butterflies, syrphid flies and the solitary bees *Hylaeus chromaticus* and *H. ruficeps*, visited the flowers. The *Hylaeus* species were the only visitors seen to remove pollinia.

Battisson, L. I. A. (2017). "The story of a nesting box in Kambah." Canberra Bird Notes 42(3): 293-294.

Beavon, M. A. and D. Kelly (2012). "Invasional meltdown: pollination of the invasive liana *Passiflora tripartita* var. mollissima (Passifloraceae) in New Zealand." New Zealand Journal of Ecology 36(1): 100-107.

Banana passionfruit (*Passiflora tripartita* var. *mollissima*) is an invasive vine in New Zealand where it lacks its natural hummingbird pollinator. We investigated the mating system and reproductive traits that facilitate its spread in the Marlborough Sounds. Flower observations revealed that visitors were almost exclusively introduced honeybees and bumblebees, indicating an invasive mutualism. We investigated the pollination system of banana passionfruit by comparing fruit set, fruit size, seed set, and germination success between hand-selfed, hand-crossed, bagged and open flowers, and inbreeding depression in seedlings grown in competition. Fruit set was reduced by 83% when pollinators were excluded (3.0% fruit set, compared with 18.0% for unmanipulated flowers) indicating reliance on pollinators for reproduction. While banana passionfruit is partially self-compatible, fruit set was significantly reduced in hand-selfed flowers (17.5%) compared with crossed flowers (29.5%), and we found significant pollen limitation (hand-crossed vs unmanipulated, Pollen Limitation Index = 0.39). There was no significant inbreeding depression found in fruit size, seeds per fruit, germination success, seedling growth or seedling survival. Combining these data showed that natural unmanipulated flowers produce more seedlings per flower (1.7) than bagged flowers (0.9), but fewer than hand-selfed (3.0) and hand-crossed (5.3) flowers. Thus, reproduction in Passiflora tripartita var. mollissima is facilitated by an (imperfect) new association with exotic bees.

Berris, K. K. and M. Barth (2020). "PVC nest boxes are less at risk of occupancy by feral honey bees than timber nest boxes and natural hollows." Ecological Management & Restoration 21(2).

Feral European Honey Bee (*Apis mellifera*) has been identified as a potential nest competitor for Australian hollow nesting species, but few studies have investigated the impact of feral honey bee competition on Threatened species. Our study used data from Glossy Black-cockatoo (*Calyptorhynchus lathami halmaturinus*) nests on Kangaroo Island, monitored and managed over an 11-year period, and found 12% of nests became occupied by feral honey bees during that period. Our results indicate that feral honey bees were less likely to occupy nest boxes made of PVC (5%) compared with wooden nest boxes (24%) or natural hollows in Eucalyptus trees (14%). The removal of feral honey bee hives from nests is a priority for long-term conservation of glossy black cockatoos on Kangaroo Island. We recommend that PVC nest boxes are chosen for future nesting habitat restoration, due to the more frequent use of wooden nest boxes by feral honey bees.

Bezemer, N., et al. (2019). "Primary pollinator exclusion has divergent consequences for pollen dispersal and mating in different populations of a bird-pollinated tree." Molecular Ecology 28(22).

Pollination by nectivorous birds is predicted to result in different patterns of pollen dispersal and plant mating compared to pollination by insects. We tested the prediction that paternal genetic diversity, outcrossing rate and realized pollen dispersal will be reduced when the primary pollinator group is excluded from bird-pollinated plants. Pollinator exclusion experiments in conjunction with paternity analysis of progeny were applied to *Eucalyptus caesia* Benth. (Myrtaceae), a predominantly honeyeater-pollinated tree that is visited by native insects and the introduced *Apis mellifera* (Apidae). Microsatellite genotyping at 14 loci of all adult *E. caesia* at two populations (n = 580 and 315), followed by paternity analysis of 705 progeny, revealed contrasting results between populations. Honeyeater exclusion did not significantly impact pollen dispersal or plant mating at Mount Caroline. In contrast, at the Chiddarcooping site, the exclusion of honeyeaters led to lower outcrossing rates, a threefold reduction in the average number of sires per fruit, a decrease in intermediate-distance mating and an increase in near-neighbour mating. The results from Chiddarcooping suggest that bird pollination may increase paternal genetic diversity, potentially leading to higher fitness of progeny and favouring the evolution of this strategy. However, further experimentation involving additional trees and study sites is required to test this hypothesis. Alternatively, insects may be effective pollinators in some populations of bird-adapted plants, but ineffective in others.

Brown, J., et al. (2020). "Flower visitation and land cover associations of above ground- and below ground-nesting native bees in an agricultural region of south-east Australia." Agriculture Ecosystems & Environment 295: 106895-106895.

How different forms of agriculture support different bee taxa through the provision of different floral and nesting resources is largely unknown. Recent studies have found wild bees that are associated with agriculture tend

to nest in soil, rather than vegetation, and so are thought to be adapted to open environments where perennial woody vegetation is sparse. However, these studies do not usually distinguish different forms of agriculture, such as open pasture versus perennial woody crops. It is possible that bees that nest in wood or stems might be tolerant of agriculture with perennial woody crops, but this idea has not been tested in landscape studies. We describe foraging preferences and land cover associations of wild bees in southeast Australia to ask: Do perennial woody crops support bees that nest in wood or stems (above ground-nesting bees), while pasture supports soil-nesting (below ground-nesting) bees? We sampled bee communities using blue vane traps and flower visitor observations at 14 sites that varied in cover of remnant forest, perennial woody crops, and pasture. We found that soil-nesting bees were positively associated with pasture cover in the landscape, except for bee taxa that rarely visited crops or agricultural weeds. Above ground-nesting bees were positively associated with forest, but not with perennial woody crop cover, despite frequently visiting flowers on these crops. Our results suggest conversion of native forest to open agriculture favours soil-nesting bee taxa that forage on crops and weeds, while restricting bee taxa that depend on forests for nesting or floral resources.

Butz Huryn, V. M. and H. Moller (1995). "An assessment of the contribution of honey bees (*Apis mellifera*) to weed reproduction in New Zealand protected natural areas." New Zealand Journal of Ecology 19(2): 111-122.

In a literature survey (79 references) it was found that 43% of weeds recorded in Protected Natural Areas in New Zealand are visited by honey bees, including half the weeds classified as 'problem'. The bees may be important in the pollination of some weeds, but not, in general, of the problem weeds which have plastic reproductive mechanisms and/or simple pollination mechanisms. Thus, honey bees probably do not contribute substantially to weed problems.

Canyon, D., et al. (2002). "Environmental and economic costs of invertebrate invasions in Australia." Biological invasions: economic and environmental costs of alien plant, animal, and microbe species: 45-66.

This chapter examines exotic invertebrates in 4 main areas: medical, veterinary, agricultural, and marine. Each section focuses on several important species - *Aedes aegypti*, *Culex gelidus*, honey bees, wasps and red imported fire ants (*Solenopsis geminata*) for invasions of medical importance; cattle tick (*Boophilus microplus*) and screw worm fly (*Chrysomya bezziana*) for invasions of veterinary importance; papaya fruit fly (*Bactrocera papayae*), banana skipper (*Erionota thrax*) and beneficial arthropods for invasions of importance to agriculture and forestry; and black-striped mussels (*Mytilopsis* spp.), Northern Pacific seastar (*Asterias amurensis*) and European fan worm (*Sabella spallanzanii*) for invasions of marine importance. Current situations in arthropod invasions in Australia are outlined. Economic and environmental costs relating to the introduction of the species are estimated.

Carthew, S. M. (1993). "An assessment of pollinator visitation to *Banksia spinulosa*." Australian Journal of Ecology. 18(3): 257-268.

Celebrezze, T. and D. C. Paton (2004). "Do introduced honeybees (*Apis mellifera*, Hymenoptera) provide full pollination service to bird-adapted Australian plants with small flowers? An experimental study of *Brachyloma ericoides* (Epacridaceae)." Austral Ecology 29(2): 129-136.

In many previous studies of the effects of introduced honeybees on Australian ecosystems, it has been assumed that floral morphology is a primary factor determining whether introduced honeybees will be effective in pollinating endemic plants. Although both honeybees and birds contacted stigmas and anthers of the small-flowered *Brachyloma ericoides* (Epacridaceae), the exclusion of birds but not honeybees resulted in a significantly lower proportion of flowers producing capsules (12.3 +/- 2 vs 21.0 +/- 2%). This suggests that native birds contributed significantly to fruit set even though honeybees were much more frequent visitors to flowers (5-6 vs 0.7-2.5 times per day) and moved more frequently between plants (25 vs 12.2% of movements). Fruit set following exposure to birds and honeybees was very low compared with shrub species in general and may have been limited by the pre-emptive removal of pollen by the 10% of honeybees that actively collected pollen.

Clemson, A. A. (1979). "Swarming bees in town areas." Australasian beekeeper 80(8): 160-162.

Curtis, K., et al. (2019). "Can native plantings encourage native and beneficial invertebrates on Canterbury dairy farms?" New Zealand entomologist. 42(2): 67-78.

Farming intensification negatively effects native habitat and associated biodiversity in New Zealand. Planting native species around field margins has been proposed as a means of restoring biodiversity within this highly modified landscape. To test this hypothesis, we collected invertebrates on a dairy farm at Lincoln, Canterbury, in three habitat types: native plantings in field corners, native plantings along a double fence line, and pasture. Invertebrates were collected from pitfall traps, yellow pan traps, wooden discs and leaf litter samples were collected from the sites over summer. Assemblages of spiders, flying insects, slugs and litter mites in the planted areas had distinct compositions compared with those found in adjacent pasture. Species richness of native spiders was increased in the planted areas compared with adjacent pasture, as was the abundance of ecosystem service providers, such as honeybees, parasitoid wasps and hoverflies. Exotic slugs were significantly more abundant under discs in pasture than in planted areas. However, not all native or beneficial invertebrates responded positively to the planted areas. Further research is required to examine whether these results are repeatable at other locations, if invertebrate assemblages at this location develop further over time, and to evaluate whether any perceived benefits of these service providers can be quantified in terms of meaningful endpoints such as reduced pest levels and/or increases in yield.

Dalgleish, E. (1999). "Effectiveness of invertebrate and vertebrate pollinators and the influence of pollen limitation and inflorescence position on follicle production of *Banksia aemula* (Family Proteaceae)." Australian Journal of Botany 47(4): 553-562.

Follicle development of *Banksia aemula* (R.Brown 1810) was studied in northern New South Wales, Australia, after exposure of inflorescences to different combinations of pollinator type and pollen quantity. When inflorescences within plants were exposed to all pollinators and provided with additional cross-pollen, follicle development was increased, suggesting that *B. aemula* was pollen-limited. The addition of cross-pollen did not increase follicle development when inflorescences within plants were exposed to invertebrate pollination only. Nor did exclusion of vertebrates significantly reduce follicle development of plants relative to that of others which were exposed to all pollinators. The vegetation surrounding plants influenced the follicle development of inflorescences, and inflorescences in peripheral positions had more follicles than inflorescences that were internal.

Davila, Y. C. and G. M. Wardle (2002). "Reproductive ecology of the Australian herb *Trachymene incisa* subsp. *incisa* (Apiaceae)." Australian journal of botany. 50(5): 619-626.

Davila, Y. C. and G. M. Wardle (2008). "Variation in native pollinators in the absence of honeybees: implications for reproductive success of an Australian generalist-pollinated herb *Trachymene incisa* (Apiaceae)." Botanical Journal of the Linnean Society 156(3): 479-490.

Most plants are generalist in terms of pollination, with the potential for significant spatial and temporal variation in their pollinators. Few studies have investigated how variable pollinators are in a generalist pollination system or how this variation affects plant reproduction. We investigated the degree of variation in pollinators and resulting reproductive success among populations of a widespread generalist-pollinated herb, *Trachymene incisa* (Apiaceae). The European honeybee was unexpectedly absent from the pollinator assemblages, providing the unique opportunity to study the native Australian pollinators. Insect visitation rates and the taxonomic composition of the pollinator assemblage varied significantly across populations, indicating that populations of *T. incisa* are not equally serviced and are not equally generalist. This highlights that sampling one population would not characterize the extent of species generalization. There was no positive correlation between insect visitation rate and reproductive success, with the Agnes Banks population receiving the highest visitation rate but producing the lowest reproductive output, and the Myall Lakes population receiving the lowest visitation rate and producing the highest seedling emergence. This study shows that variation in pollinators can have measurable effects on populations of generalist-pollinated plants, therefore there is potential for large-scale change in all plant-pollinator interactions.

Davis, A. R. (1992). "Evaluating honey bees as pollinators of virgin flowers of *Echium plantagineum* L. (Boraginaceae) by pollen tube fluorescence." Journal of apicultural research. 31(2): 83-95.

de Jesus, M. C., et al. (2019). "Pyrrolizidine alkaloids of blue heliotrope (*Heliotropium amplexicaule*) and their presence in Australian honey." Journal of Agricultural & Food Chemistry 67(28): 7995-8006.

Blue heliotrope (*Heliotropium amplexicaule*) is an invasive environmental weed that is widely naturalized in eastern Australia and has been implicated as a source of pyrrolizidine alkaloid (PA) poisoning in livestock. Less well-documented is the potential of such carcinogenic alkaloids to contaminate honey from bees foraging on this plant species. In this study, the PA profile of *H. amplexicaule* plant material, determined by HRAM LC-MS/MS, revealed the presence of nine PAs and PA-N-oxides, including several PAs and PA-N-oxides of the indicine class, which have not previously been reported. The predominant alkaloid, indicine, represents 84% of the reduced PA content, with minor alkaloids identified as intermedine and the newly reported helioamplexine, constituting 7 and 9%, respectively. NMR analysis confirmed the identity of helioamplexine as a previously unreported indicine homologue. This is the first report of the isolation of intermedine, helioamplexine, and 3'-O-angelylindicine from H. amplexicaule. Also described is the identification of N-chloromethyl analogues of the major alkaloids as isolation-derived artefacts from reactions with dichloromethane. Analysis of regional-market honey samples revealed a number of honey samples with PA profiles analogous to that seen in *H. amplexicaule*, with measured PA contents of up to 2.0 mu g of PAs per gram of honey. These results confirm the need for honey producers to be aware of *H. amplexicaule* as a potential PA source, most particularly in products where honey is sourced from a single location.

Dell, B. (1977). "The collection of poplar rust spores by honey-bees." Western Australian Naturalist 13(8): 199-201.

Urediospores of *Melampsora larici-populina* were identified from corbiculae of bees (*Apis mellifera*) collected in stands of *Populus nigra* var. *italica* heavily infected with the rust and from the contents of larval food reserves in a beehive near Kalamunda, Western Australia. ADDITIONAL ABSTRACT: Uredospores of *Melampsora larici-populina* were found on the corbiculae of honeybees collected in stands of *Populus nigra* var. *italica* that were heavily infected with the rust, and in pollen stores in a hive near Kalamunda, Western Australia.

Eakin-Busher, E. L., et al. (2020). "Mating strategies dictate the importance of insect visits to native plants in urban fragments." Australian Journal of Botany 68(1): 26-36.

Plant species conservation relies on their reproductive success and likelihood of population persistence. Knowledge of plant mating systems, particularly the relationship between plants and their pollinators, is fundamental to inform conservation efforts. This knowledge could be critical for prioritising efforts in human-dominated fragmented landscapes such as the world's biodiversity hotspots, where reproductive success can be compromised due to habitat loss, limited access to pollinators or other factors. Yet, fundamental data on plant mating systems are lacking for many Australian plants. Here we determined the mating systems of native plant species growing in native woodland fragments within Perth's urban landscape in south-western Australia. We manipulated insect access to flowers and pollen transfer on five locally common native species, then observed floral visitors and examined reproductive success. *Hemiandra pungens* and *Patersonia occidentalis* had mixed mating systems with some ability to self-pollinate, whereas *Dianella revoluta* and *Jacksonia sericea* were reliant on insects for outcross pollination. The fruits and seeds produced by *Tricoryne elatior* were too low to draw conclusions about its mating system. The introduced honey bee (*Apis mellifera*) was the sole visitor to the mixed mating species, whereas native bees visited *D. revoluta* and *J. sericea* (one bee species each). Overall, our data suggest that *D. revoluta* and *J. sericea* are more vulnerable to fragmentation than *H. pungens* and *P. occidentalis*. Although insects contributed significantly to the reproductive output of the two former plant species, our observations suggested low frequency and richness of insect visitors to these urban fragments. More research is required to determine the generality of our findings. A comparative study in larger native woodland fragments would help estimate the effect of fragmentation on insect pollinators and consequences for the insect-reliant plant species.

England, P. R., et al. (2003). "Effects of seed bank disturbance on the fine-scale genetic structure of populations of the rare shrub *Grevillea macleayana*." Heredity 91(5): 475-480.

Dispersal in most plants is mediated by the movement of seeds and pollen, which move genes across the landscape differently. *Grevillea macleayana* is a rare, fire-dependent Australian shrub with large seeds lacking adaptations for dispersal; yet it produces inflorescences adapted to pollination by highly mobile vertebrates (eg birds). Interpreting fine-scale genetic structure in the light of these two processes is confounded by the recent imposition of anthropogenic disturbances with potentially contrasting genetic consequences: (1) the unusual foraging behaviour of exotic honeybees and (2) widespread disturbance of the soil-stored seedbank by road building and quarrying. To test for evidence of fine-scale genetic structure within G. macleayana populations and to test the prediction that such structure might be masked by disturbance of the seed bank, we sampled two sites in undisturbed habitat and compared their genetic structure with two sites that had been strongly affected by road building using a test for spatial autocorrelation of genotypes. High selfing levels inferred from genotypes at all four sites implies that pollen dispersal is limited. Consistent with this, we observed substantial spatial clustering of genes at 10 m or less in the two undisturbed populations and argue that this reflects the predicted effects of both high selfing levels and limited seed dispersal. In contrast, at the two sites disturbed by road building, spatial autocorrelation was weak. This suggests there has been mixing of the seed bank, counteracting the naturally low dispersal and elevated selfing due to honeybees. Pollination between near neighbours with reduced relatedness potentially has fitness consequences for *G. macleayana* in disturbed sites.

Ettershank, G. (1993). "Bees and native insects associated with leatherwoods (*Eucryphia* spp.) in Tasmania." Victorian Naturalist (South Yarra) 110(6): 251-254.

Ettershank, G. and J. A. Ettershank (1993). "Tasmanian leatherwoods (*Eucryphia* spp.) - floral phenology and the insects associated with flowers." Tasmanian NRCP Report(11): viii-pp.

Leatherwoods (*Eucryphia lucida* and *E. milliganii*) are typical understorey tree species in the cool temperate rain forests and mixed forests of W. Tasmania. Much of these forests lie within the Tasmanian Wilderness World Heritage Area and state forests. *E. lucida* is more extensive at lower altitudes and is the major honey-producing species in Tasmania. *E. milliganii* is a subalpine species and of minor importance as a honey source. A study was made of the range of native insects that utilize leatherwoods as a pollen or nectar resource, and to determine if interactions could be observed between foraging *Apis mellifera* and native insects. The sequence of development of the flowers and the quantity and quality of nectar were also studied, together with some aspects of growth and distribution of *E. lucida*. The studies were carried out in 1990 and 1991. A diverse insect fauna was associated with both species of leatherwood. Many of the common insects were also found on other plant species. Visitations by native insects and by *A. mellifera* (both feral and managed) were low. Leaf and flower bud development started in early winter, with flowering starting in early summer. The flowers were protandrous. Nectar was secreted at night; it was either harvested or withdrawn, as it could not be detected by late morning. Nectar production started with the ripening of the pollen and continued through the receptive (female) phase. Seed development continued through winter, the seed being ready to be dispersed in the next season. Flowers were usually insect pollinated, but when insects were excluded, pollination still occurred. Vegetative growth occurred from spring to early summer and was negligible for the remainder of the year. In undisturbed stands, trees were distributed in clumps. Flowering only occurred on the small proportion of trees that entered the canopy and on trees facing clearings created by the fall of other trees.

Fijn, N. (2014). "Sugarbag dreaming: the significance of bees to Yolngu in Arnhem Land, Australia." Humanimalia: A Journal of Human/Animal Interface Studies 6(1): 41-61.

Bees, with their ability to make sweet tasting honey, have been highly valued across many human cultures spanning thousands of years. In relation to western husbandry techniques, honeybees (Apidae) have been domesticated by humans to produce honey in large quantities for human consumption. The focus of this paper is not on the well-known, widespread honeybee but a close family relative of the Apidae, the smaller, stingless bee (Meliponidae). For Yolngu living on country, in the homeland communities of northeast Arnhem Land, Australia the relationship with these local, endemic bees is quite different from the large-scale beekeeping industry used to pollinate major agricultural crops. A highly anticipated activity is sugarbag season where Yolngu men, women and children undertake excursions into the bush in search of these tiny bees to extract honey. The bee is celebrated through "Sugarbag Dreaming": in song, dance, painting and ceremony. This paper examines some of the ways that

people and bees converge in Arnhem Land. Through the many layers of meaning, the paper aims to demonstrate how Yolngu philosophy recognises bees as being an integral part of an interconnected and complex ecology.

Gilpin, A. M., et al. (2017). "The use of digital video recorders in pollination biology." Ecological Entomology 42(4): 383-388.

Digital video recording (DVR) devices, such as the GoPro Hero, have the potential to greatly benefit pollination ecology, but the advantages of digitally recording pollinator activity over direct human observation have not been formally assessed. Two plant taxa, Lavandula angustifolia and Canna 'sp.', with differing floral morphology, were used to compare the value of DVR and direct observations in estimating honeybee (*Apis mellifera*) visitation, flower density and number of flowers visited per foraging bout. The two methods yielded identical results when observing the structurally simple L. angustifolia at both high (10.54+or-0.52 per plant) and low honeybee density (2.24+or-0.20 per plant). However, DVR underestimated the number of flowers scored in the field of view (28.7+or-1.8 direct vs. 22.7+or-0.9 DVR), the number of honeybees observed (5.3+or-0.8 direct vs. 3.7+or-0.7 DVR) and the number of flowers visited during foraging bouts (8.3+or-1.2 direct vs. 5.5+or-1.0 DVR) on the more complex Canna 'sp.' It is concluded that portable weatherproof DVR devices such as the GoPro Hero are valuable tools for pollination biologists, allowing a single researcher to make simultaneous observations of multiple plants in one or more sites, whilst also allowing the footage to be reviewed. However, DVR devices are limited by their depth and field of view when target plants are large or structurally complex.

Gilpin, A.-M., et al. (2019). "Are there magnet plants in Australian ecosystems: Pollinator visits to neighbouring plants are not affected by proximity to mass flowering plants." Basic & Applied Ecology 35: 34-44.

Aggregations of resource-rich plants can act as "magnets" drawing pollinators from other plants. Magnets can leave positive and negative impacts on co-flowering neighbours: enhanced pollination via a 'spill over-effect' or a reduction in pollination via competition. Support for the importance of magnets largely comes from studies conducted in the northern hemisphere. We used a comparative approach to test two hypotheses for three pairs of Australian native plants: (1) putative magnets attract a greater number and more diverse suites of pollinators than co-flowering species; and (2) the quantity, diversity and specificity of pollinators varies with distance from putative magnets. We surveyed pollinator activity on co-flowering plants before and after bagging to experimentally exclude pollinators from putative magnets, dominant flowering species with populations ranging in size from 700 to 4000 m(2). Selected focal species were found to be pollinator magnets but did not appear to influence the pollination of neighbours. Prior to bagging, putative magnets received more visits but visitors were predominantly (90-100%) exotic honeybees (*Apis mellifera*). The number and diversity of pollinators on co-flowering species did not consistently increase when magnets were bagged. Moreover, pollinator visitation, diversity and constancy did not vary with distance from putative magnets before or after bagging. All sampled (n = 388) honeybees had pollen of only one plant species on their bodies and no honeybee sampled on a co-flowering species carried pollen of magnet species (n = 212), We found that interactions between pollinators and co-flowering Australian plants differ substantially from those reported for the northern hemisphere; this is most likely due to the impact of abundant, introduced honeybees.

Godley, E. J. (1979). "Flower biology in New Zealand." New Zealand Journal of Botany 17(4): 441-466.

Research on flower biology began in New Zealand in the early 1870s under the influence of Darwin's work on orchids, but from the turn of the century there was a decline in interest until the 1950s. Spring and summer are the main flowering periods, but many species flower in winter and examples are described. Of some 1800 indigenous species of flowering plants 12–13% are dioecious, c. 2% gynodioecious, and 9% monoecious. But in many cases the unisexuality is characteristic of a widespread family or genus and cannot be claimed as having evolved in New Zealand. The morphological differentiation between male and female flowers settles down at a level characteristic of the genus and the degree of differentiation need not reflect the time since differentiation began. In hermaphrodite species heterostyly is not known, and demonstrated examples of self-sterility are few. A classification of 649 species with attractive flowers gives 60.6% white, 17.2% yellow, 12.4% blue lilac or dark purple, 5.7% red to crimson, and 4% green. A large sample from the British Isles has 25.1% white flowers. It is emphasised the flowers classified as white are rarely completely so, that a white plus yellow group is important, and that not all the flower colours need have evolved under New Zealand conditions. Nectar and honeydew from native plants provide useful honey sources, but

work on nectar has been confined to cases of bee poisoning. Available pollinators are birds (7 spp.), bats (1 sp.), butterflies (16 spp.), and solitary bees (c. 40 spp.) as well as many species of moths, beetles, and flies and several introduced bees. The general impression is of widespread self-fertility in hermaphrodite plants and variety in respect of insect visitors. It is emphasised that although much attention, everywhere, has been given to methods of pollination, more attention should be given to the results, i.e., the percentage of ovules which produce seeds. And it is also emphasised that a better understanding of the characteristics of New Zealand flowers will be obtained by studying their relatives in other lands. © 1979 Taylor & Francis Group, LLC.

Goebel, R. L. (1987). "Beekeeping - some plants of use to beekeeping in central Queensland [Australia]." Beekeeping Information Sheet, Queensland Department of Primary Industries(200): 4-pp.

Goldingay, R. L., et al. (2020). "Nest box contentions: Are nest boxes used by the species they target?" Ecological Management & Restoration 21(2).

Nest boxes have grown in popularity as a habitat management tool in Australia during the last decade. This management use remains contentious because some studies suggest nest boxes are ineffective. There are three recent contentions: (i) nest boxes mostly benefit common species, (ii) exotic species may be dominant users of nest boxes, and (iii) species of conservation concern use nest boxes infrequently. We address these contentions using data from 1865 nest boxes involving eight nest box designs. These nest boxes were installed predominantly <200 m from a road in association with highway duplication and re-alignment across 16 projects in New South Wales. The Common Brushtail Possum (*Trichosurus vulpecula*) is the species of most relevance to contention 1. It used 9% of boxes overall including 26% of 'possum' designated boxes. The most frequent nest box users were small petaurid gliders (mostly Sugar Gliders, *Petaurus breviceps*) which used 63% of 'small glider' designated boxes. This nest box and another suited to the Sugar Glider comprised 40% of all boxes installed, so it is not surprising that this species might be a common user. Exotic species were uncommon users of the nest boxes enabling contention 2 to be rejected. Active hives of Feral Honeybees (*Apis mellifera*) occupied just 1% of boxes, and another 1% of boxes were used by introduced rodents and birds. The Squirrel Glider (*Petaurus norfolcensis*) is the species most relevant to contention 3. It was seen in 80 boxes across 11 projects, representing 7% of the three types most frequently used. These observations are not consistent with the third contention. Nest boxes can provide many important insights about the requirements and interactions of hollow-dependent fauna. However, they are not intended as an alternative to retaining hollow-bearing trees.

Goldingay, R. L., et al. (2015). "Specific nest box designs can improve habitat restoration for cavity dependent arboreal mammals." Restoration ecology. 23(4): 482-490.

Tree cavity dependent wildlife faces future shortages of cavities due to a decline in the abundance of large, old trees in many parts of the world. Nest boxes are proposed as a tool to restore habitat value but evidence of their effectiveness for arboreal mammals remains equivocal. This may arise from a poor understanding of design preferences. We conducted investigations in two landscapes in eastern Australia to determine whether species show a preference for specific designs. We observed a preference by some mammal species for particular designs (3378% occupied/used), suggesting that design refinement can improve the frequency with which nest boxes are used. Although feral species may outcompete target species for nest boxes, we did not observe this. We recorded feral honeybees (*Apis mellifera*) in 69% of nest boxes but they did not remain, and many occupied boxes were later used by mammals. The introduced common myna bird (*Acridotheres tristis*) was prevalent in one landscape, but competition for nest boxes was localized. For nest boxes to be an effective habitat restoration tool, they must be able to be occupied over long periods of time. We investigated this for the squirrel glider (*Petaurus norfolcensis*), an arboreal marsupial threatened through part of its geographic range. Squirrel gliders occupied and bred within nest boxes (100% used) at two locations continuously over a 10year period with minimal nest box maintenance. Individuals occupied boxes for up to 7 years. This confirms that targeted nest box programs can be an effective restoration tool for cavity dependent arboreal mammals.

Goulson, D. and L. C. Derwent (2004). "Synergistic interactions between an exotic honeybee and an exotic weed: pollination of *Lantana camara* in Australia." Weed research. 44(3): 195-202.

Goulson, D. and E. L. Rotheray (2012). "Population dynamics of the invasive weed *Lupinus arboreous* in Tasmania, and interactions with two non-native pollinators." Weed Research (Oxford) 52(6): 535-541.

The factors that determine which plant species become invasive weeds are not well understood and there have been few studies of population dynamics in the early stages of invasion. Here, we examine changes in population size, pollinator visitation and seed set of the tree lupin, *Lupinus arboreous*, in Tasmania between 1999 and 2010. *Lupinus arboreous* is a native of California that has become a major environmental weed in New Zealand and Chile, but has not yet become a serious weed in Tasmania. Our data suggest that the main pollinators are honeybees and the bumblebee, *Bombus terrestris*, which invaded in 1992. There was no clear evidence for an impact of the arrival of bumblebees. *Lupinus arboreus* population size increased by 76% between 1999 and 2010, despite weed control programmes. Populations appeared to be unstable; 43% of populations detected in 1999 were extinct by 2010, but this was more than offset by establishment of new populations. Inland populations tended to be smaller and were more likely to go extinct, compared with coastal populations, and some coastal populations had increased fourfold in 11 years. Large populations in 2010 tended to have higher seed set than smaller populations. The overall rate of increase suggests that arboreous may become a major environmental weed in Tasmania. Control of expanding populations is likely to become more difficult if, as we observed, seed set increases with population size.

Goulson, D., et al. (2002). "Do exotic bumblebees and honeybees compete with native flower-visiting insects in Tasmania?" Journal of Insect Conservation 6(3): 179-189.

Honeybees, *Apis mellifera*, have been introduced by man throughout the globe. More recently, other bee species including various bumblebees (*Bombus* spp.) have been introduced to several new regions. Here we examine the impacts of honeybees and the bumblebee, *Bombus terrestris*, on native flower-visiting insects in Tasmania. To assess whether native insects have lower abundance or are excluded in areas that have been colonised by exotic bees, we quantified the abundance, diversity and floral preferences of flower-visiting insects at sites where bumblebees and honeybees were present, and compared them to sites where they were absent. This was achieved by hand searches at 67 sites, and by deploying sticky traps at 122 sites. Honeybees were by far the most abundant bee species overall, and dominated the bee fauna at most sites. There was considerable niche overlap between honeybees, bumblebees and native bees in terms of the flowers that they visited. Sites where bumblebees were established had similar species richness, diversity and abundance of native flower-visiting insects compared to sites where bumblebees were absent. In contrast, native bees were more than three times more abundant at the few sites where honeybees were absent, compared to those where they were present. Our results are suggestive of competition between honeybees and native bees, but exclusion experiments are needed to provide a definitive test.

Gross, C. L. (2001). "The effect of introduced honeybees on native bee visitation and fruit-set in *Dillwynia juniperina* (Fabaceae) in a fragmented ecosystem." Biological Conservation 102(1): 89-95.

The endemic shrub *Dillwynia juniperina* is found in fragmented woodlands on the Northern Tablelands of New South Wales, Australia. The species obligatorily relies on pollinators to effect fruit-set and in this study the effect of fragmentation and the presence of the introduced honeybee on fruit-set was examined at two locations. Over two seasons *Dillwynia juniperina* was not pollen-limited indicating that flowers were saturated with pollen and that adequate bee servicing was occurring. Two native bee species (*Leioproctus* sp. 1 and *Lasioglossum* sp.) and the introduced honeybee, *Apis mellifera* L., were the most common visitors to flowers. Bee abundance varied between sites with honeybees being more common than native bees at one site. Native bees were never the most dominant pollinator. Visitation data show that native bees spend more time at flowers than introduced bees, although on average honeybees visit slightly more flowers on a bush than do native bees. Visitation data also revealed that native bee presence at bushes is negatively correlated with the presence of honeybees at the same bushes. At one of the study sites, honeybees were very abundant, but very few native bees were ever recorded over the 3 years. Results show that flowers can be pollinated from a single visit by a honeybee or native bee. Extrapolation of visitation data

showed that native bees could on their own adequately service flowers in some years at some sites while at other times introduced honeybees may be necessary to augment pollination services.

Gross, C. L., et al. (2010). "Honeybees facilitate the invasion of *Phyla canescens* (Verbenaceae) in Australia – no bees, no seed!" Weed Research 50(4): 364-372.

Several environmental weeds rely on the pollination services of introduced bees. The transfer of this knowledge to weed control management has not been fully explored. In part, this may be because it is difficult to quantify the economic impact of environmental weeds. This diminishes the prospects for expensive research and development required for integrated weed management. In this study, we examine the reproductive ecology of *Phyla canescens*, a species native to South America that is an aggressive agricultural and environmental weed in many parts of the world. We found that *P. canescens* is self-compatible, but not capable of automatic self-pollination. A vector is required to effect seed set. Field studies showed that 45% of seeds produced through open pollination are viable. Using enclosure cages, we showed that non-native *Apis mellifera* L. (honeybee) was the primary floral visitor and pollinator. Honeybee abundance was positively correlated with *P. canescens* abundance. Within the study site of 0.51 ha, almost 500 000 seeds ha−1 would be produced annually, as a result of honeybee pollination. This study shows that a shared evolutionary history is not required for honeybees to be successful pollinators. Facilitation is demonstrated through the obligate need for pollinators and the successful recruitment of the species through seed. Models for the control of feral honeybees in agricultural systems require development

Gross, C. L. and D. Mackay (1998). "Honeybees reduce fitness in the pioneer shrub (Melastomataceae)." Biological Conservation 86(2): 169-178.

The agistment of managed hives of the introduced honeybee, *Apis mellifera*, in or adjacent to conservation areas in Australia is controversial. The effects, if any, of honeybee-foraging on native plants and their native-bee pollinators is poorly understood as most studies to date have concentrated on bird-pollinated systems. Furthermore, such studies have been undertaken in temperate Australia where feral and managed hives have been present for more than 150 years. In tropical Australia the impact of honeybees on the native biota is not known-yet the information is needed to assist with planning for the management of the large areas now under control of conservation authorities. We undertook a comparative study of honeybee and native bee pollination of the pioneer species *Melastoma affine* in tropical north Queensland, Australia, at a site where honeybees were recently introduced as managed hives. *Melastoma affine* is utilised by many animals in this ecosystem and its pollination mechanism is representative of several other pioneer species of the rainforest margin. *Melastoma affine* obligately relies on bee pollination to effect seed-set. Native bees were the most abundant floral visitors to *M. affine* although significantly more honeybees than native bees were sometimes present at flowers at the end of the morning. Honeybees were poor pollinators of *M. affine* compared with native bees. Honeybees deposited significantly less pollen on stigmas than native bees and honeybees actively removed pollen from stigmas. Consequently, fruit-set was less likely, and seed-set was significantly lower in flowers to which honeybees were the last visitor, compared with cases where native bees were the last visitor-and the last visitor to *M. affine* flowers was most often *A. mellifera*. In 91% of interactions between honeybees and native bees, native bees were disturbed from foraging at flowers by honeybees. Honeybees reduced fitness in *M. affine* in this study and we thus conclude that honeybees are an undesirable introduction in montane tropical-rainforest systems in Australia and based on our findings we strongly recommend that honeybees not be agisted in or adjacent to conservation areas in the wet tropics of Australia.

Gross, C. L., et al. (2017). "Unsuccessful introduced biocontrol agents can act as pollinators of invasive weeds: Bitou Bush (*Chrysanthemoides monilifera* ssp *rotundata*) as an example." Ecology & Evolution 7(20): 8643-8656.

The extent of self-compatibility and reliance on pollinators for seed set are critical determinants of reproductive success in invasive plant species. Seed herbivores are commonly used as biocontrol agents but may also act as flower visitors, potentially resulting in pollination. However, such contrasting or potentially counterproductive interaction effects are rarely considered or evaluated for biological control programs. We investigated the breeding system and pollinators of Bitou Bush (*Chrysanthemoides monilifera* ssp. *rotundata*), an invasive species in Australia that has been the subject of biocontrol programs since 1987. We found the species to be obligate outcrossing in all six populations tested. From 150 video hours, we found 21 species of potential pollinators, including Mesoclanis

polana, the Bitou Seedfly, native to South Africa and released in Australia as a biocontrol agent in 1996. *Mesoclanis polana* transferred pollen to stigmas and was the most common pollinator (52% of pollinator visits), followed by the syrphid fly *Simosyrphus grandicornis* (9%) and introduced honeybee, *Apis mellifera* (6.5%). Fruit-to-flower ratios ranged from 0.12 to 0.45 and were highest in the population with the greatest proportion of *Mesoclanis polana* visits. In an experimental trial, outside the naturalized range, the native bee *Homalictus sphecodoides* and the native syrphid *Melangyna viridiceps* were the primary pollinators, and fruit-to-flower ratios were 0.35, indicating that Bitou Bush would have ready pollinators if its range expanded inland. Synthesis. Invasive Bitou Bush requires pollinators, and this is affected by a range of generalist pollinators in eastern Australia including the Bitou Seedfly, introduced as a biocontrol agent, and the major pollinator detected in this study. Fruit-to-flower ratios were highest when the Bitou Seedfly was in high abundance. This study underscores the importance of evaluating the pollination biology of invasive species in their native ranges and prior to the introduction of biocontrol agents.

Hall, M. A., et al. (2019). "The response of wild bees to tree cover and rural land use is mediated by species' traits." Biological Conservation 231: 1-12.

Worldwide, bees have an important role in ecosystem function and the provision of ecosystem services through their role as pollinators. The diversity of bee species in rural landscapes is influenced by the type of landscape features present, and by land-use and management practices. A key challenge is to understand and predict how species vary across the landscape; and the role of functional traits in determining compositional patterns. We systematically sampled wild bees in four types of landscape feature - open farmland, scattered farmland trees, roadside vegetation and streamside vegetation - in rural landscapes in southern Australia. Landscapes were selected to represent wooded or non-wooded combinations of these site types (e.g. roadside vegetation with or without trees), embedded in farmland with different land-uses (e.g. cropping, grazing). The species richness and abundance of bees was greater at sites containing little or no tree cover; and the cumulative richness of species was greater for tree-less sites than for those with trees. In contrast, species evenness was greatest in wooded site types, indicating these were less dominated by abundant generalist species. Open farmland and treeless roadsides had greater functional diversity (based on species traits) than wooded site types. Strong species trait associations were more numerous with open parts of the landscape, reflecting the greater functional diversity of open site types. These results suggest that a suite of the extant bee fauna can exploit large-scale transformation from former extensively wooded ecosystems to open agricultural landscapes. However, not all species are able to exploit modified landscapes and may disappear with further loss of wooded vegetation. Trait-based approaches provide insight into how changes in landscape pattern affect the bee fauna. Failure to adequately cater for multiple functional groups of bees across all landscape features could mean a substantial loss in species that rely on more natural cover, thus affecting ecosystem function.

Hall, M. A. and E. L. Reboud (2019). "High sampling effectiveness for non-bee flower visitors using vane traps in both open and wooded habitats." Austral Entomology 58(4): 836-847.

Many non-bee insects are important for pollination, yet few studies have assessed the effectiveness of sampling these taxa using low-cost techniques, such as coloured vane traps, among different habitat types. This study sampled 192 sites - 108 in wooded and 84 in open habitats - within an agricultural region of southern Australia. Pairs of blue and yellow vane traps were placed at each site for a period of seven days during the austral spring. Overall, 3114 flies (Diptera) from 19 families and 528 wasps (non-bee and non-formicid Hymenoptera) from 16 families were collected during the study. This sampling was representative of the region, with vane traps equally or more likely to collect as many families from both taxa as those reported on the Atlas of Living Australia (ALA) database for the sampling area. Blue vane traps (BVTs) had greater average richness of both flies and wasps and greater activity density (abundance per 7-day sampling period) of individuals than yellow vane traps (YVTs). BVTs were particularly favoured by fly and wasp families known to pollinate flowers (e.g. Syrphidae, Bombyliidae and Scoliidae), whilst YVTs sampled flower visitors that also provide additional ecosystem services, such as pest control and nutrient cycling. Here, vane traps were an effective sampling technique to capture non-bee flower visitors, such as flies and wasps. This study supports the use of vane traps as a component of the sampling protocol for ecological

census and population monitoring within multiple habitat types, where colour attraction will more effectively sample a comprehensive pollinator community.

Heard, T. A. (1994). "Behaviour and pollinator efficiency of stingless bees and honey bees on macadamia flowers." Journal of apicultural research. 33(4): 191-198.

Hermansen, T. D., et al. (2014). "Effects of stand size on pollination in temperate populations of the mangrove *Avicennia marina*." Plant Ecology 215(10): 1153-1162.

Populations of the mangrove *Avicennia marina* in the Sydney region exist as stands of varying size, reflecting both natural and anthropogenic fragmentation. We hypothesised that, as observed in many terrestrial forests, small stands (<100 plants) would experience lower pollinator densities and altered pollinator behaviour and visitation and, in consequence, would display reduced pollen deposition as compared with large stands (>10,000 plants). Nevertheless, we recognise that such predictions may be overly simplistic because within this region A. marina attracts a diversity of flower visitors, but its only significant pollinator is the exotic honeybee *Apis mellifera*. Moreover, it is unclear how readily *A. mellifera* moves among groups of plants within different mangrove stands of varying sizes separated either by water or urban habitat matrix. Our detailed surveys within pairs of large and small stands in two locations support the predictions that pollinator density and pollen deposition are reduced or altered within small stands. Within small stands honeybee abundance and pollen deposition were on average reduced significantly by 84 and 61%, respectively. Moreover, within small stands there was a non-significant 12% increase in the meantime that honeybees spent foraging on individual plants and hence potentially depositing self-pollen. Taken together, our data indicate that fragmentation affects the performance of *A. mellifera* as a pollinator of A. marina and reduce pollinator abundance, leading to pollen limitation in small as compared to large stands, which may negatively affect reproductive output.

Hermansen, T. D., et al. (2015). "Small urban stands of the Mangrove *Avicennia marina* are genetically diverse but experience elevated inbreeding." Estuaries and coasts. 38(6): 1898-1907.

Anthropogenic impacts contribute to the fragmentation of urban mangrove forests, and in the Sydney region of Australia, *Avicennia marina* is commonly found in small stands of <50 adult trees that have altered pollinator services. However, genetic diversity may not vary with stand size because insufficient time has passed since stands were established or pollen and propagule dispersal are sufficient to overwhelm the effects of genetic drift and founder events. We tested the predictions that, despite the potential of mangroves for dispersal of propagules by water and long-distance dispersal of pollen by honeybees, fragmentation and localized foraging by honeybees causes small stands of A. marina to display reduced genetic diversity and elevated inbreeding. Using four microsatellite markers, we quantified the genetic and genotypic diversity present within samples of 20 adults taken from three large (>1500 trees), intermediate (300500 trees) and small (<50 trees) stands within each of two urbanized estuaries and estimated mating system parameters using progeny arrays for sets of five adults within the large and small stands. We detected no significant effect of stand size on levels of single-locus genetic diversity. There were low, although significant, levels of allelic differentiation within (F SE=0.021, P=0.003) and among (F ET=0.055, P=0.005) estuaries but no evidence of isolation by distance. In contrast, our analysis of progeny arrays revealed that, while all stands displayed high levels of biparental inbreeding, an expected consequence of pollination by honeybees, current outcrossing rates (t) were significantly lower in small (0.55) as compared to large (0.75) stands. The genetic makeup of the adult populations imply that stands are interconnected and suggest little impact of habitat fragmentation, while the progeny arrays suggest that plants within small stands may display reduced fitness.

Hingston, A. B. and B. M. Potts (1998). "Floral visitors of *Eucalyptus globulus* subsp. *globulus* in eastern Tasmania." Tasforests 10: 125-139.

Diurnal anthophiles (floral visitors) associated with the flowers of *Eucalyptus globulus* were studied in natural populations in eastern Tasmania, Australia. Seven bird and 71 insect species were recorded. Insect species diversity was dominated by native colletid bees, although the introduced honeybee (*Apis mellifera*) was the

dominant species. Geographical variation occurred in the avian species composition, whereas insect communities appeared to vary temporally and according to flowering intensity. However, insects were rarely observed to contact stigmas and showed little evidence of movement between trees. It is argued that birds, particularly anthophilous Swift parrots (*Lathamus discolor*) and wattlebirds (*Anthochaera* spp.), are likely to be the major diurnal contributors to outcrossing in *E. globulus*. Lists are given of plant species in SE Tasmania studied earlier by Hingston (1997) which share the greatest numbers of species of bird and insect visitors, respectively, with *E. globulus*.

Hingston, A. B. and S. Wotherspoon (2017). "Introduced social bees reduce nectar availability during the breeding season of the swift parrot (*Lathamus discolor*)." Pacific Conservation Biology 23(1): 52-62.

Numerous pollinators are declining across the world. One of these, the swift parrot (*Lathamus discolor*) is a critically endangered Australian bird that feeds largely on the nectar and pollen of Eucalyptus trees. The Swift Parrot Recovery Plan includes competition for food from introduced social bees as a threatening process, although little evidence exists in support of this. Here, we present the strongest evidence yet to support this theory. We examined nectar standing crops in the species of trees that are important to swift parrots during their breeding season, Tasmanian blue gum (*Eucalyptus globulus*) and black gum (*E. ovata*). By comparing the amounts of nectar between flowers exposed to visitors and those bagged to exclude visitors throughout the day, we discovered that introduced honey bees (*Apis mellifera*) and bumble bees (*Bombus terrestris*) consumed most of the nectar and that exposed flowers often contained little nectar. Honey bees were the more common species, but bumble bees had greater per capita rates of nectar consumption. However, at low densities these bees had no effect on standing crops of nectar, and in such situations some nectar could be harvested by managed honey bees without reducing nectar availability for swift parrots. Although this study suggests that introduced social bees may pose a threat to swift parrots, further work is needed to determine whether our results are indicative of the impacts of bees across greater scales of time and space and whether these affect the reproductive success and conservation status of the swift parrot. © 2017 CSIRO.

Hinson, E. M., et al. (2015). "The density of feral honey bee (*Apis mellifera*) colonies in South East Australia is greater in undisturbed than in disturbed habitats." Apidologie. 46(3): 403-413.

Apis mellifera is an important pollinator but is sometimes associated with adverse effects on natural ecosystems. We surveyed pairs of disturbed and undisturbed sites across three biomes in South East Australia. We used pheromone lures to trap drones, genotyped the drones to infer the number of colonies within flight range and then estimated colony densities using synthetic sampling distributions. Estimated colony densities ranged from 0.1 to 1.5 colonies km^{-2} and significantly lower in agricultural land relative to national parks. We suggest that colony density may be lower in disturbed than natural areas due to the reduced availability of nest sites and possibly pesticide usage. Because the number of colonies recommended for adequate pollination is 100–1000 colonies km^{-2}, there are insufficient bees to provide optimal crop pollination in the areas we surveyed.

Holm, E. (1988). "On pollination and pollinators in Western Australia." On pollination and pollinators in Western Australia.

The flowers of 53 plant species observed in Western Australia, mainly Proteaceae, Myrtaceae and Goodeniaceae, are described. Most of the pollinators observed were birds (Meliphagidae, Zosteropidae, Psittacidae) and mammals (Marsupialia, Chiroptera) and some species of these are also described. The morphology of some flowers indicated that they were adapted for insect pollination, but almost no insect pollinators were seen. The final part of the book discusses the adaptations for bird pollination in plants, the role of the honey bee in the ecology of the native flora and fauna, and various evolutionary aspects. There is a list of 115 references and a subject index.

Hooper, S. D. and A. J. M. Hopkins (1983). "Detrimental effects of honey bees on the conservation of native flora and fauna." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 209-209.

Hopper, S. D. (1980). "Bird and mammal pollen vectors in Banksia communities at Cheyne Beach Western Australia." Australian Journal of Botany 28(1): 61-76.

A study of several autumn-flowering plants at Cheyne Beach was undertaken to compare pollen loads of their bird and mammal vectors and to investigate hypotheses concerning adaptations for bird and mammal pollination in Banksia. New Holland honeyeaters [Phylidonyris novaehollandiae], white-cheeked honeyeaters [P. nigra], western spinebills [Acanthorhyncus superciliosus] and honey possums [Tarsipes spenceae] all carried pollen of species of Banksia, Adenanthos, Lambertia (Proteaceae), Beaufortia and Calothamnus (Myrtaceae); southern bush rats [Rattus fuscipes] and house mice [Mus musculus] carried virtually none. Honeyeaters carried significantly larger pollen loads of the Proteaceae species than did honey possums. The honey possums carried the largest loads of Myrtaceae pollen. The loads on honey possums and southern bush rats may have been underestimated because these mammals were live-trapped and may have preened themselves prior to sampling for pollen. The 2 dominant banksias had divergent floral characteristics, some of which were possibly adaptations to either bird or mammal pollination (e.g., straight styles in B. baxteri as against hooked styles in B. occidentalis). Birds and mammals may feed without preference on, and carry the pollen of, both species. The net effect of the divergent characteristics of the 2 banksias was that B. occidentalis transferred more pollen to vertebrate vectors and set more seed per inflorescence than did B. baxteri. Further work is needed to clarify the functional roles and adaptive significance of floral characteristics in these and other banksias.

Hopper, S. D. (1980). "Pollination of the rain forest tree *Syzygium-tierneyanum* Myrtaceae at Kuranda northern Queensland Australia." Australian Journal of Botany 28(2): 223-238.

The identity, abundance and foraging behaviours of the pollinators of the self-compatible mass-flowering tree *S. tierneyanum* were investigated. Species of nectarivorous animals (45) were recorded during 4.5 h of observation at night and 28 h during the day. Diurnal visitors included 7 bird, 9 butterfly, 4 moths (including 2 hawkmoth), 2 bee, 2 ant, 1 wasp, 3 blowfly, 1 fruit fly, 2 beetle and 1 weevil species. Nocturnal visitors included 1 bat and 12 moth (including 3 hawkmoth) species. Floral dimensions were such that only the vertebrate and larger insect species regularly contacted anthers and stigmas while foraging. Of these groups, the feral honey bee (*Apis mellifera*) was the most common flower visitor. Honeyeaters and hawkmoths may be the most important native pollinators; they were abundant in the study area and visited numerous flowers (50-250) in quick succession (1-3 s/flower) on each foraging bout. The only major differences in foraging times observed in the pollinator array were between diurnal, diurnal and crepuscular and nocturnal floral visitors. Spatial partitioning of the nectar resource was limited to 1 instance of territoriality involving a Macleay's honeyeater (*Meliphaga macleayana*) on a densely flowering branch prior to peak blooming time, occasional aggressive chases by honeyeaters and a division of foraging modes into rapid, erratic flights of 0.5-4 m between flowers (hawkmoths) as against nearest-flower movements (all other groups). This lack of major spatial partitioning may have been due to the mass flowering of S. tierneyanum and the resultant superabundance of nectar. The vast majority (about 99.95%) of inter-flower movements observed in foraging bouts of birds (and of hawkmoths) were within the same plant. Most seeds of *S. tierneyanum* may be derived from self-pollination.

Horskins, K. and V. B. Turner (1999). "Resource use and foraging patterns of honeybees, *Apis mellifera*, and native insects on flowers of *Eucalyptus costata*." Australian Journal of Ecology 24(3): 221-227.

Introduced honeybees have become well established throughout Australia and concerns have been raised about their impact on the native flora and fauna. Such concerns include the possible depletion of nectar resources by honeybees to the detriment of native animals and the ability of honeybees to pollinate Australian plants. The foraging patterns and resource utilization of honeybees (*Apis mellifera*) and native insects on flowers of yellow Mallee (*Eucalyptus costata*) (Behr and F. Muell, ex F. Muell.) were studied in Wyperfeld National Park during spring 1994. Seventy-four insect species visited the flowers with the most prevalent being honeybees, native bees (*Lasioglossum* and *Hylaeus*) and ants (*Iridiomyrmex*). Honeybees began foraging at lower temperatures than native bees and hence had initial access to the nectar supply that was primarily produced overnight by *E. costata*. However, the majority (90%) of early morning visits to flowers by honeybees involved the collection of pollen. Honeybees did not forage for nectar in substantial numbers until after native insects were active. Despite both consumption and evaporation, nectar supplies remained available at midday and at one site remained available for consumption at dusk. Honeybees regularly made contact with the receptive stigmata while foraging for pollen and hence had pollen

loads consisting of numerous E. costata grains present on their body. These activities are indicative of the behaviour required by insects to facilitate pollination. Given the unique morphology of many flowers and the contrasting findings from studies to date, it is critical that generalisations about the effect of honeybees in the Australian environment are not made from studies on a limited number of native plant species.

House, S. M. (1989). "Pollen movement to flowering canopies of pistillate individuals of three rain forest tree species in tropical Australia." Australian Journal of Ecology 14(1): 77-94.

This study measured the quantities of effective pollen vectors and their pollen loads arriving at the canopies of dioecious tropical rain forest trees in north-east Queensland. Population flowering synchrony, effective pollinator populations and pollen loads transferred between staminate and pistillate trees were compared among three insect-pollinated tree species. All three were visited by a wide range of insects, 75% of which (mostly 3-6 mm long) carried conspecific pollen. Fewer than 8% of individual insects were found to be carrying single-species pollen exclusively and none could be described as specialist pollen foragers. The introduced honeybee carried greater quantities of pollen than any native species but was not necessarily a reliable pollinator. The brief flowering periods in *Neolitsea dealbata* (3-4 weeks) and *Litsea leefeana* (4-5 weeks) populations were synchronized among individuals. Flowering in the *Diospyros pentamera* population extended over 15 weeks and most individuals were in flower for most of this period. Staminate trees began flowering earlier, produced more flowers and attracted relatively more insects than did pistillate trees, suggesting a density-dependent response of pollinators to flowering performance. Pollen was trapped in greater quantities on insects at staminate trees than at pistillate trees. Insect numbers increased at peak flowering periods and Diptera were the most abundant flower visitors. Anthophilous Coleoptera were more numerous at staminate than at pistillate trees in all three species populations. Larger quantities of pollen were mobilized during peak flowering times although the greatest quantities were transferred to pistillate canopies towards the end of the population flowering periods. Diptera carried pollen more often to pistillate *N. dealbata* and *L. leefeana* trees than did other groups whereas Coleoptera carried pollen more often to pistillate *D. pentamera* trees. The two contrasting flowering performances in the three tree species are discussed with reference to mechanisms that facilitate pollen transfer between staminate and pistillate trees.

Howell, V. and L. K. Jesson (2013). "The effect of bird and bee visitation on pollination and reproductive success in Phormium tenax." New Zealand Journal of Botany 51(3): 194-205.

To study how pollinator composition and abundance influence reproduction of *Phormium tenax*, we compared pollen deposition by bees and birds to unvisited flowers, and plant reproductive success and outcrossing rates in populations on island and mainland sites that vary in bird abundance. Bees deposited pollen on stigmas if stigmas were close to the anthers but deposited little pollen on stigmas of emasculated flowers, suggesting that they are largely depositing self-pollen. Birds deposit pollen on both intact and emasculated flowers with well-exerted stigmas, suggesting they are depositing more outcross pollen. High frequencies of bird claw marks on inflorescences were associated with high fruit set, but not seed set. Seed set and seed outcrossing rates were positively correlated with the number of unique maternal allozyme genotypes in a population and seedlings also showed higher outcrossing rates than seeds, suggesting that genetic diversity, selfing and inbreeding depression limit reproductive success. These results highlight the interplay of pollination and breeding systems in determining plant reproductive success.

Howlett, B. G. and B. J. Donovan (2010). "A review of New Zealand's deliberately introduced bee fauna: current status and potential impacts." New Zealand Entomologist 33: 92-101.

Eight bee species have been deliberately released into New Zealand since the 1830's. The honey bee (*Apis mellifera* L.) was introduced primarily for honey production but has become the most important insect pollinator of seed, vegetable, fruit crops and pastures. The remaining species (*Bombus terrestris* (L.), *B. hortorum* (L.), *B. ruderatus* (F.), *B. subterraneus* (L.), *Megachile rotundata* (F.), *Nomia melanderi* (Cockerell), Osmia coerulescens (L.) were introduced to pollinate either red clover (*Trifolium pratense*) or lucerne (*Medicago sativa*). The honey bee has almost exclusively been relied upon for crop pollination although species of *Bombus* and *M. rotundata* are occasionally used commercially. The spread throughout New Zealand of the varroa mite (*Varroa destructor* Anderson & Trueman), a

parasite that exclusively kills honey bees, has increased the cost of managing honey bee hives. The use of alternative bee species for crop pollination may reduce the potential impact of factors influencing the availability and cost of honey bee pollination services. However, consideration must be given to the potential impact that expanding populations of introduced bees could have on native and exotic flora and fauna. This review examines the current and potential use of the eight deliberately introduced bee species in New Zealand, their distribution, and potential impact on New Zealand's biota.

Howlett, B. G., et al. (2005). "Between and within field variability of New Zealand indigenous flower visitors to onions." New Zealand Plant Protection, Volume 58, 2005. Proceedings of a conference, Wellington, New Zealand, 9-11 August 2005: 213-218.

In New Zealand, few studies have documented the occurrence of indigenous flower visitors within crops. A five-year survey is examining the distribution, diversity and abundance of flower visitors in onion (*Allium cepa*) fields located throughout New Zealand. Day-time observations from the first year of the survey recorded nine arthropod orders visiting onion flowers in the South Island, with Diptera (flies) and Hymenoptera being the most abundant. Over six fields the proportion of bees that were indigenous species (Apoidea) ranged from <1% to 63.6%. Common bee genera and fly families varied considerably in their presence and abundance, even over 17 km. Moreover, counts of *Lasioglossum* spp. at five points within one field ranged from 0 to 576, demonstrating that the distribution of some flower visitors can be highly variable. Understanding crop flower visitors may help develop systems to reduce transgene flow should genetically modified crops be commercially produced in New Zealand.

Howlett, B. G., et al. (2017). "Stigmatic pollen delivery by flies and bees: Methods comparing multiple species within a pollinator community." Basic & Applied Ecology 19: 19-25.

A wide variety of insect species provide pollination services in natural and agricultural ecosystems, but in order to quantify their contribution it is necessary to evaluate their effectiveness. An important component of this is to determine their ability to transfer pollen to stigmas which typically requires observers to wait for insects to visit focal flowers (static approach); a time-consuming process not amenable to obtaining measures for pollinating species of low local abundance. An alternative method (active approach) is to detach test flowers and present them to the targeted flower visitor. This offers a number of advantages (e.g. increased speed and flexibility), but may alter insect behaviour. We compared pollen deposition within flowering onion crops using three bee (Apoidea) and three fly (Diptera) species. The two approaches resulted in similar numbers of pollen grains being deposited onto stigmas for each insect species, thereby supporting the validity of the active as an alternative to the static approach in our test crop. The ability to rapidly assess stigmatic pollen deposition of a broad range of insects using the active approach can greatly assist assessments of pollinator contribution within plant pollinator assemblages.

Howlett, B. G., et al. (2019). "*Bombus terrestris*: a more efficient but less effective pollinator than *Apis mellifera* across surveyed white clover seed fields." New Zealand Journal of Crop and Horticultural Science 47(1): 32-47.

White clover (*Trifolium repens* L.) seed crops require insects for pollination. *Apis mellifera* Linnaeus, 1758 are normally placed within fields but other insects might also be contributing additional pollination. To understand their potential contribution, we evaluated abundances across fields during peak flower; measured loose body pollen on four bee and two fly species and compared the rate of movement between inflorescences and florets for *A. mellifera* and *B. terrestris* (Linnaeus, 1758). *A. mellifera* were the most abundant verified flower visitor, although *B. terrestris* and long-tongued *Bombus* species also visited fields. Other insects recorded included Lasioglossum bees and two hover fly species, but these were considered ineffective pollinators (either low abundances or carried few pollen grains). *B. terrestris* were considered a more efficient pollinator than *A. mellifera* moving faster between florets but were less effective due to low abundances. Many *Bombus* spp. will forage under weather conditions unfavourable to *A. mellifera*, therefore, providing complimentary pollination.

Howlett, B. G., et al. (2009). "Window traps and direct observations record similar arthropod flower visitor assemblages in two mass flowering crops." Journal of Applied Entomology 133(7): 553-564.

Understanding the role of unmanaged arthropod flower visitors as crop pollinators is critical if robust and reliable long-term alternatives are to be found for honey bee pollination. However, data on pollinator assemblages can be scant. Field observation of crop flower visitors is a common data collection technique, but it can be inadequate for species identification and is labour-intensive if used across many sites. Trapping may reduce this problem, but trap performance and sampling consistency over long distances (sites separated by >100 km) are rarely examined. Window traps were designed to collect flower-visiting arthropods from peak-flowering onion (*Allium cepa*) and pak choi (*Brassica rapa* var. chinensis) fields across several regions throughout New Zealand. Trap efficacy was evaluated by comparing trapped samples with observations of flower visiting arthropods during the same trapping period, from dawn (6:00 to 7:00 hours) through to dusk (20:00-21:00 hours) at the same locations. Similar types of larger arthropods (length ≥3 mm) were observed and trapped within both crops, with the hymenopteran genera Apidae, Colletidae and Halictidae and the dipteran families Syrphidae, Calliphoridae, Anthomyiidae, Stratiomyidae, Sarcophagidae, Bibionidae, Tachinidae and Muscidae the most commonly recorded. The total counts of these taxa across fields were strongly correlated between the two methods; however, the ratio of trapped to observed individuals could vary greatly between taxa. Trapping allowed more arthropods to be identified to the species level and also helped record more small arthropods (body length <3 mm) when compared with observation. Window traps can be effective for assessing the relative diversity of flower visitor assemblages and the abundance of specific taxa in specific cropping systems at the regional scale, but variation in trap efficiency between arthropod taxa must be assessed for a true measure of assemblage composition. © 2009 Blackwell Verlag, GmbH.

Hurst, P. S., et al. (1997). "Increased nest cofounding and high intra-colony relatedness in the bee *Exoneura bicolor* (Hymenoptera: Apidae): Results from an experimental situation." Australian Journal of Ecology 22(4): 419-424.

Identifying differences in a key social trait between two populations of the same species is important for understanding the evolution of sociality. Previous studies of new colonies in *Exoneura bicolor*, an Australian allodapine bee, have shown that there are high levels of kin cofounding in a montane population. The only study to examine intra-colony relatedness in a heathland population has found that new multifemale colonies are not formed by kin. In this study we used an experiment to investigate both cofounding behaviour and intra-colony relatedness in *E. bicolor* from a heathland population. Nest substrate was placed either 0.05 or 1 m distant from source nests in a novel environment. Although there were no differences in cofounding rate or intra-colony relatedness between the two treatments there was, overall, a high rate of cofounding: 53% of new nests were multifemale, approximately twice as high as found in previous field-based studies. Relatedness among cofoundresses was not only different from zero, r plus or minus SE = 0.597 plus or minus 0.097, but almost identical to that found in montane populations. A constraint, such as nest substrate distribution, is suggested as a proximate factor affecting the expression of cofounding behaviour in *E. bicolor*. The implication of such proximate constraints for inferring the phylogenetic origins of social behaviour is discussed.

Huryn, V. M. and H. Moller (1995). "An assessment of the contribution of honey bees (*Apis mellifera*) to weed reproduction in New Zealand protected natural areas." New Zealand Journal of Ecology, 19 (2) pp. 111-122, 1995.

Huryn, V. M. B. (1997). "Ecological impacts of introduced honey bees." Quarterly Review of Biology 72(3): 275-297.

Honey bees (*Apis mellifera* L.), native to Eurasia and Africa, have been introduced to most of the rest of the world. Many plant species are used by introduced honey bees, which suggests a high potential for disturbance of native plant/pollinator relationships. Few species are used intensively, however, thus decreasing the opportunity for disturbance. Pollination studies show that honey bees are effective pollinators of some native plants and less effective pollinators of others; they also reduce floral resources in some species with little or no pollination. Data are insufficient to show whether honey bee foraging on native plants significantly alters pollen and gene flow, but unusual foraging behaviour by honey bees is not evident compared to many other pollinators. Honey bees do not physically damage plants; they are also unlikely to increase hybridization of native flora. Pollination by honey bees probably contributes little to the success of most weeds. Experiments have not shown competition for nesting sites between honey bees and native fauna. The presence of honey bees, however, alters the foraging behaviour and abundance of some native fauna on flowers, but not studies have shown detrimental impacts of honey bees on

population abundance of any native animals or plants. Anecdotal and quantitative reports of increased honey bee abundances on flowers compared with native fauna are often confounded with habitat changes induced by men.

Iwasaki, J. M., et al. (2018). "Floral usage partitioning and competition between social (*Apis mellifera*, *Bombus terrestris*) and solitary bees in New Zealand: Niche partitioning via floral preferences?" Austral Ecology 43(8): 937-948.

Worldwide, studies of interactions between introduced and native bees have produced contradictory evidence regarding the potential for competition. Different resource requirements and the impact of tongue length on resource use are often overlooked aspects of these studies. Here, we examine floral resource use and niche overlap between introduced social bees and native solitary bees over two flowering seasons on The Remarkables mountain range, South Island, New Zealand. The native bee fauna of New Zealand is composed of short-tongued solitary bees in the families Colletidae and Halictidae. Long-tongued social bees were introduced 150 years ago, and *Apis mellifera* and *Bombus* species are now widespread. We analysed floral resource utilization by introduced bees (mainly *Bombus terrestris*) and native bees in relation to resource abundance across elevations in montane to alpine grassland communities. We modelled resource utilization and overlap between bee taxa using a novel index of floral resource availability, developed to more accurately describe floral density. Additionally, we sought to quantify the impact of honey bees by introducing hives, however, low densities in study plots prevented direct conclusions from being drawn. Native and introduced bees did, however, have distinctly different floral preferences over the flowering season with more niche overlap within, rather than between, native and introduced groups. Introduced bees showed a preference for introduced species in the family Fabaceae which native bees could not access. Native bees heavily utilized introduced Asteraceae as well as native floral resources that introduced bees did not prefer. The limited resource overlap between bee taxa indicated that bee communities in New Zealand may have reduced potential for competition, owing to the different resource requirements of solitary versus social bees and their differing abilities to access floral resources. These findings provide some potential explanations for contradictory evidence worldwide regarding the perceived detrimental impacts of introduced social bees.

Johanson, L. G., et al. (2019). "Bees of the Victorian Alps: Network structure and interactions of introduced species." Austral Ecology 44(2): 245-254.

Bees are considered the most important plant pollinators in many ecosystems, yet little is known about pollination of native plants by bees in many Australian ecosystems including the alpine region. Here we consider bee pollination in this region by constructing a bee visitation network and investigating the degree of specialism and network nestedness', which are related to the robustness of the network to perturbations. Bees and flowers were collected and observed from 10 sites across the Bogong High Plains/Mt Hotham region in Victoria. Low nestedness and a low degree of specialism were detected, consistent with patterns in other alpine regions. Twenty-one native and one non-indigenous bee species were observed visiting 46 of the 67 flower species recorded. The introduced *Apis mellifera* had a large floral overlap with native bees, which may reduce fecundity of native bees through competition. The introduced plant, Hypochaeris radicata (Asteraceae), had the largest and most sustained coverage of any flower and had the most visitations and bee species of any flower. The network developed in this study is a first step in understanding pollination patterns in the alpine/subalpine region and serves as a baseline for future comparisons.

Johnson, B., et al. (2020). "Non-native plants and nitrogen addition have little effect on pollination and seed set in 3-year-old restored woodland." Austral Ecology 45(8): 1156-1168.

Human activities can disrupt the insect pollination process, which can trigger a decline in pollination and plant reproductive output. Floral visitors are not equally effective pollinators, and it is unknown how multiple changes to an environment further change the effectiveness of insect pollination for native plants. We investigated how herbicide treatment, the presence of non-native plants and addition of nitrogen fertiliser change the relative importance of different species of floral visitors to four native plant species: *Callistemon phoeniceus*, *Calothamnus quadrifidus*, *Hakea lissocarpha* and *Banksia sessilis*. Our field site was a large-scale revegetation site in south-west Western Australia in which the presence of non-native plants and nitrogen deposition were experimentally manipulated. Experimental exclusion of floral visitors revealed pollinators were likely required for the seed set of

three of the native species, and none of the four plant species were pollen limited. We observed 8936 floral visitors of 249 morphospecies from 14 insect orders on four native and two non-native plant species. From PIV calculations, 57% of floral visitors were potential pollinators, with the remainder considered just visitors due to their low Pollinator Importance Value (PIV). The introduced *Apis mellifera* (European honey bee, Apidae) was the most frequent floral visitor and the most effective pollinator of all four native plant species. The presence of two non-native plant species and addition of nitrogen fertiliser did not affect the effectiveness of the potential pollinators, or the viable seeds produced by the four native plant species. © 2020 Ecological Society of Australia

Johnstone, R. E. and T. Kirkby (2007). "Feral European honey bees: A major threat to Cockatoos and other tree hollow users." Western Australian Naturalist 25(4): 252-254.

Jones, W. A. (1996). ""To bee or not to bee": honey-bees in the Australian environment." Australasian beekeeper 98(1): 29-34.

The important current and potential benefits of a stable beekeeping industry in New South Wales are set out. However, the increasing restriction of access to forest areas is considered to be a threat to the long-term viability of beekeeping and agriculture. It is hoped that the National Parks and Wildlife Service will reconsider its policy of restricting access by beekeepers to conserved areas.

Keith, D. (2017). "The decline of Melliferous native flora for European honey bees in Queensland - some reflections." Proceedings of the Royal Society of Queensland 122: 35-43.

Ladd, P. G. and S. J. Wooller (1997). "Explaining variation in pollination and seed set in an andromonoecious genus of the Proteaceae." Proceedings of the 7th International Symposium on Pollination, Lethbridge, Alberta, Canada, 23-28 June 1996.: 115-120.

The genus *Stirlingia* comprises 7 shrub species, endemic to Western Australia, which are unusual in the Proteaceae in that they have inflorescences with male and hermaphrodite flowers. Virtually all hermaphrodite flowers produce a fruit, although seed set is variable. Observations and experiments on 3 species showed that although *S. latifolia* was foraged on by pollen-collecting honey bees (*Apis mellifera*), it was wind-pollinated. The low pollen:ovule ratio in *S. tenuifolia* indicates that this species is entomophilous, and *S. simplex* may be pollinated by insects and/or wind, but no insect visitors were observed on these 2 species.

Lomov, B., et al. (2010). "Pollination and plant reproductive success in restored urban landscapes dominated by a pervasive exotic pollinator." Landscape & Urban Planning 96(4): 232-239.

Although insect pollination is fundamental to the persistence of plants in restored habitats, it is rarely taken in to account in evaluations of restoration success. We evaluated a recovery of interactions between the insect-pollinated shrub *Dillwynia sieberi* and its pollinator assemblage dominated by exotic honeybee *Apis mellifera* in 5-year-old revegetated pastures and remnants of endangered Cumberland Plain Woodland (the aim of revegetation) in Sydney, Australia. We examined plant size, plant flower density, flower visitation rates by insects, counts of pollen per stigma and presence/absence of germinated pollen, fruit and seed set ratios and rates of pre-dispersal seed predation. Flower densities on plants in restored areas were significantly higher than in forest remnants. Bees were the most common flower visitors. Plants in revegetated areas attracted significantly more flower visitors with visitor assemblages usually dominated by *A. mellifera*. Plants in revegetated areas had similar numbers of flowers per inflorescence, while fruit and seed set per inflorescence was significantly higher in forest remnants. There was no significant difference in the rates of pre-dispersal seed predation. Plants in revegetated areas and forest remnants had similar seed output with no apparent negative effect of *A. mellifera* on seed production. Restoration of native vegetation in an urban context is a challenging long-term process. However, introduction of dominant plant species can foster a rapid return of their pollinators. The interactions between the plants and their native pollinators were resilient to pervasive exotic *A. mellifera*, and plants in restored ecosystems had an adequate reproductive output. (C) 2010 Elsevier B.V. All rights reserved.

Low, T. (1996). "Land of nectar." Nature Australia 25(5): 20-20.
Features nectarivores in Australia. Proliferation of honey plants in the region; Role of bird-pollination in the evolution of Australia as a distinct continent; List of bird-pollinated flowers.

Luck, G. W., et al. (2014). "Interactions between almond plantations and native ecosystems: Lessons learned from north-western Victoria." Ecological Management & Restoration 15(1): 4-15.
Five years of research on interrelationships between fauna use of almond plantations and native vegetation in north-western Victoria shows that almond plantations have a strong influence on fauna dynamics and in some cases may provide important habitat for threatened species.

Macfarlane, R. P. (1980). "Bees, bee forage and pollination on the Chatham Islands." New Zealand beekeeper. 41(1): 5-6.

Maclaren, P. (1984). "Trees and bees." New Zealand beekeeper(181): 24-25.
Wood for hives, trees for pollen and nectar

Mallick, S. A. and M. M. Driessen (2009). "Impacts of hive honeybees on Tasmanian leatherwood *Eucryphia lucida* Labill. (Eucryphiaceae)." Austral ecology. 34(2): 185-195.
Despite honeybees (*Apis mellifera* L.) occurring as a feral and commercially managed species in many parts of Australia, the effects of honeybees on native Australian ecosystems are poorly understood. We examined the impacts of honeybee apiaries on Tasmanian Leatherwood *Eucryphia lucida* Labill. (Eucryphiaceae) by comparing commercial apiary sites with control sites >2 km from the nearest apiary. Feral honeybees were common at control sites (73% of honeybees feral) but were scarce at apiary sites (2%), and hive honeybees appeared to be competitively displacing feral honeybees near apiaries. Visit rates by native insects appeared to be un-affected by the increased numbers of hive honeybees near apiaries. Standing crops of nectar sugar were significantly depressed at apiary sites. Pollen was rapidly removed from flowers at apiary sites resulting in full separation of the male and female flower-phases (flowers completely dichogamous). In contrast, at control sites, pollen tended to remain in flowers into the female phase (flowers partially dichogamous). There was no difference in the total number of pollen grains deposited on stigmas or in percentage seed set among apiary and control sites. However, fruit set was elevated at apiary sites, possibly owing to reduced autonomous (within-flower) selfing. Our study indicated that honeybees significantly reduce floral resources (nectar and pollen) around apiaries, although any competitive effects on native insects may have been obscured by large variation in the abundance of native insects among experimental sites.

Manning, R. (1997). "The honey bee debate: A critique of scientific studies of honey bees *Apis mellifera* and their alleged impact on Australian wildlife." Victorian Naturalist (Blackburn) 114(1): 13-22.
Six factors - the nectar resource and use by Honey Bees, poor knowledge of the biology of native fauna, bee predation by birds, resource utilisation by commercial beehives on apiary sites, mutual exclusion of apiary sites where buffer zones exist and environment - are discussed in this paper which I believe could influence or cause the interactive effects between Honey Bees and wildlife which appear to have been demonstrated by published research results. The conclusion reached is that there is no conclusive proof that Honey Bees have a significant effect on wildlife and that any interaction which can be found could arguably be a normal reaction in a complex ecosystem that has its primary food source as nectar and pollen. After 170 years some form of equilibrium has probably been reached.

Markwell, T. J., et al. (1993). "Competition between honey bees (*Apis mellifera*) and wasps (Vespula spp.) in honeydew beech (*Nothofagus solandri* var. *solandri*) forest." New Zealand Journal of Ecology 17(2): 85-93.
Honeydew of the scale insect *Ultracoelostoma brittini* is an important food source in black beech (*Nothofagus solandri*) forests in the South Island of New Zealand. Two of the most prominent foragers of honeydew are honey bees (*Apis mellifera*) and wasps (*Vespula germanica* and *V. vulgaris*). Observations in the field and using an

experimental hive were used to investigate competition between bees and wasps feeding on honeydew. In laboratory trials, interference competition was often strong, and many cases of aggression were noted. In the forest, there was invariably enough room on the trees for bees and wasps to feed while rarely encountering one another. Over the whole year, environmental variables (especially low temperatures and rain) were found to constrain honey bee foraging to a greater degree than competition with wasps. Because the competition that did occur was primarily exploitation competition, reciprocal effects were likely to be felt. At Coopers Creek, bees may be reducing wasp densities, compared with the situation in Nelson-Marlborough where commercial hives are scarce.

Milner, J. R. D., et al. (2020). "Plant evolution can mediate negative effects from honey bees on wild pollinators." Ecology and Evolution 10(10): 4407-4418.

Pollinators are introduced to agroecosystems to provide pollination services. Introductions of managed pollinators often promote ecosystem services, but it remains largely unknown whether they also affect evolutionary mutualisms between wild pollinators and plants. Here, we developed a model to assess effects of managed honey bees on mutualisms between plants and wild pollinators. Our model tracked how interactions among wild pollinators and honey bees affected pollinator and plant populations. We show that when managed honey bees have a competitive advantage over wild pollinators, or a greater carrying capacity, the honey bees displace the wild pollinator. This leads to reduced plant density because plants benefit less by visits from honey bees than wild pollinators that coevolved with the plants. As wild pollinators are displaced, plants evolve by increasing investment in traits that are attractive for honey bees but not wild pollinators. This evolutionary switch promotes wild pollinator displacement. However, higher mutualism investment costs by the plant to the honey bee can promote pollinator coexistence. Our results show plant evolution can promote displacement of wild pollinators by managed honey bees, while limited plant evolution may lead to pollinator coexistence. More broadly, effects of honey bees on wild pollinators in agroecosystems, and effects on ecosystem services, may depend on the capacity of plant populations to evolve.

Moezel, P. G. v. d., et al. (1987). "Pollen selection by honeybees in shrublands of the Northern Sandplains of Western Australia." Journal of apicultural research. 26(4): 224-232.

Moller, H. (1996). "Lessons for invasion theory from social insects." Biological Conservation 78(1-2): 125-142.

Reproductive and dispersal modes of social insects mean that fundamentally different models may be required for predicting determinants of their invasions from those for sexually reproducing non-social animals or non-insects. This suggests that it is unrealistic to expect the same predictors of invasiveness will apply to all biota. Many species of social wasps, bees and ants are extraordinarily invasive. The main general advantage promoting invasiveness of social insects may be the flexibilities arising from having both individual and colony responses that enable them to withstand biotic resistance and to better match conditions in the receiving community. Social insect invasion case studies have revealed strong evidence for biotic resistance to invasions in some instances. Intercorrelated species characters and ecological variations in different disturbance regimes, regions, habitats and community histories hamper further advances in the understanding of invasion biology from comparing invasive and non-invasive species. Mole incorporation of models of conservation biology, community ecology and genetics may assist invasion biology. Experimentally designed release programmes and detailed follow-up studies of biological control agents could greatly assist the quest for better invasion models. More prolonged invasion case studies, where the underlying mechanisms of invasion are researched, and experimental manipulations are the best way that a more robust and predictive theory of invasions can be generated. Social insects provide splendid opportunities for such research. Copyright (C) 1996 Elsevier Science Limited

Murphy, C. and A. Robertson (2000). "Preliminary study of the effects of honey bees (*Apis mellifera*) in Tongariro National Park." Science for Conservation(139): 1-18-pp.

A study of the effects of *A. mellifera* in Tongariro National Park was conducted during the summers of 1993-1994 and 1994-1995. Three possible effects of the introduced honey bee were examined. Firstly, honeybee impact on the reproductive success of heather, an important weed species in Tongariro National Park, was examined. Insect

visitation rates on heather flowers were low at each of the 4 study sites within the park. Bagging plants to exclude flower visitors had little effect on the level of seed set. The potential of other pollen vectors, wind and Thripidae, as pollinators of *Calluna vulgaris* was also examined. None of these vectors significantly effected the amount of viable seed production and so it was concluded that heather is capable of autonomous self-pollination. The second part of the study examined the impact of honey bees on the pollination systems of flax. *Phormium tenax* is thought to be predominately bird pollinated, but the floral resources are also utilized by a variety of native and introduced insect species including honey bees. Fruit and seed set was significantly higher at sites with bird visitation. It is also suggested that flax has a flexible pollination system that enables it to maintain a range of fruit and seed set levels under different pollinator regimes. In the third study, competition between native flower visitors and honey bees was examined for two common alpine shrubs, *Leptospermum scoparium* and *Hebe stricta*. The abundance and diversity of insect visitors varied considerably between sites, and between observational periods. Some of this variation may be ascribed to differences in the weather or to altitude. However, the abundance and diversity of *Diptera* appeared to also be strongly negatively influenced by levels of honey bee activity. This indicates that honey bees do play a role in determining the structure of pollinator communities and may be a threat to local biodiversity.

Nash, M. A. (2013). "Alien invertebrates are invading the Australian Alps." Victorian Naturalist (Blackburn) 130(3): 127-136.

In temperate ecosystems, invasive alien species pose a major threat to species diversity. The first step in understanding likely ecological consequences of invasive species is to record new distributions. Three invertebrate species likely to affect Australian alpine and subalpine ecosystems are recorded for the first time above 1500 m ASL from the Victorian Alps: European Honey Bee *Apis mellifera* L., Grey Field Slug *Deroceras reticulatum* Muller, and European Wasp *Vespula germanica* (F.). Single records of other invasive alien species are mentioned but not explored. I present a simple online tool that is commonly used to model the distribution of species. Results show the value of extensive sampling, naturalist records and the need for reliable species distribution data. Building ecological models that can predict the likely consequences of invasive species is reliant on continual updating of historical species distribution records.

New, T. R. (1997). "Significance of honey bees in the Australian environment: Setting the scene." Victorian Naturalist (Blackburn) 114(1): 4-7.

Newstrom-Lloyd, L., et al. (2013). "Planting trees for bees." New Zealand Tree Grower 34(1): 18-20.

Planting trees for bees has become a topical issue in New Zealand. Security of pollination services has become a major concern for domestic and export markets and work is needed to protect pollination. This is especially important as our most important agricultural pollinator is the honey bee. The Trees for Bees programme was set up to look at bee pollinator security because a lack of pollen is an increasingly urgent problem on farms, and it has a simple solution.

Noble, A. S., et al. (2020). "A core phyllosphere microbiome exists across distant populations of a tree species indigenous to New Zealand." PLoS One 15(8): e0237079-e0237079.

The phyllosphere microbiome is increasingly recognised as an influential component of plant physiology, yet it remains unclear whether stable host-microbe associations generally exist in the phyllosphere. *Leptospermum scoparium*(manuka) is a tea tree indigenous to New Zealand, and honey derived from manuka is widely known to possess unique antimicrobial properties. However, the host physiological traits associated with these antimicrobial properties vary widely, and the specific cause of such variation has eluded scientists despite decades of research. Notably, the manuka phyllosphere microbiome remains uncharacterised, and its potential role in mediating host physiology has not been considered. Working within the prevailing core microbiome conceptual framework, we hypothesise that the phyllosphere microbiome of manuka exhibits specific host association patterns congruent with those of a microbial community under host selective pressure (null hypothesis: the manuka phyllosphere microbiome is recruited stochastically from the surrounding environment). To examine our hypothesis, we characterised the phyllosphere and associated soil microbiomes of five distinct and geographically distant manuka

populations across the North Island of New Zealand. We identified a habitat-specific and relatively abundant core microbiome in the manuka phyllosphere, which was persistent across all samples. In contrast, non-core phyllosphere microorganisms exhibited significant variation across individual host trees and populations that was strongly driven by environmental and spatial factors. Our results demonstrate the existence of a dominant and ubiquitous core microbiome in the phyllosphere of manuka, supporting our hypothesis that phyllosphere microorganisms of manuka exhibit specific host association and potentially mediate physiological traits of this nationally and culturally treasured indigenous plant. In addition, our results illustrate biogeographical patterns in manuka phyllosphere microbiomes and offer insight into factors contributing to phyllosphere microbiome assembly.

Ogilvie, J. E., et al. (2009). "Pollination biology of the sclerophyllous shrub *Pultenaea villosa* Willd. (Fabaceae) in southeast Queensland, Australia." Plant Species Biology 24(1): 11-19.

The pollination biology of the common shrub *Pultenaea villosa* Willd. was examined in a subtropical dry sclerophyll forest in eastern Australia. We determined floral phenology and morphology, the timing of stigma receptivity and anther dehiscence, nectar availability, the plant breeding system, and flower visitors. The shrub's flowers are typical zygomorphic pea flowers with hidden floral rewards and reproductive structures. These flowers require special manipulation for insect access. A range of insects visited the flowers, although bees are predicted to be the principle pollinators based on their frequency on the flowers and their exclusive ability to operate the wing and keel petals to access the reproductive structures. Nectar and pollen are offered as rewards and were actively collected by bees. Nectar is offered to visitors in minute amounts at the base of the corolla. In Toohey Forest, *P. villosa* flowers in spring and is the most abundant floral resource in the understory of the forest. The breeding system experiment revealed that *P. villosa* requires outcrossing for high levels of seed set and that the overlap of stigma receptivity and pollen dehiscence within the flower suggests the potential for self-incompatibility.

Oldroyd, B. P., et al. (1994). "Do feral honey-bees (Apis *mellifera*) and regent parrots (*Polytelis anthopeplus*) compete for nest sites." Australian Journal of Ecology 19(4): 444-450.

Surveys of nesting sites of feral honey bees (*Apis mellifera*) and regent parrots (*Polytelis anthopeplus*) were made in the red gum/black box woodlands of Wyperfeld National Park, Victoria, Australia. Data on tree species and size, and number of hollows were collected from all trees within seven 500 X 100 m plots. Nest site characteristics were quantified for both bees and parrots. We found 27 feral honey bee colonies, suggesting a density of 77.1 colonies per km(2). The average occupation rate for bees was 1.3% of trees and 0.7% of available hollows. The height, aspect and entrance characteristics of honey bee nests at Wyperfeld were not qualitatively different to those reported elsewhere. We found 15 pairs of nesting regent parrots. Nest sites chosen by these birds overlapped those chosen by honey bees, but 52% of bee nests were in cavities unsuitable for regent parrots. We suggest that honey bee population growth may be limited in the park by a lack of water.

Oldroyd, B. P., et al. (1997). "Population demography of Australian feral bees (*Apis mellifera*)." Oecologia. 111(3): 381-387.

Paini, et al. (2005). "No short-term impact of honey bees on the reproductive success of an Australian native bee." Apidologie 36(4): 613-621.

The European honey bee was introduced to Australia 180 years ago and feral populations now occupy most coastal environments. Although much debate has taken place regarding the possible impact of honey bees on Australian native bees, there has been little direct research. This study presents the results of a replicated Before-After Control-Impact (BACI) experiment simulating the putative impact of feral honey bees on an undescribed species of Australian solitary bee (Megachile sp. M323/F367). Although a large resource overlap occurred between the two species, there was no significant change in the reproductive success of the native bee. The realised precision of the experiment was assessed and showed appropriate sensitivity for three important reproductive variables. The native bee, being better adapted to the high summer temperatures experienced during the period of this experiment, may be able to withstand honey bee competition.

Paini, D. R. (2004). "Impact of the introduced honey bee (*Apis mellifera*) (Hymenoptera: Apidae) on native bees: A review." Austral Ecology 29(4): 399-407.

Interspecific competition for a limited resource can result in the reduction of survival, growth and/or reproduction in one of the species involved. The introduced honey bee (*Apis mellifera* Linnaeus) is an example of a species that can compete with native bees for floral resources. Often, research into honey bee/native bee competition has focused on floral resource overlap, visitation rates or resource harvesting, and any negative interaction has been interpreted as a negative impact. Although this research can be valuable in indicating the potential for competition between honey bees and native bees, to determine if the long-term survival of a native bee species is threatened, fecundity, survival or population density needs to be assessed. The present review evaluates research that has investigated all these measurements of honey bee/native bee competition and finds that many studies have problems with sample size, confounding factors or data interpretation. Guidelines for future research include increasing replication and using long-term studies to investigate the impact of both commercial and feral honey bees.

Paini, D. R. and J. D. Roberts (2005). "Commercial honey bees (*Apis mellifera*) reduce the fecundity of an Australian native bee (*Hylaeus alcyoneus*)." Biological Conservation 123(1): 103-112.

European honey bees used for commercial honey production represent a potential source of competition for floral resources with native nectar and pollen feeding insects. This study reports the results of an experiment run over two years on the impact of commercial honey bees on the fecundity of a solitary native bee, Hylaeus alcyoneus. Registered apiary sites were used as treatment sites (with honey bees) while control sites (without honey bees) were interspersed between. The fecundity of *H. alcyoneus* was measured using trap nests. We compared the number of nests produced, number of eggs per nest and emerging progeny mass of H. alcyoneus in sites with and without commercial bee hives. The number of nests produced by *H. alcyoneus* was 23% less (Wilcoxon's T) at treatment sites than control sites. Analysis of individual measurement intervals using ANOVA was compromised by a general lack of power. This result highlights that even though honey bees have been present in certain areas for many years, competition with native bees may still be occurring.

Patel, V., et al. (2020). "Using a social-ecological system approach to enhance understanding of structural interconnectivities within the beekeeping industry for sustainable decision making." Ecology & Society 25(2): 24

The social-ecological system framework (SESF) is a comprehensive, multitiered conceptual framework often used to understand human-environment interactions and outcomes. This research employs the SESF to understand key interactions within the bee-human system (beekeeping) through an applied case study of migratory beekeeping in Western Australia (WA). Apiarists in WA migrate their hives pursuing concurrent flowering events across the state. These intrastate migratory operations are governed by biophysical factors, e.g., health and diversity of forage species, as well as legislated and negotiated access to forage resource locations. Strict biosecurity regulations, natural and controlled burning events, and changes in land use planning affect natural resource-dependent livelihoods by influencing flowering patterns and access to valuable resources. Through the lens of Ostrom's SESF, we (i) identify the social and ecological components of the WA beekeeping industry; (ii) establish how these components interact to form a system; and (iii) determine the pressures affecting this bee-human system. We combine a review of scholarly and grey literature with information from key industry stakeholders collected through participant observation, individual semi structured interviews, and group dialog to determine and verify first-, second-, and third-tier variables as SESF components. Finally, we validate the identified variables through expert appraisal with key beekeepers in the industry. Our results identify the governance system, actors, resource system, and resource units comprising the beekeeping industry in WA. Using this approach, we identify three principal system pressures including access to apiary sites, burning of forage, and climate change impacts on the system, which influence the SES and its sustainability. Our approach provides for an improved understanding of SES complexities and outputs that should be used to support improved sustainable management of common pooled resources to ensure effective pollination and sustained apiary production.

Paton, D. C. (1993). "Honeybees in the Australian environment." BioScience 43(2): 95-103.

Provides an overview of the interactions between honeybees and the Australian biota by describing some of the research results. It is pointed out where further research is required and outlines possible strategies for the management of honeybees in the Australian environment. The plants and animals that interact with honeybees; Consumption of floral resources by honeybees; Management of honeybees in the environment.

Paton, D. C. (1993). "Honeybees in the Australian environment: does *Apis mellifera* disrupt or benefit the native biota?" BioScience - American Institute of Biological Sciences. 43(2): 95-103.

Paton, D. C. (1997). "Honey bees *Apis mellifera* and the disruption of plant-pollinator systems in Australia." Victorian Naturalist (Blackburn) 114(1): 23-29.

Honey Bees *Apis mellifera* visit the flowers of a wide variety of Australian plants harvesting nectar, and pollen. Depending on the plant species they may consume 80-90% of the floral resources, displace native pollinators and alter rates of pollination. These interactions are illustrated for several predominantly bird-pollinated plants. For Scarlet Bottlebrush *Callistemon rugulosus*, seed production decreased when Honey Bees displaced birds from flowers, and the removal of pollen from the flowers of Common *Correa reflexa* by Honey Bees reduced the quantities of pollen subsequently dispersed by birds. In Ngarkat Conservation Park natural rates of seed production by Desert *Banksia ornata* were severely pollinator limited. When Honey Bees were introduced to this reserve seed production for *Banksia ornata* was enhanced. These studies illustrate the dilemma in managing Honey Bees in areas set aside for conservation in that some plants and animals are likely to suffer if Honey Bees remain in a reserve while others are likely to suffer if Honey Bees are excluded.

Paton, D. C. (2000). "Disruption of bird-plant pollination systems in Southern Australia." Conservation biology : the journal of the Society for Conservation Biology. 14(5): 1232-1234.

Paton, D. C., et al. (1999). "Impact of commercial honeybees on flora and fauna in Ngarkat Conservation Park."

Paton, D. C. and V. Turner (1985). "Pollination of *Banksia ericifolia* Smith: birds, mammals and insects as pollen vectors." Australian Journal of Botany 33(3): 271-286.

Banksia ericifolia growing in coastal heath in eastern Australia set fruit after cross-pollination but not after controlled self-pollination. Nectar and pollen were collected by visitors during the day but not overnight. Honeybees and birds (Meliphagidae, Zosteropidae) visited flowers frequently, carried pollen on their body surfaces and were likely to transfer pollen between plants. Native bees, nocturnal moths and ants also visited flowers but did not appear to be important pollinators. No mammals were seen visiting flowers. Exclusion experiments confirmed that pollination occurred during the day, but they were insufficient to determine the relative importance of honeybees and birds as pollinators. Only 3% of *B. ericifolia* flowers developed follicles under natural conditions. Since multiple cross-pollination did not increase follicle production, it was concluded that resources rather than pollinators were the limiting factor.

Patterson, R. W. and A. Bach (1968). "Contrasting land use reflected in pollen grain content of honeys from two Tasmanian districts." Australasian beekeeper 70(3): 76-77.

Pearson, W. D. and V. Braiden (1990). "Seasonal pollen collection by honeybees from grass/shrub highlands in Canterbury, New Zealand." Journal of apicultural research. 29(4): 206-213.

Prider, J. N., et al. (2011). "Multispecies interactions among a plant parasite, a pollinator and a seed predator affect the reproductive output of an invasive plant, *Cytisus scoparius*." Austral ecology. 36(2): 167-175.

Interactions between species pairs are almost always mediated by interactions with other species. The outcomes of these multispecies interactions are often difficult to predict and are rarely studied. In addition to their

theoretical importance, multispecies interactions are also important for management situations. Where multiple agents are used to control invasive species, interactions between agents may either enhance or reduce the impacts on the target species, or may simply have additive effects. In this study, conducted in a Mediterranean-type woodland in Australia, we examined how the interaction between an invasive legume, Cytisus scoparius (Leguminosae), its pollinator, *Apis mellifera* and a seed predator, *Bruchidius villosus* (Bruchidae), are modified by a native hemi parasitic vine, *Cassytha pubescens* (Loranthaceae). The parasite had a direct negative effect on *C. scoparius*, reducing flowering by 50% and consequently fruit and seed production. Despite having fewer flowers, infected plants had the same proportion of tripped' flowers, an indirect measure of pollinator visitation, as uninfected plants; although fruit formed on infected plants it was more likely to abort prematurely. Seed predation by B. villosus was lower on parasite-infected *C. scoparius* plants than in uninfected plants. Although *C. pubescens* had an antagonistic effect on *B. villosus*, in consort, the two agents reduced overall seed production by an average of 62%. The acquired parasite Ca. pubescens was more effective in reducing reproductive output than the introduced seed predator, *B. villosus*, and shows potential as a biocontrol agent for *C. scoparius*. We documented a sub additive effect of two biological enemies on the invasive species, where the acquired parasite had a stronger effect than the introduced seed predator.

Pyke, G. H. (1999). "The introduced Honeybee *Apis mellifera* and the Precautionary Principle: reducing the conflict." Australian zoologist. 31(1): 181-186.

For more than 20 years there has been conflict arising from different points of view concerning the role of the introduced honeybee. There is a strong prima facie argument, and some supporting evidence, that introduced honeybees are likely to adversely affect the environment. Some land management agencies have consequently adopted a policy of removal of hive honeybees from areas devoted primarily to conservation. On the other hand, some argue that the scientific evidence on the issue remains poor, point out the economic benefits that arise from the honeybee industry and suggest that removal of apiaries from such areas is unjustified. It is suggested in this paper that adoption of the Precautionary Principle could significantly reduce this conflict. Instead of the focus being on obtaining definitive proof concerning possible impacts of honeybees, it could shift to finding ways to reduce the density of feral honeybees, and hence their impacts on both the natural environment and honeybees in hives. The focus could also shift to finding sites where reduction in honeybee density is feasible and the likely conservation gains arising from such a reduction are relatively high. In this way both the honeybee industry and the natural environment could benefit.

Pyke, G. H. and L. Balzer (1983). "The effects of the introduced honeybee (*Apis mellifera*) on Australian native bees." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 264-267.

Qureshi, S. A., et al. (2010). "A comparison of alternative plant mixes for conservation bio-control by native beneficial arthropods in vegetable cropping systems in Queensland Australia." Bulletin of Entomological Research 100(1): 67-73.

Cucurbit crops host a range of serious sap-sucking insect pests, including silverleaf whitefly (SLW) and aphids, which potentially represent considerable risk to the Australian horticulture industry. These pests are extremely polyphagous with a wide host range. Chemical control is made difficult due to resistance and pollution, and other side-effects are associated with insecticide use. Consequently, there is much interest in maximising the role of biological control in the management of these sap-sucking insect pests. This study aimed to evaluate companion cropping alongside cucurbit crops in a tropical setting as a means to increase the populations of beneficial insects and spiders so as to control the major sap-sucking insect pests. The Population of beneficial and harmful insects, with a focus on SLW and aphids, and other invertebrates were sampled weekly oil four different crops which could be used for habitat manipulation: Goodbug Mix (GBM; a proprietary seed Mixture including self-sowing annual and perennial herbaceous flower species); lablab (Lablab purpureus L. Sweet); lucerne (*Medicago sativa* L.); and niger (Guizotia abyssinica (L.f.) Cass.). Lablab hosted the highest numbers of beneficial insects (larvae and adults of lacewing (Mallada signata (Schneider)), ladybird beetles (Coccinella transversalis Fabricius) and spiders) while GBM hosted the highest numbers of European bees (*Apis mellifera* Linnaeus) and spiders. Lucerne and niger

showed little promise in hosting beneficial insects, but lucerne hosted significantly more spiders (double the numbers) than niger. Lucerne hosted significantly more of the harmful insect species of aphids (Aphis gossypii (Glover)) and Myzus persicae (Sulzer)) and heliothis (Heliothis armigera Hubner). Niger hosted significantly more vegetable weevils (Listroderes difficillis (Germar)) than the other three species. Therefore, lablab and GBM appear to be viable options to grow within cucurbits or as field boundary crops to attract and increase beneficial insects and spiders for the control of sap-sucking insect pests. Use of these bio-control strategies affords the opportunity to minimise pesticide usage and the risks associated with pollution.

Rader, R., et al. (2009). "Alternative pollinator taxa are equally efficient but not as effective as the honeybee in a mass flowering crop." Journal of applied ecology. 46(5): 1080-1087.

1. The honeybee *Apis mellifera* is currently in decline worldwide because of the combined impacts of Colony Collapse Disorder and the *Varroa destructor* mite. In order to gain a balanced perspective of the importance of both wild and managed pollination services, it is essential to compare these services directly, a priori, within a cropping landscape. This process will determine the capacity of other flower visitors to act as honeybee replacements. 2. In a highly modified New Zealand agricultural landscape, we compared the pollination services provided by managed honeybees to unmanaged pollinator taxa (including flies) within a *Brassica rapa* var. chinensis mass flowering crop. 3. We evaluate overall pollinator effectiveness by separating the pollination service into two components: efficiency (i.e. per visit pollen deposition) and visit rate (i.e. pollinator abundance per available flower and the number of flower visits per minute). 4. We observed 31 species attending flowers of B. rapa. In addition to *A. mellifera*, seven insect species visited flowers frequently. These were three other bees (Lasioglossum sordidum, *Bombus terrestris* and Leioproctus sp.) and four flies (Dilophus nigrostigma, Melanostoma fasciatum, Melangyna novae-zelandiae and Eristalis tenax). 5. Two bee species, *Bombus terrestris* and Leioproctus sp. and one fly, Eristalis tenax were as efficient as the honeybee and as effective (in terms of rate of flower visitation). A higher honeybee abundance, however, resulted in it being the more effective pollinator overall. 6. Synthesis and applications. Alternative land management practices that increase the population sizes of unmanaged pollinator taxa to levels resulting in visitation frequencies as high as *A. mellifera*, have the potential to replace services provided by the honeybee. This will require a thorough investigation of each taxon's intrinsic biology and a change in land management practices to ensure year-round refuge, feeding, nesting and other resource requirements of pollinator taxa are met.

Rader, R., et al. (2012). "Spatial and temporal variation in pollinator effectiveness: Do unmanaged insects provide consistent pollination services to mass flowering crops?" Journal of Applied Ecology 49(1): 126-134.

Recent declines in honeybee populations have focused attention on the potential for unmanaged insects to replace them as pollinators of food crops. The capacity of unmanaged pollinators to replace services currently provided by honeybees depends on the spatial and temporal variability of these services, but few quantitative assessments currently exist. We investigated spatial variation in pollinator importance by comparing pollinator efficiency and effectiveness in stigmatic pollen loads, stigmatic contact and visitation rate between honeybees and the seven most abundant unmanaged taxa in 2007. We assessed temporal variability in pollinator visitation using floral visits recorded three times a day over four consecutive years (2005-2008) in 43 'Pak Choi'*Brassica rapa* ssp. chinensis mass flowering fields in the Canterbury region of New Zealand. Further, we compared the aggregate effect of the unmanaged pollinator assemblage to the managed honeybee. Pak Choi was visited by many insect species that vary in abundance and effectiveness as pollen transfer agents. There was spatial variation in the four measures of pollinator importance. Pollen deposited on stigmas and flower visits per minute were not significantly different comparing the unmanaged assemblage to honeybees, although stigmatic contact and visitor abundance per number of open flowers were greater in honeybees. Unmanaged taxa were frequent visitors to the crop in all 4years. The pooled services provided by the unmanaged assemblage did not differ within a day and were equal to or greater than those provided by honeybees in 2 of the 4years. Pollinator importance changed little irrespective of the spatial and temporal variations among taxa. Synthesis and applications. The results of this study suggest that some unmanaged insect taxa are capable of providing consistent pollination services over a 4-year period in a commercial mass flowering crop. As these taxa already contribute substantially to the pollination of food crops, they offer a safety net in the case of sudden collapse of managed honeybee hives. To optimize pollination services, we

recommend pollinator-specific farm management practices that consider the needs of both managed and unmanaged pollinator taxa. © 2011 The Authors. Journal of Applied Ecology © 2011 British Ecological Society.

Ramsey, M. W. (1988). "Differences in pollinator effectiveness of birds and insects visiting *Banksia menziesii* (Proteaceae)." Oecologia. 76(1): 119-124.

Ramsey, M. W. (1988). "Floret opening in *Banksia menziesii* R. Br.; the importance of nectarivorous birds." Australian Journal of Botany 36: 225-232.

The rates and causes of floret opening in Banksia menziesii were investigated in woodland near Perth, Western Australia. Visitors observed foraging at the inflorescences were honeybees and 4 species of nectarivorous birds. Of the florets that opened during the observation periods, 82% did so in response to probing by birds, whereas only 7% opened after honeybee foraging, although bees accounted for 77% of all visits. More florets opened on unvisited inflorescences (11%) than on inflorescences visited by honeybees, suggesting that honeybees are unimportant for floret opening.

Richardson, M. B. G., et al. (2000). "Pollinator behaviour, mate choice and the realised mating systems of *Grevillea mucronulata* and *Grevillea sphacelata*." Australian Journal of Botany. 48(3): 357-366.

Roberts, G. E. and L. A. Freed (2001). Community effects of introduced honeybees (*Apis mellifera*) on native bee fauna and plant pollination. ProQuest Dissertations and Theses. Ann Arbor, University of Hawai'i at Manoa: 131-131.

Introduced species can contribute to the decline of native species through competition, predation, or parasitism, but the frequency with which they do so is largely unknown. Introduced species are commonly blamed for the devastation of native communities; however, the evidence supporting these claims is generally correlative and post hoc. This study investigates the impacts of introduced honeybees (*Apis mellifera*) on species interactions and abundances in Australian Banksia woodlands. A priori predictions about the effects of honeybees on native bee fauna were tested through the experimental manipulation of honeybee populations. Honeybees had a significantly negative impact on native bee forager abundance and trap-nest use. This effect is apparently driven by exploitative competition for floral resources; honeybees are able to out-compete some native bee species by foraging at lower ambient temperatures. In subtropical Queensland, Australia, honeybees started foraging at 15 C, while *Trigona* spp. did not start foraging until the ambient air temperature reached 18 C. This difference allowed honeybees to pre-empt floral resources: >90% of *Xanthorrhoea johnsonii* (Xanthorrhoeaceae) pollen was harvested before *Trigona* spp. started to forage. Honeybees also influenced the pollination dynamics of the native plant community. Honeybees were effective pollinators of three plant species with generalized flowers. They were less efficient than native bee species at transferring pollen to these plant species, but they were also more abundant than any of the native bee species. Overall, honeybees were the most important agents of pollen transfer to these generalized flowers. Since generalized pollination systems are thought to persist only when all visitors are roughly equivalent in pollination ability, the presence of honeybees has long-term implications for the persistence and evolution of generalized plant species in this community. For the vertebrate-pollinated plant species examined, honeybees were effective pollinators of *X. johnsonii*, but ineffective or unimportant pollinators of *Banksia aemula* (Proteaceae). This suggests that honeybees may be relatively poor pollinators of plant species with highly specialized flowers. In summary, introduced honeybees have significant impacts on native bee communities and on plant-pollinator dynamics.

Robertson, A. W., et al. (2005). "Effectiveness of Short-Tongued Bees as Pollinators of Apparently Ornithophilous New Zealand Mistletoes." Austral Ecology 30(3): 298-298.

Two species of threatened New Zealand mistletoes require force to open the flowers for pollination. This is applied by some birds or two species of native bees. Once opened, the flowers are pollinated by a variety of insects and birds. Although ornithophilous, both species may respond to bees. The effectiveness of pollination by bees and birds was examined at three sites. Bees and other insects were the dominant visitors, and two bee species were found to open the flowers of one species, but only rarely the other. Opening the buds did not distribute the pollen,

so pollination required later visits. Both species were pollen-limited, either because buds did not open and set seeds, or buds opened but did not receive sufficient pollen.

Rymer, P. D., et al. (2005). "Reproductive success and pollinator effectiveness differ in common and rare *Persoonia species* (Proteaceae)." Biological Conservation 123(4): 521-532.

In plants, understanding the interactions between breeding systems and pollination ecology may enable us to predict the impacts of rarity. We used a comparative approach to test whether rarity is associated with reproductive biology in two closely related species pairs. This system has been recently altered by changes in fire regimes and the introduction of European honeybees. More than 35% of flowers matured fruits in the common species after natural pollination compared to <20% of flowers in the rare species. All species were obligate out crossers in each of the study populations, but only the two rare species were pollen-limited, having significantly lower fruit-set on open-pollinated flowers than those cross-pollinated by hand (mean+or-SE; 0.18+or-0.02 vs. 0.42+or-0.05; p<0.001). Native bees (*Leioproctus* species) and introduced honeybees (*Apis mellifera*) visited all species. The native bees visited fewer flowers within a plant and moved greater distances between plants while foraging than honeybees, so the native bees are expected to be more effective in promoting outcrossing. While honeybees were the most frequent visitors to flowers of all species, native bees made more visits to common than rare species (0.65+or-0.20 vs. 0.20+or-0.09). Our results suggest that the poorer reproductive success in rare Persoonia species is associated with lower pollinator effectiveness, which is exacerbated by frequent fires and introduced honeybees. If this is a causal relationship, this may increase the probability of extinction in populations of these species.

Sandrey, R. A. (1985). "Biological control of gorse: an ex-ante evaluation." Research Report, Lincoln College, University of Canterbury, New Zealand(172): xi-pp.

Gorse (*Ulex europaeus*) is the most serious scrub weed in New Zealand and research has been carried out on the possible introduction of various insects and mites in order to control it. Although this action might be of benefit to farmers and foresters, beekeepers are concerned because gorse is a major spring and autumn pollen source. This report estimates the potential costs and benefits to New Zealand if biological control agents were introduced, and it examines the benefits and potential benefits of gorse, including its use for hedging, animal fodder, and erosion control. A survey of all beekeepers with over 50 colonies confirmed that gorse is a major pollen source, and estimates of costs to beekeepers are given should there be a 10, 25 or 50% reduction in gorse flowers. The report finds, however, that the benefits of gorse control would be substantial should the control agents become established, and it concludes that the introduction of these agents would be economically efficient. The assumptions and limitations of this study are discussed; for instance, it is assumed that if the honeybee population stays at the same level, but with increased costs, then there would be no loss of pollination services. The potential loss of pollination services is regarded as "double counting" and is therefore not included in the cost analysis. The study is recommended as a basis for further discussion and future research is suggested.

Scaccabarozzi, D., et al. (2020). "Pronounced differences in visitation by potential pollinators to co-occurring species of Fabaceae in the Southwest Australian biodiversity hotspot." Botanical Journal of the Linnean Society 194(3): 308-325.

Despite their diversity and the potential for specialized pollination systems, Australian Fabaceae have received little attention in pollination studies. In the Southwest Australian Floristic Region (SWAFR), a recognized biodiversity hotspot, co-occurring and abundant species of Faboideae exhibit a range of floral colours and forms, suggestive of adaptation to different groups of pollinators. For four communities of Fabaceae in the SWAFR we investigated whether co-occurring species overlap in pollinator genera, whether these pollinators show differences in behaviour on the pea flower and whether variations in stamen length and nectar composition among species are associated with different pollinator types. Species of Fabaceae were visited by one to four genera of native bees, suggesting varying levels of ecological specialisation. In Fabaceae with more specialized interactions, co-occurring species showed marked differences in the bee genera attracted. Unexpectedly, some Fabaceae frequently attracted beetles, which may play an important role in their pollination. There was no evidence for an association between stamen length or nectar composition and the type of pollinator. The introduced honeybee, visited all studied species

of Fabaceae, suggesting that they may act both as a pollinator and a potential competitor with native pollinators. © 2020 The Linnean Society of London, Botanical Journal of the Linnean Society, 2020, 194, 308-325

Schmidlin, F. G., et al. (2018). "Insect flower visitors of planted native species within the arable landscape on the Canterbury Plains, New Zealand." New Zealand Plant Protection 71: 198-206.

Almost all of the original native vegetation of Canterbury Plains has been replaced with an arable landscape of managed exotic vegetation. A previous study planted small areas of native trees on arable farms in 2013 to enhance the abundance and diversity of beneficial insect crop pollinators. The aim of the current study was to assess insect flower visitation at three sites in the fifth year after planting. Weekly standardised surveys of native flower visitors were conducted between September 2017 and February 2018. A total of 2349 insects from 37 taxa were observed within three native plantings. Native bees (*Lasioglossum sordidum* 20%) and the honey bee, *Apis mellifera* (19%), were the most common followed by the large hoverfly, Melangyna novaezelandiae (16%). The calliphorid flies, brown blowfly Calliphora stygia (8%) and blue blowfly *Calliphora vicina* (6%), were also well represented. The most abundant insects visited four or more of the eight study plant species. Most (52%) of the flower visitors where natives. Many of these insects are known crop pollinators and it is likely that they assist with crop pollination.

Schwarz, M. P. and P. S. Hurst (1997). "Effects of introduced honey bees on Australia's native bee fauna." Victorian Naturalist (Blackburn) 114(1): 7-12.

The introduced Honey Bee, *Apis mellifera*, has been present in Australia as both a commercially managed and feral species for over 150 years and there is considerable concern that it may have negative impacts on Australian flora and fauna. We briefly describe several aspects of Australia's native bee fauna and then discuss the potential for resource competition between honey bees and native bees. Three factors which may augment the competitive ability of Honey Bees compared to native bees are outlined: the extended foraging periods and seasonal activity of Honey Bees, their ability to rapidly recruit foragers in the exploitation of food sources; and their ability to forage over long distances. However, the few Australian investigations into resource competition between Honey Bees and native bees have been inconclusive. In some cases, experimental designs were inadequate, and in all cases, study sites were in areas with relatively rich floral resources. It is proposed that competition for floral resources will be greater in areas of low floristic abundance and that future studies should examine the effects of Honey Bee presence in these areas. In addition, bee species with a restricted range of food resources, such as some short-tongued bees, may be more susceptible to competition and therefore warrant investigation. Finally, the problem of controlling feral Honey Bee populations is discussed.

Sedgley, M., et al. (1992). "Insect visitors to flowering branches of Acacia mangium and Acacia auriculiformis." ACIAR Proceedings Series(37): 51-56.

Insect visitors to flowering branches of *A. mangium* and *A. auriculiformis* in Malaysia and Australia were collected and identified. Insects collected in Sabah were examined by scanning electron microscopy for the presence of pollen on their ventral surfaces. A range of insect types was observed on the trees in Australia, but bees were the most common visitors to Acacia flowers in Sabah. Numerous polyads adhered to their hairy bodies and the bees collected polyads in their pollen baskets. Most insect visitors had only Acacia polyads on their bodies, with the exception of some dipterans which had Asteraceae pollen grains. Most of the insects foraged for pollen, although a minority foraged also for nectar. The insects with hairy bodies had most Acacia polyads on their ventral surfaces, suggesting that they may act as pollen vectors. Trigona spp., *Apis mellifera* and bees of the family Colletidae carried the most pollen.

Shaw, D. E. (1993). "Honeybees collecting Neurospora spores from steamed *Pinus l*ogs in Queensland." Mycologist 7(4): 182-185.

Shaw, D. E. (1998). "Species of Neurospora recorded in Australia, and the collection of *Neurospora conidia* by honey bees *in lieu* of pollen." Mycologist 12(4): 154-158.

Species of *Neurospora* (*N. intermedia, N. sitophila* and *N. tetrasperma*) are reported on various substrates in the wild in Australia. In addition, honey bees are reported collecting Neurospora conidia in lieu of pollen, this activity having now been recorded intermittently over a period of 20 years.

Shrestha, M., et al. (2020). "Australian native flower colours: does nectar reward drive bee pollinator flower preferences?" PLoS One 15(6).

Colour is an important signal that flowering plants use to attract insect pollinators like bees. Previous research in Germany has shown that nectar volume is higher for flower colours that are innately preferred by European bees, suggesting an important link between colour signals, bee preferences and floral rewards. In Australia, flower colour signals have evolved in parallel to the Northern hemisphere to enable easy discrimination and detection by the phylogenetically ancient trichromatic visual system of bees, and native Australian bees also possess similar innate colour preferences to European bees. We measured 59 spectral signatures from flowers present at two preserved native habitats in South Eastern Australia and tested whether there were any significant differences in the frequency of flowers presenting higher nectar rewards depending upon the colour category of the flower signals, as perceived by bees. We also tested if there was a significant correlation between chromatic contrast and the frequency of flowers presenting higher nectar rewards. For the entire sample, and for subsets excluding species in the Asteraceae and Orchidaceae, we found no significant difference among colour categories in the frequency of high nectar reward. This suggests that whilst such relationships between flower colour signals and nectar volume rewards have been observed at a field site in Germany, the effect is likely to be specific at a community level rather than a broad general principle that has resulted in the common signalling of bee flower colours around the world.

Simpson, et al. (2005). "Broom and honeybees in Australia: An alien liaison." Plant Biology, 7 (5) pp. 541-548, 2005.

Facilitative interactions between non-indigenous species are gaining recognition as a major driver of invasion success. *Cytisus scoparius* (L.) Link (Fabaceae), or Scotch broom, is a cosmopolitan invasive shrub that lacks the capacity for vegetative reproduction and is a good model to study facilitative interactions. Its success in pioneer environments is determined by constraints on its reproduction. We determined whether pollinators were required for seed set in *C. scoparius* at Barrington Tops, NSW, Australia, where the species has infested ca. 14000 ha across the plateau. Field and laboratory experiments showed that *C. scoparius* is an obligate outcrossing species at Barrington Tops. Monitoring of plants (10.7 h) showed that the flowers of *C. scoparius* have to be tripped to effect seed set and the only pollinator to do this was the introduced honeybee, *Apis mellifera* L. Most floral visits by honeybees result in fruit set (84%) and because fruits have many ovules (10-18 per ovary) a single bee on an average foraging day can affect the production of over 6000 seeds. A review of *C. scoparius* pollination across four continents revealed major differences in pollen quantity, which may explain differences in the efficiencies of honeybees as pollinators of *C. scoparius*. The incorporation of pollinator management in an integrated approach for the control of *C. scoparius* is discussed. (copyright) Georg Thieme Verlag KG Stuttgart.

Simpson, K. (1982). "Bees and plants [New Zealand]." Small Farmer(19): 9-13.

Includes a short list of spring-flowering plants.

Slater, A. T. and D. M. Calder (1988). "The pollination biology of *Dendrobium speciosum* Smith: a case of false advertising?" Australian Journal of Botany 36: 145-158.

Potential pollinators of the orchid *Dendrobium speciosum* in Queensland, Australia, were attracted by the large, cream to yellow, aromatic inflorescences. Plants in natural populations flowered synchronously. Osmophores scattered over the perianth produced a strong, sweet scent. Foraging insects were guided into the flowers by the colour gradation of the perianth, including an area of high UV reflectance near the centre and a bright yellow ridge along the labellum, but the flowers produced no nectar. Flowers varied in size within the 6 recognized varieties and were pollinated by bees of appropriate size (*Apis mellifera*, *Trigona carbonaria*, *Homalictus brisbanensis*, *Lasioglossum* sp. and *Hylaeus disjuntus*). Bees were observed to enter the floral tube and, after a short time, to reverse out, but they did not appear to collect any reward. Flowers closed after pollination. Low fruit set is

considered to be the combined result of self-incompatibility, absence of a nectar reward and climatic conditions. The frequent occurrence of hybrids is thought to be due to the similarity of attraction and pollination mechanisms in all observed varieties of *D. speciosum* and in some closely related species.

Somerville, D. (2019). Honey and pollen flora of South Eastern Australia. [S.l.], Tocal College, NSW DPI.

Understanding the biology of flora and its value to honey bees is the core foundation for successful beekeeping. Bees feed on nectar and pollen. No food equals no bees! The flowers on which bees forage have a major impact on stocking rates and the level of nutrition available to the colony, two subjects that need to be understood for a beekeeper to be successful. Whether a beekeeper owns one hive or a thousand, the principle is the same. Floral resources within Australia underpin so many systems and animal species. Building knowledge and understanding of what they are, and how they are adapting to a changing climate, is a critical field of scientific endeavour. This publication is part of the journey to focus on the value of plants to nectarivores and honey bees in particular. The result of over 30 years of research, it distils both scientific knowledge and the opinions of hundreds of beekeepers into a reference work that will be the cornerstone of floral understanding in apiculture for years to come.

Stace, P. (1994). "Bushfires and bees." Bee Briefs 10(3/4): 2-3.

Sugden, E. A. and G. H. Pyke (1991). "Effects of honey bees on colonies of *Exoneura asimillima*, an Australian native bee." Australian journal of ecology. 16(2): 171-181.

Sugden, E. A., et al. (1996). "Honey bee-native bee competition: focal point for environmental change and apicultural response in Australia." Bee world. 77(1): 26-44.

Sunita, P. and G. M. Gurr (2019). "Conservation biological control using Australian native plants in a *Brassica* crop system: seeking complementary ecosystem services." Agriculture, Ecosystems & Environment 280: 77-84.

Habitat management can enhance the strength of ecosystem services but carries also the risk of leading to ecosystem disservices unless trophic links and ecosystem functions are well understood. In this study, intercropping with Australian native flowering plants was compared with the use of an exotic plant, buckwheat (*Fagopyrum esculentum*) and naturally occurring weedy grass vegetation for the provision of multiple ecosystem services in a cabbage agroecosystem. Among the native plants studied, *Mentha satureioides* had the most comprehensive positive effects on pest management. Compared with the grassy control, *M. satureiodides* significantly enhanced parasitism of the pest, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) larvae and reduced pest *Brevicoryne brassicae* densities and was comparable to *F. esculentum*. Flowers of *M. satureiodides* appeared attractive to adult Pieris rapae and the adjacent cabbage foliage held high densities of this pest's eggs but, reflecting high densities of parasitoids and predators (especially spiders), larval densities were not elevated compared to other treatments. Lotus australis also enhanced natural enemies, especially coccinellids and spiders, but this did not translate into the ecosystem service of pest suppression. Swainsona galegifolia harboured elevated numbers of spiders but the adjacent crop did not benefit from enhanced enemy densities or suppressed pests. For complementary ecosystem services, pollinator abundance was enhanced by the exotic plant *F. esculentum* and two natives (*L. australis* and *M. satureioides*). Honey bees (*Apis mellifera*) were highly attracted to *F. esculentum*, while native bees were attracted to the native plants. Native butterflies were monitored as a proxy for benefit to native invertebrate biodiversity and two native plants *(L. australis* and *M. satureioides)* were found to be attractive. Soil biological activity, a proxy for soil-associated ecosystem services, was lower in the *F. esculentum* treatment compared to all other treatments. These results show scope for farmers to take advantage of particular, and potentially multiple, ecosystem services by incorporating native flowering plants into farming systems but highlights the importance of plant selection and the risk of trade-offs among services.

Taylor, G. and R. J. Whelan (1988). "Can honeybees pollinate *Grevillea?*" Australian Zoologist 24(4): 193-196.

The likely impact of the honeybee on a native pollination system was examined by studying the effectiveness of honeybees (*Apis mellifera*) as pollen vectors of *Grevillea* .times. gaudichaudii, near Bargo, New South Wales [Australia]. Honeybees were the most frequent visitors to *Grevillea* inflorescences at the study site. Bees were found to be specific in their foraging, because only one pollen type was represented in the corbicula of each bee returning to a hive, but the *Grevillea* was not present in these pollen loads. Bees were observed foraging for nectar on Grevillea plants in the study area, but had no Grevillea pollen on their bodies and failed to transfer pollen to stigmas of 500 flowers during two hours of observations over two days. It is concluded that bees harvested nectar from this plant species without effecting pollination, and would therefore make the plants less attractive to native pollinators without compensating for any consequent reduction in reproductive success.

Tomlinson, S., et al. (2017). "Landscape context alters cost of living in honeybee metabolism and feeding." Proceedings of the Royal Society. Biological Sciences 284(1848): 20162676-20162676.

Field metabolic rate (FMR) links the energy budget of an animal with the constraints of its ecosystem, but is particularly difficult to measure for small organisms. Landscape degradation exacerbates environmental adversity and reduces resource availability, imposing higher costs of living for many organisms. Here, we report a significant effect of landscape degradation on the FMR of free-flying *Apis mellifera*, estimated using 86Rb radio-isotopic turnover. We validated the relationship between 86Rb kb and metabolic rate for worker bees in the laboratory using flow-through respirometry. We then released radio isotopically enriched individuals into a natural woodland and a heavily degraded and deforested plantation. FMRs of worker bees in natural woodland vegetation were significantly higher than in a deforested landscape. Nectar consumption, estimated using 22Na radio-isotopic turnover, also differed significantly between natural and degraded landscapes. In the deforested landscape, we infer that the costs of foraging exceeded energetic availability, and honeybees instead foraged less and depended more on stored resources in the hive. If this is generally the case with increasing landscape degradation, this will have important implications for the provision of pollination services and the effectiveness and resilience of ecological restoration practice.

Vaughton, G. (1992). "Effectiveness of nectarivorous birds and honeybees as pollinators of *Banksia spinulosa* (Proteaceae)." Australian Journal of Ecology 17(1): 43-50.

The effectiveness was compared of nectarivorous birds (honeyeaters; Meliphagidae), especially Eastern spinebills (*Acanthorhynchus tenuirostris*), and honeybees (*Apis mellifera*) as pollinators of *Banksia spinulosa* var. *neoanglica* in dry sclerophyll forest in New England National Park, NE New South Wales, in 1986, 1987 and 1988. Honeyeaters visited in early (May-June), middle (July-August) and late (September) flowering periods. Honeybees visited only in September when maximum temperatures were >15 degrees C. Self-pollen remained on pollen presenters of flowers for up to 5 days in the early and middle periods. In the late period, when honeybees visited inflorescences, self-pollen was removed within 2 days. Pollen removal was similar for caged (birds excluded) and open inflorescences in the late periods, indicating that most pollen was removed by honeybees. In the early and middle periods, honeyeaters pollinated 22% and 27% flowers on open inflorescences, respectively. In the late period, when both birds and bees visited inflorescences, 64-73% of flowers on open inflorescences were pollinated. Foraging by honeybees resulted in pollen deposition as 38% of flowers on caged inflorescences were pollinated. Throughout the flowering season a similar number of pollen grains were deposited per stigma. There were 3.0-3.7 pollen grains per stigma on open inflorescences in the late period, although only 2.0 grains per stigma on caged inflorescences. In the early and middle periods, fewer caged than open inflorescences produced fruits, indicating the importance of honeyeaters to reproductive success at these times. In contrast, in the late period when honeybees visited inflorescences, fruit-set was similar on caged and open inflorescences. The results indicate that honeybees were effective pollinators of *B. spinulosa* in the late season. However, most inflorescences had completed flowering at this time and resource constraints could limit fruit-set and therefore limit the effect of honeybees on the reproductive success of *B. spinulosa*. ADDITIONAL ABSTRACT: *B. spinulosa* was visited by nectarivorous birds (especially honeyeaters) throughout the flowering season in New South Wales, Australia, whereas honey bees visited only on days in the late flowering period when maximum temperatures exceeded 15 degrees C. Self-pollen remained on pollen presenters (modified style ends) of flowers for up to 5 days in the early and middle periods of flowering. In the late flowering period, as a result of honey bee visits, self-pollen was removed within 2 days. Pollination by

honeyeaters was 22% and 27% of flowers in early and mid-flowering, respectively. In the late flowering period, when both honeyeaters and honey bees visited, 64-73% of inflorescences were pollinated.

Vaughton, G. (1996). "Pollination disruption by European honeybees in the Australian bird-pollinated shrub *Grevillea barklyana* (Proteaceae)." Plant Systematics & Evolution 200(1-2): 89-100.

European honeybees (*Apis mellifera*) were less efficient pollinators of *Grevillea barklyana* than nectar-feeding birds. Nectar-collecting honeybees did not contact reproductive parts of flowers. Pollen-collecting honeybees preferentially visited male-stage flowers but rarely visited female-stage flowers. Fruit set on caged inflorescences that allowed access to honeybees but excluded birds was reduced by more than 50% compared to inflorescences that were visited by both types of visitors. Further, fruit set on caged inflorescences was less than on bagged inflorescences that excluded both birds and honeybees, indicating that pollen removal by bees decreased opportunities for delayed autonomous selfing in the absence of birds. Although fruit set was not pollen-limited at the study site, pollen removal by honeybees would decrease fruit set in small populations where birds are scarce. In addition, pollen removal by honeybees would reduce opportunities for outcrossing and reproductive success through male function. Although honeybees have been in Australia for insufficient time to have exerted selection on floral traits, evolutionary shifts in response to these animals are likely to occur in the future.

Whelan, R. J., et al. (2009). "The birds and the bees: pollinator behaviour and variation in the mating system of the rare shrub *Grevillea macleayana*." Annals of botany. 103(9): 1395-1401.

BACKGROUND AND AIMS: In Australia, honeybees have invaded systems that evolved without social insect pollinators, where many plants are adapted to vertebrate pollination. Behavioural differences between pollinators are likely to influence mating patterns, but few studies have examined this empirically in long-lived, woody, perennials. It was shown previously that outcrossing rates in *Grevillea macleayana* vary among populations. Here tests were conducted to determine whether the behaviour of birds and honeybees differed between a population previously found to be highly outcrossed and two inbreeding populations. METHODS: Visit frequencies and movement patterns of the visitors to inflorescences at three sites over two seasons were compared. A caging experiment was used to test the effects of excluding birds on pollen removal from newly opened flowers and on pollen deposition on stigmas that had been washed clean. KEY RESULTS: Honeybees were the most frequent visitors overall, but honeyeaters were more frequent visitors in the population previously found to have a high outcrossing rate than they were in either of the other populations. More visits by honeyeaters were from distant plants. Pollen removal did not vary greatly among sites, and was not affected by bird exclusion; however, more pollen was deposited on the stigmas of cleaned pollen presenters in the population previously observed to be highly outcrossing than in the other two. This high level of pollen deposition was reduced by experimental bird exclusion. CONCLUSIONS: Honeybees were the most frequent visitors, by an order of magnitude, and excluding vertebrates revealed that bees were removing most of the pollen but deposited fewer pollen grains on stigmas. Birds were more frequent visitors at the site previously found to be outcrossing than the other two sites, and they moved further between plants and visited fewer inflorescences on a plant during a foraging bout than bees did. These characteristics of bird visits to *G. macleayana* would be sufficient to produce significant variation in outcrossing rates among sites.

White, E. M., et al. (2008). "Diversity and abundance of arthropod floral visitor and herbivore assemblages on exotic and native *Senecio* species." Plant Protection Quarterly 23(2): 90-98.

The enemy release hypothesis predicts that native herbivores prefer native, rather than exotic plants, giving invaders a competitive advantage. In contrast, the biotic resistance hypothesis states that many invaders are prevented from establishing because of competitive interactions, including herbivory, with native fauna and flora. Success or failure of spread and establishment might also be influenced by the presence or absence of mutualists, such as pollinators. *Senecio* madagascariensis (fireweed), an annual weed from South Africa, inhabits a similar range in Australia to the related native S. pinnatifolius. The aim of this study was to determine, within the context of invasion biology theory, whether the two *Senecio* species share insect fauna, including floral visitors and herbivores. Surveys were carried out in south-east Queensland on allopatric populations of the two *Senecio* species, with

collected insects identified to morphospecies. Floral visitor assemblages were variable between populations. However, the two *Senecio* species shared the two most abundant floral visitors, honeybees and hoverflies. Herbivore assemblages, comprising mainly hemipterans of the families Cicadellidae and Miridae, were variable between sites and no patterns could be detected between *Senecio* species at the morphospecies level. However, when insect assemblages were pooled (i.e. community level analysis), S. pinnatifolius was shown to host a greater total abundance and richness of herbivores. *Senecio madagascariensis* is unlikely to be constrained by lack of pollinators in its new range and may benefit from lower levels of herbivory compared to its native congener *S. pinnatifolius*.

White, E. M., et al. (2008). "Plant-pollinator interactions in sympatric exotic and native *Senecio* species: is facilitation or competition for pollinators occurring?" Plant Protection Quarterly 23(3): 120-126.

The role of indirect interactions in invasion biology has rarely been addressed. Indirect interactions between two plant species may be mediated by shared pollinators: the presence of one plant species can have either a negative impact on pollination (and seed set) in another by competing for pollinators, or a positive effect by facilitating pollinator visitation. We investigated whether facilitation or competition for pollination was occurring between the closely related native *Senecio* pinnatifolius (A.Rich) and exotic S. madagascariensis (Poiret) in south-east Queensland. Visitation rates by honeybees and syrphid species, as well as seed set in each *Senecio* species, were assessed in naturally occurring mixed and pure stands. The exotic *S. madagascariensis* did not affect visitation rates to the native, but seed set of the native species was higher in mixed populations. The presence of native *S. pinnatifolius* caused a reduction in honeybee visits and an increase in syrphid visits to the exotic plant, but altered visitation patterns were not reflected in a change in seed set in the exotic.

Williams, G. and P. Adam (2001). "The insect assemblage visiting the flowers of the subtropical rainforest pioneer tree *Alphitonia excelsa* (Fenzl) Reiss. ex Benth. (Rhamnaceae)." Proceedings of the Linnean Society of New South Wales(123): 235-259.

Alphitonia excelsa is a bisexual, protandrous, pioneer rainforest tree. Anthesis and nectar production are diurnal. Populations studied on the Mid-North Coast of New South Wales flower between January and March. *Alphitonia excelsa* is dependent upon insects for pollen transfer. Flower-visiting insect assemblages are dominated by Hymenoptera, Coleoptera, and especially Diptera but vary over time, and geographically. Most of the visiting insects were 6 mm or less in size. Approximately 200 genera, from 116 families, were recorded from *A. excelsa* flowers. This fauna comprises taxa that, currently, are known within the region only from *A. excelsa*, and species shared with other mass-flowering rainforest trees. Aculeate wasps were a conspicuous element of the anthophilous insect fauna visiting A. excelsa in a littoral rainforest remnant at Harrington. Introduced honey bees, *Apis mellifera*, were active at blossoms at all study sites, but visitation varied over the 3 seasons of study.

Williams, G. A. (1996). Pollination ecology of lowland subtropical rainforest. ProQuest Dissertations and Theses. Ann Arbor, University of New South Wales (Australia): 1-1.

Aspects of the pollination ecology of selected mass-flowering rainforest trees and shrubs were investigated in lowland rainforest remnants on the North Coast of New South Wales. Features investigated were phenology, breeding system, floral biology and morphology, and pollen structure. Experimental exclusion of pollinators indicated that the majority of species studied had some ability for self-fertilization. This has important implications for the survival of isolated remnant plant populations. Approximately 60,000 insects were collected from inflorescences during the study. These were identified at least to order and assigned to morphospecies (which in many cases could be specifically identified). The data were subjected to multivariate analysis to explore spatial and temporal variation in the collections. The collections indicate that most of the plants studied recruit potential pollinators from an unspecialised guild comprising principally Diptera, Coleoptera and Hymenoptera. Membership of the pollinator guild is not constant but varies spatially and temporarily. However, the analyses consistently suggest that the assemblage in littoral rainforest is distinct from the assemblage in lowland subtropical rainforest. Although generalist strategies predominated a number of specialist interactions were recorded. The trees and shrubs with close relationships were mainly ecotonal or successional species rather than being restricted to mature rainforest. Plant-pollinator mutualisms for *Wilkiea huegeliana* (Monimiaceae), *Daphnandra micrantha* (Monimiaceae), *Rapanea howittiana* (Myrsinaceae) and *Eupomatia laurina* (Eupomatiaceae) were studied in greater detail. *R. howittiana* and *W.*

huegeliana are dependent on thrips for pollination. Large native insects ($>$9mm) amounted to less than 5% of total insects collected. Large insects have the potential to undertake relatively long-distance movements and this may be important in achieving outcrossing in spatially disjunct tree species. Introduced honey bees were the most numerous large sized insects and the influence of honey bees on native pollinators is discussed. The implications of the findings on guild structure for the conservation and management of rainforest remnants are discussed. The diversity and lack of constancy of guild composition suggests that the pollination system is robust and impacts of fragmentation may not limit the ability of even small plant populations to reproduce.

Yates, C. J., et al. (2005). "Native insect flower visitor diversity and feral honeybees on jarrah (*Eucalyptus marginata*) in Kings Park, an urban bushland remnant." Journal of the Royal Society of Western Australia 88 (Part 4): 147-153.

This study aims to determine firstly the diversity of native insect visitors to flowers on the mass-flowering canopy tree jarrah (*Eucalyptus marginata*), and secondly the relative abundance of feral honeybees and native insects visiting jarrah flowers. Flower density and nectar production were measured, and observations of animals visiting flowers were made during peak flowering of jarrah in Kings Park. Insects were the most commonly observed floral visitor; 83 species from 63 genera in 38 families across 5 orders were recorded. The overall richness and abundance of insect species visiting jarrah flowers changed through the day. Feral honey bees were by far the most common visitor, accounting for 47 % of observations, and suggesting they are a significant pollinator of jarrah in Kings Park. However, the presence of a number of exclusively nectar- and pollen-feeding native bees and flies, and native anthophilous tiphid wasps and beetles, suggests that the native fauna is still affecting some pollination. The diversity of insects observed visiting jarrah flowers is higher than reported for other eucalypts throughout Australia, and confirms that remnants like Kings Park are significant for the conservation of biodiversity.

HISTORY AND ECONOMICS

(1920). "Regulations for the Introduction of Bees, Honey, and Appliances into New Zealand." New Zealand Journal of Agriculture 21(5): 295-p.

Details are given of the regulations made under the Apiaries Amendment Act of 7th October 1913 with regard to the introduction of bees, honey and appliances into New Zealand.

(1922). "Quarantine Proclamation No. 99." Extract from Commonwealth of Australia Gaz.(81).

This proclamation of the 4th October 1922 repeals one published on the 26th January 1922, and prohibits the importation into Australia of bees and used or second-hand hives from all countries of the world, except the United States of America and Canada.

(1939). "Department of Agriculture. Annual Report for 1938-39. Presented to both Houses of the General Assembly by Command of His Excellency." Department of Agriculture. Annual Report for 1938-39. Presented to both Houses of the General Assembly by Command of His Excellency.: 72-pp.

The Animal Research Division came into being in March 1939. Its functions are to coordinate the whole of the animal research work conducted by the Department and to act in co-operation with other institutions. Livestock returns show an increase on the previous year except in the number of pigs. In 1938 there were 278, 167 horses, 4, 506, 082 cattle, 32, 378, 774 sheep, and 756, 466 pigs. All apiaries are registered, the number of beekeepers being 4751, with some 113, 465 colonies of bees. The Director of the Livestock Division reports that a decline in heavy horse breeding is evident in several districts, but the Stallions Act will be in operation during the next season and in time should do much to increase breeding of sound stock. The Remounts Encouragement Act of 1914 was made operative and provides for payment of a subsidy to owners of selected and approved light stallions. Serious outbreaks of photosensitisation affected cattle and sheep in the North Island. The Superintendent of the Swine Industry reports on the increasing benefits derived from pedigree sow recording, the pig production returns, national instruction service, grading of baconers, and the carcass quality scheme, all being projects initiated since 1936. The Chief Poultry Instructor reports on the encouragement of farm poultry keeping, the establishment of uniform conditions to govern all egg-laying tests, chick-sexing examinations, and on other aspects of the industry. The instructional service in connection with the production and preparation of wool for marketing is reviewed. Dr Hopkirk reports on the activities of the Veterinary Laboratory, Wallaceville. Work on sterility would seem to indicate that cows once served by a bull of inferior fertility are difficult to get into calf even with a bull of proven potency. ' A departmental trial of artificial insemination on a large scale (637 cows) demonstrated the difficulty of using bulls untrained for hand service and of obtaining daily the amount of semen for bulk insemination within a period of 3-4 wks. The relation between dietary protein and sterility, and other nutritional problems were studied. The report of the Dairy Division includes information on certificate-of-record and herd testing. The Chemistry Section at Ruakura investigated various problems of animal health in relation to nutrition. The Lands and Survey Department contribute two useful maps illustrating the main phases of land utilization in the North and South Island.

(1944). "Fires in Victoria." The Times(17, 20 January).

Fires which swept hundreds of square miles of the grass and forest lands of Victoria in the middle of January have caused widespread damage. Several people have died, and many have been admitted to hospital. " Across thousands of acres of some of the most fertile grazing lands in Victoria there is nothing, but blackened pastures dotted with the ruins of homesteads. Over this desolate landscape wander maimed and blinded sheep and cattle awaiting slaughter. Hundreds of people are homeless and have lost all their possessions. Relief is being rushed from Melbourne and from Ballarat." " The Victorian Cabinets bushfire relief committee estimates that the cost of repairing the damage caused by the fires will probably exceed A5, 000, 000. So far it has been estimated that 3, 000 square miles of country have been burnt out and that 12, 000 miles of fencing, 500 to 750 dwellings, 1,000,000 sheep, 50,000 cattle, 1,000 horses, 1, 000 pigs, 200, 000 head of poultry, and 5,000 hives of bees have been destroyed. " The bushfires have rendered useless for a long period large area of highly productive country, comprising possibly 1, 000, 000 acres. The losses of stock and pasture are unprecedented even in a State with such a bad bushfire record as

Victoria, and they cannot be assessed merely in terms of the animals, hay, and green fodder destroyed. The entire machinery of production must be rebuilt in the fire swept areas; homesteads and fences re-erected, implements and. stock replaced. The cost of this reparation is estimated at A4 a sheep, though in some areas it may be twice as much. The fires destroyed the Merino, Polwarth, and Corriedale sheep studs and the Aberdeen Angus, Shorthorn, and Hereford cattle studs. The total cost of rehabilitation may exceed A2, 000, 000. " The full effect of the disaster on the food supply situation cannot yet be gauged, but lamb in particular is likely to be in short supply next spring, as a large proportion of the lost sheep were breeding ewes of types most favoured as producers for the fat lamb trade. They were scarce before the fires and their replacement will be difficult. Losses of mutton and beef are enormous, and dairy produce and meat production programmes have been seriously deranged.".

(1972). "First Australian Bee Congress." First Australian Bee Congress.: 239-pp.

The theme of the congress was "presenting Australian honey to the world', and 38 papers are published, on the following topics: beekeeping and organizations in different countries; characteristics of individual honeybee workers; races of honeybees; bee forage; beekeeping management; hives and hive parts; rearing and breeding; digestive diseases; poisoning of bees; honey composition, properties and processing; pollination by honeybees.

(1975). "Pure Food Act, 1908. Regulation 43. Honey - amendment." Pure Food Act, 1908. Regulation 43. Honey - amendment.: 1-p.

(1978). "Papers presented at the honeydew seminar, 10 August 1978, Christchurch." Papers presented at the honeydew seminar, 10 August 1978, Christchurch.: 80-pp.

Of the 9 papers presented, 6 covered various aspects of beech honeydew honey production in South Island, New Zealand. Also D. A. Briscoe reported on the toxic honeydew of North Island, and B. J. Donovan gave a paper on the wasp *Vespula germanica* which builds large nests in the beech forests, and which is a major enemy of honeybees there. P. Walker

(1979). "Sixteenth annual report 1978-1979." Sixteenth annual report 1978-1979.: 30-pp.

On pp. 10 and 11 the research projects grant-aided by the Board are listed as continuing: Nutritional management of colonies on the basis of body protein of the bee; The incidence of *Nosema* disease in relation to the overall nutrition of the bee; Pollination of agricultural and horticultural crops; Synthesis and evaluation of repellents to reduce the pesticide hazards to honeybees. New projects are: Evaluation of strains of honeybees; Prevalence of Streptococcus pluton in honeybee colonies in South Australia; Epizootiology and management of European foul brood disease of honeybees in Australia. E. E. Crane

(1980). "Act No. 61. An Act to amend the Apiaries Act 1969." Act No. 61. An Act to amend the Apiaries Act 1969.: 6-pp.

Includes control measures for a number of honeybee diseases.

(1982). "Importing bees into the Northern Territory." Australasian beekeeper 84(1): 3-3.

Honeybees have been declared to be stock under the Stock Diseases Act, and imports to NT must be accompanied by a health certificate.

(1983). "Inquiry by the Industries Assistance Commission into the honey industry." Inquiry by the Industries Assistance Commission into the honey industry.: ii-pl.

The honey industry of New South Wales, Australia, has 3 main sectors-honey production, honey packing sector, and honey retailing sector. These are described, and market factors affecting prices are analysed. Proposals for market reform are made, but the implementation of any formal price equalization scheme is not recommended.

The Appendices give details of honey packer market shares, gross margins for a 500-hive apiary, and honeybee pollination market potential.

(1990). "APHIS [USDA's Animal and Plant Health Inspection Service] proposes to OK New Zealand bee imports." Speedy Bee 19(2): 1-2.

Queens and package bees.

(1990). "Commercial beekeeping in Tasmania." Commercial beekeeping in Tasmania.

In Tasmania, Australia, 70% of honey is produced from leatherwood (*Eucryphia lucida* and E. milliganii), virtually all of which is located on public land. An average of 822 t of honey and 13 t of beeswax are produced annually: currently there are 777 beekeepers owning 15 213 hives. AFB and EFB are widespread: oxytetracycline is fed to prevent AFB (the only Australian state in which this is permitted) and EFB, though there is considerable variation among beekeepers in disease prevention practices. Other diseases and pests include Nosema disease, sac brood, wax moth, Braula coeca and possibly chronic bee paralysis. The report describes in detail seasonal colony management, hive and apiary equipment, honey processing and marketing and provision of pollination services. There is a useful summary containing recommendations for improvements in beekeeping practices. Appendices include detailed statistics, beekeeping legislation and lists of flora.

(1990). "Proceedings of the 1990 fall Annual Conference, Apiary Inspectors of America, Tucson, Arizona, September 29 - October 5, 1990." Proceedings of the 1990 fall Annual Conference, Apiary Inspectors of America, Tucson, Arizona, September 29 - October 5, 1990.: ii-pp.

The proceedings of this conference give details of the officers, constitution, bylaws, responsibilities and duties of the Apiary Inspectors of America, and also include various brief research reports and news items. Some of the lengthier contributions concern aspects of current importance to beekeeping in the USA, such as pests and diseases, Africanised honey bees, allergy to stinging insects, imports of queens and package bees from New Zealand, beekeeping ordinances, *Varroa jacobsoni*, regulations about moving bees, and apiary inspection operating procedures.

(1990). "Report of the Honey Research Council Workshop, Review of nutrition work in Queensland and New South Wales, University of Queensland, Gatton College, Lawes Campus, 7-8 February 1990." Report of the Honey Research Council Workshop, Review of nutrition work in Queensland and New South Wales, University of Queensland, Gatton College, Lawes Campus, 7-8 February 1990.: 52-pp.

A workshop of 13 specialists reviewed research on honey bee nutrition, especially proteins. Eighteen reports were presented, on the role of protein in bee nutrition, fluctuations in bee protein levels in Queensland, practical methods of feeding proteins and carbohydrates, interrelationships between nutrition and disease, trials with adding isoleucine to bee diets, and research priorities.

(1991). "Commercial beekeeping in Western Australia." Commercial beekeeping in Western Australia.

This is the second in a series of reports analysing beekeeping practice in Australia. In Western Australia there are 1248 beekeepers and 51 526 hives: 87 beekeepers, with at least 200 hives each, produce 92% of the state's average honey production of 2454 t. The state produces 10% of Australia's honey, and 60% of its production is exported. Most honey comes from native flora on public land, and most beekeeping is migratory: pollen nutrition is normally adequate, and sugar feeding is not practised. No queen bees are imported to the state, and a government bee breeding programme aiming to provide quality bee stock is described in detail [see also Allan & Carrick, Australasian Beekeeper (1989) 90 (2) 72, 74, 78]. AFB is the most serious bee disease present, and the report details government disease inspection and compensation programmes, and beekeepers' disease prevention systems. EFB is not present in the state, so importation of bees, bee products and hive equipment are controlled by permit. Sac brood is also present, *Nosema* disease is thought to occur but has not been confirmed, and wax moth infestations are adequately controlled by hydrogen phosphide (Phostoxin) fumigation. This report describes the hive

and apiary equipment used, methods of product processing and marketing, and the provision of pollination services. It is a valuable analysis of the strengths and weaknesses of a beekeeping industry.

(1992). "Revised conditions for the importation of honeybees (*Apis mellifera*) into Australia." Australasian beekeeper 94(5): 199-204.

The regulations described came into force on 9 August 1992.

(1993). "Beekeeping in Australia." Australian Bee Journal 74(9): 8-9.

Figures are given for the numbers of beekeepers and honey bee colonies, the annual production and value of honey and beeswax, in Australia for 1985-86 to 1991-92 seasons inclusive. Data for each category are broken down by state. In 1991-92 production was 18 948 t of honey and 390 t of beeswax, worth $A 25 million and $A 1.5 million respectively, from 366 000 colonies. Honey production figures for that year are further broken down by hive holding category, with 9348 t (49%) produced by beekeepers with 800 colonies or more.

(1993). "MAF quality management report." New Zealand beekeeper(219): 14-19.

This report includes New Zealand statistics for numbers of beekeepers, apiaries and hives (1992, 1993), honey production by area (1988-1993), exports of honey, beeswax (1992) and live bees (to June 1993), incidence of American foul brood (to June 1993).

(1994). "Future development of the Australian honey industry." Bee Briefs 11(3): 11-15.

This article describes and discusses the Australian honey industry's relationship with the Australian Horticultural Corporation (AHC), a statutory marketing organization set up in 1988. The role of the Australian Honey Bureau is also dealt with.

(1995). "MAF Quality Management (MQM) Report to the Annual Conference of the National Beekeepers' Association of New Zealand, Christchurch 13-14 July 1995." New Zealand beekeeper 2(7): 16-18.

Statistics are reported for the year ending 30 June 1995. The 8409 registered beekeepers had a total of just over 293 000 colonies; total honey production was 8047 t (27.5 kg/colony). Incidence of AFB is also reported. Work under the Honey Bee Exotic Disease Surveillance Programme is summarized; no exotic diseases were found in inspections of 338 apiaries, and in tests of other bee samples.

(1995). "New Zealand imports OK'd, but only for transhipments." Speedy Bee 24(1): 1-2.

In a final rule published in the Federal Register, the USDA has permitted the trans-shipment of honey bees (*Apis mellifera*) from New Zealand through the USA to another country, subject to specified conditions. This restores the situation which prevailed before a recent legal opinion which barred New Zealand honey bees from transiting Hawaii, USA.

(1996). "MAF Quality Management (MQM) Report to the Annual Conference of the National Beekeepers' Association of New Zealand, Wanganui 17-18 July 1996." New Zealand beekeeper 3(8): 18-20.

Statistics for the year ended 30 June 1996 showed that there were 5306 registered beekeepers owning 286 806 colonies, which yielded 8610 t honey (average yield 30 kg/colony). In a disease control programme, 8% of the country's apiaries were inspected; many were in areas where AFB might be expected. This disease was found in 17.7% of apiaries and 6.1% of hives inspected. These levels are slightly lower than in 1994/95 when they were 18.9% and 6.8%, respectively.

(1996). "A new organisation to head up the Australian beekeeping industry." Australasian beekeeper 97(11): 451-454.

The proposed body will be provisionally known as the Honey Industry Council of Australia (or possibly the Council of Australian Honeybee Industries). The preferred plan is to form a council consisting of members from all sections of the industry and all states. Its proposed structure and budget are outlined and its responsibilities, which will devolve from the FCAAA, are set out.

(1996). "Research Report 1980-1995." Research Report 1980-1995.: vii-pp.

This report contains summaries of research projects funded by the statutory research levy introduced in the Australian Honey Research Act 1980. Since 1980, there have been 13 projects on bee diseases and pests, 1 on hive husbandry and management, 7 on honey bee nutrition, 10 on pollination, 6 on the effects of pesticides, 7 on the marketing of Australian honey, 7 on breeding and genetics, 10 on resources (bee forage), and 3 on economic aspects. During the period under review, the HRDC held 7 workshops and also published 5 reports on commercial beekeeping (in New South Wales, Tasmania, Western Australia, South Australia and Queensland). A bibliography lists 178 publications, by author, for research relating to the Australian honey industry, including work carried out before 1980.

(2007). "$60 million." BRW 29(13): 16-16.

The article presents trivia on the honeybee culture in Australia. The honeybee products industry makes a direct annual contribution of sixty million dollars to the economy of the country. The information was provided by the Committee on Agriculture, Fisheries and Forestry of the Australian House of Representatives.

(2009). "Deloitte Fast 50 named." NZ Business 23(11): 5-5.

The article highlights the success of Dunedin's New Zealand Honey Co as the top business in the annual Deloitte Fast 50 Index in New Zealand. Established in 2005, New Zealand Honey Co recorded a revenue growth of 995% between 2007 and 2009. Matt McKendry of Deloitte's Fast 50 Index stated that New Zealand Honey Co was an example of a company which develops high-value niche products from an indigenous Kiwi source and uses their value-add potential.

(2011). "Australia abandons search for Asian bee." Bee Culture 139(3): 74-74.

The article reports on the decision of Australia's Asian Honeybee National Management Group (AHB NMG) to abandon the fight against the Asian bee incursion that makes the U.S. ban on Australian bee imports. It states that the AHB NMG gave up the fight due to factors including the tendency of bees to swarm, the rapid breeding of bees, and the limitations of surveillance procedures. It notes that it agrees to recommend continued funding for the activities under the program until March 31, 2011.

(2016). "Bushfires have a sting in the tail for Tasmania's honey industry." Ecos(217): 1-4.

The article discusses the negative impact of bushfires in western Tasmania in 2016 on the honey industry. Bushfires may prevent the industry from gaining access to apiary sites that may be restricted during the peak honey flow season due to road closures as a result of the efforts to fight these fires, and can destroy the fire-sensitive communities supporting the leatherwood, which produces a unique style of honey. These fires can also affect the state's energy and tourism sectors.

(2016). "Sociology-Related Marsden Successes - 2016." New Zealand Sociology 31(7): 319-323.

The article discusses that after colonization by Britishers, New Zealand has been known as a -˜land of milk and honey', also the country of natural abundance and various opportunity. In the twenty-first century, the New Zealand's agricultural exports from milk and honey dominate the country’s economy. The article also mentions New Zealand's political identity and constitution.

(2017). "MPI Taking More Time to Review Manuka Honey Submissions." World Food Regulation Review 27(2): 18-18.

The New Zealand Ministry for Primary Industries said July 6 it is taking more time to review submissions to its consultation on the definition of manuka honey. Because of the number and complexity of submissions, the Ministry has decided to build approximately 6 to 8 weeks into the process to ensure all feedback is thoroughly reviewed. They received a lot of useful feedback throughout the consultation from beekeepers and honey producers as well as members of the public, said director systems audit, assurance and monitoring, Allan Kinsella.

(2017). "New Zealand Manuka Honey Science Definition." World Food Regulation Review 26(11): 14-14.

(2017). "NZ facing sticky-fingered crime wave." Bee Culture 145(5): 101-101.

Abbott, P. (2004). "Australia/New Zealand approach to food allergens." Journal of food science. 69(4): FCT345-FCT346.

In Australia and New Zealand, there is now a set of common food regulations that cover composition and labelling. As a result, the foods and substances in foods that may cause severe allergy or intolerance in sensitive individuals must be declared on the label of packaged foods (in the list of ingredients). These foods include cereals containing gluten, crustaceans, eggs, fish, milk, peanuts and soybeans, nuts, royal jelly, propolis, bee pollen, and added sulfites in concentrations above 10 mg/kg. With the exception of sulfites, the new allergen labelling requirements apply when the listed food or ingredient is present in the food product, irrespective of the level at which it is present. Furthermore, the new regulations require that any products derived from these substances must be declared, irrespective of the level of refinement or processing. The new allergen labelling requirements recognize that, for some individuals, trace amounts of an allergenic food may cause a severe reaction. While the new regulations provide an increased level of protection for susceptible individuals, there is concern that in some circumstances the labelling requirements are causing compliance difficulties for industry. Examples of such difficulties will be presented. The current debate around the issue of threshold levels for allergenic proteins from certain foods may help to address these problems and establish international consensus on appropriate labelling.

Alonso, A. D., et al. (2020). "Understanding entrepreneurial deviance through social learning and entrepreneurial action theory: an empirical study." European Business Review 32(4): 643-666.

Purpose The purpose of this exploratory study is to examine entrepreneurial deviance from the perspective of New Zealand's commercial honey producers. The study adopts entrepreneurial action and social learning theories and proposes a theoretical framework in the context of entrepreneurial deviance. Design/methodology/approach Data were collected through online surveys from 52 professional beekeepers. Findings Overstocking of beehives, encroachment, biosecurity threats and unfair competition were most common forms of deviance affecting participants. While these predominantly responded through investing in disease prevention, security equipment or by reporting deviant incidents, finding proper solutions remains elusive. The findings revealed robust alignments with both theories. Overall, offenders' perceived incentives to act illustrate alignment with social learning theory's four key constructs. Entrepreneurial action emerged through individual perpetrators' evaluation and subsequent maximisation of potentially lucrative opportunities. Originality/value- the study addresses an important and under-researched dimension, notably, the negative or "dark" side of entrepreneurs, in this case, illustrated through greed and disregard for fair and proper ways of conducting business. This knowledge gap is even more obvious among small and medium business, which is also the focus of the research.

Altaffer, P. and G. Washington-Smith (2011). "New Zealand: The Land of Milk & Honey." Nutraceuticals World: 30-31.

The article discusses the economic opportunities of New Zealand as a supplier for the U.S. natural products industry. It says that the New Zealand government has partnered with research organizations and universities to develop natural food product innovations like their pastoral dairy industry which produces milk with higher lactoferrin and lactoperoxidase content and can be extracted by ion-exchange technology. Meanwhile, their Manuka honey has been known for its antimicrobial properties.

Anonymous (2009). "Honey bees succumb to cocaine's allure." Journal of Experimental Biology 212(2): I-I.

Anonymous (2013). "Minister Announces Manuka Honey Consultation." World Food Regulation Review 23(5): 10-11.
New Zealand Food Safety Minister, Nikki Kaye, announced on September 12 that consultation has begun to define manuka honey to enable truth in labelling. "The Ministry for Primary Industries will be asking the honey industry, scientists and other interested stakeholders for their say through this consultation process," said Ms Kaye. The New Zealand honey industry has been working for many years to come up with an accurate way to label, market and brand manuka honey and unfortunately has been unable to reach consensus. There is no international standard for a definition of manuka honey.

Anonymous (2013). "Symposium Abstracts: The Rise and Fall of the Honeybee: Entomological Society of British Columbia Annual General Meeting, Pacific Forestry Centre, Victoria, B.C., Nov. 1-2, 2013." Journal of the Entomological Society of British Columbia 110: 40-43.

Anonymous (2014). "Australia's Biosecurity May be Shocked." World Food Regulation Review 24(7): 3-3.
A human disease pandemic, European honey bee colonies wiped out and an invasion of a devastating wheat disease are just three potential biosecurity threats facing Australia, according to a report released on November 24. These three events alone could devastate Australia's agricultural industries, economy and environment, according to experts, and could severely alter the national way of life. As an island nation, Australia has largely been able to maintain an enviable biosecurity status. However, experts warn that the 12 biosecurity mega shocks identified in a new report -- Australia's Biosecurity Future -- could turn into reality if it became complacent with its biosecurity measures. Dr Gary Fitt, CSIRO Biosecurity Flagship Science Director, said it was much better to pre-empt and avoid biosecurity issues than have to deal with the consequences. Dominating the news right now is the Ebola virus crisis, which is an obvious global health concern.

Anonymous (2016). "High Court finds "Manuka Doctor" and "Manuka Pharm" to be 'health claims'." World Food Regulation Review 25(10): 14-15.
The High Court of New Zealand held Feb 15, 2016 that the trademarks "Manuka Doctor" and "Manuka Honey" each amount to a health claim, which contravenes the Australian and New Zealand Food Standards Code 2012. The decision effectively stops Honey New Zealand (International) Pty Ltd from exporting its honey branded under those marks to some countries. Though consumers are free to use products however they want once they've made a purchase, New Zealand businesses still have regulations they must adhere to before products can reach consumers. The New Zealand Ministry for Primary Industries (MPI) believed that the term "doctor" would mislead consumers because of the associations that come with it, and therefore the MPI supported the High Court's rejection of the appeal.

Anonymous (2018). "Health Check for Bees to Begin." World Food Regulation Review 28(3): 17-17.
New Zealand Agriculture Minister, Damien O'Connor, urged the country's beekeepers 5 August to complete a survey to check the health of NZ bee stocks. "Pollination underpins our primary industries and the apiculture sector estimates the bees' busy work is worth $5 billion a year to the New Zealand economy. Bees are also vital visitors to our gardens and parks. "The Ministry for Primary Industries' Colony Loss and Survival survey is an important part of the work the Government and beekeepers do together to understand bee health, losses and beekeeping practice. "Typically, only a third of the hard-working apiculture sector of nearly 8000 registered beekeepers, who look after nearly 900,000 hives, complete the survey. Losses are anticipated over winter because there are very few nectar sources at this time of year and give us the most complete picture. Bees are solely reliant on the stocks of honey they have accumulated during summer or supplementary feeding from beekeepers.

Australian Honey Bee Industry, C. (1999). "Honey news."

Barrett, P. (1995). "The immigrant bees 1788-1898: a cyclopaedia on the introduction of European honey bees into Australia and New Zealand." 200-pp.

This is a well-documented account of the very earliest beekeeping history of Australia and New Zealand, based on extensive research into the available literature. It describes the earliest introductions of English or German 'black' bees [*Apis mellifera* mellifera] into New South Wales, Tasmania, Western Australia, and the North and South Islands of New Zealand. The period involved was 1788-1842, although the first undisputed successful introduction of honey bees into Australasia appears to have occurred in 1822, from the ship 'Isabella'. The subsequent introduction of Italian bees [A. m. ligustica] into New South Wales, Tasmania, South Australia (Kangaroo Island) and New Zealand in the period 1862-1880 is also described, and methods of transporting bees by sea during the period from the 1820s to the 1890s are discussed. Once established in Australia and New Zealand, bees were transported by land and accounts of such movements in the period 1827-1870 are given. Some figures for 19th century exports of honey, bees and beeswax are included. A selected bibliography of books, journals, newspapers, encyclopedias and unpublished manuscripts is given and there is a detailed combined author and subject index. This book will be of value to all those with an interest in beekeeping history.

Batchelor, C. (2016). "Food for thought. (cover story)." Money (Australia Edition)(189): 82-83.

The article presents the Australian food companies listed on the Australian Securities Exchange Ltd. (ASX) that qualify for Skaffold's premium ratings of A1 to B2. These include the organic infant food producer Bellamy's Australia. It notes the supplier of fresh fruit and vegetables Costa Group Holdings (CGC). It mentions the honey producer Capilano Honey.

Beard, C. (2010). "Show me the money honey." NZ Business 24(3): 59-59.

The article provides information on New Zealand Honey Co., the fastest growing exporter in New Zealand in 2009. It says that the effective, targeted and clever approach of the company came at a time when there was a marked shift in the global market towards more healthy and natural products. According to the author, New Zealand Honey Co. has a reputation for producing high quality and natural food. New Zealand Honey Co. sales director Chris McElroy adds that the company's success is attributed to its consumer-driven and market-focused approach.

Berry, I. (1982). "Palletised hives for orchard pollination Honeybees, colony management, costs, pollination service fees, New Zealand." New Zealand beekeeper. 43(4): 14-15.

Berry, J. (2016). "Crisis In New Zealand." Bee Culture 144(8): 11-12.

A letter to the editor is presented by beekeeper and chairman of the Apiculture New Zealand (APINZ) in Hawke's Bay, regarding massive increase in the bee population due to rapid booming in the establishment of corporate beekeeping that focuses only on manuka honey production that is not only changing nature but putting the country at a huge risk.

Biddle, S. (1981). "Costs and returns of honey production in Victoria." Agnote, Department of Agriculture, Victoria(1740/81): 2-pp.

Briggs, L. (1983). "Beekeepers associations--their role in Australian apiculture." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 323-326.

Briggs, L. (1989). "The next 200 years. The Second Australian and International Bee Congress, 21-26 July 1988. Keynote address - melliferous flora." Australasian beekeeper 90(7): 307-323.

This keynote address to the 2nd Australian and International Bee Congress surveyed the distribution and importance of the main bee forage plants of Australia. These include both native plants that evolved with native bees (not honeybees) and other insects and animals and birds, and introduced plants. Since European settlement 200 years ago, much forest and woodland, especially in the south, has been taken for farming land, and much remaining eucalypt woodland is threatened, for various reasons. The proposal to exclude beekeeping from conserved public land is being discussed, but there are insufficient data to allow a decision to be made and further research is needed. Looking ahead over the next 200 years, a fairly optimistic view is taken that the native bee plants in the forests will not be diminished. It is more difficult to make predictions about introduced crops and weeds.

Brown, A. (2016). "Current Developments -- New Zealand." Intellectual Property Forum(105): 87-89.

The article focuses on the legal and case law developments in New Zealand related to intellectual property which include Crocodile International Pte Ltd v Lacoste and Honey New Zealand (International) Limited v Director General of the Ministry for Primary Industries on trademarks.

Brown, P., et al. (2018). "Winter 2016 honey bee colony losses in New Zealand." Journal of Apicultural Research 57(2): 278-291.

Estimating winter losses for managed honey bee (*Apis mellifera*) colonies is critical for understanding hive productivity and health. This study reports estimates of overwinter colony losses in New Zealand, which has seen exponential growth in the number of managed colonies in recent years. Over 35% of all beekeepers, and 50% of all commercial beekeepers in the country responded to the internet-based 2016 New Zealand Colony Loss Survey, providing detailed information on over 275,000 colonies (over 40% of all registered colonies) that entered winter 2016. Using three different methods, we estimate overall winter losses to be below 10%. However, nearly 29% of beekeepers lost more than 15% of their colonies over winter 2016, and nearly 25% of beekeepers lost more than 20%, indicating considerable skewness. These results are subject to strong regional variation, with the highest losses reported in areas with significant Manuka resources. Similarly, non-commercial beekeepers report substantially higher loss rates than commercial beekeepers. Beekeepers who lost colonies over the winter of 2016 most frequently attributed the cause to colony death, queen problems, or wasps. However, varroa and competition for apiary sites were also identified as important areas of concern. In this analysis, we explore variation in both region and operation size for all five of these challenges.

Bryant, T. G. and P. J. Hook (1977). "Bulk suppliers put producer/packers in the shade." New Zealand beekeeper 39(4): 7-8.

This article compares the average producer-packer with the average bulk producer and analyses their economic strengths and weaknesses.

Bryant, T. G. and P. J. Hook (1977). "MAF survey shows Southland apiarists sinking." New Zealand beekeeper 39(2): 9-10.

A financial survey of commercial beekeepers shows that greater efficiency in terms of hives per man is being outstripped by increasing production costs.

Cameron, P. J., et al. (1987). "Invertebrates imported into New Zealand for biological control of invertebrate pests and weeds, for pollination, and for dung dispersal, from 1874 to 1985." Bulletin, Department of Scientific and Industrial Research, New Zealand(242): 51-pp.

This booklet lists over 250 invertebrate species that have been introduced to New Zealand to control invertebrate pests and weed species. The control agents are listed under the names of the primary target species, which are grouped under higher taxa. There is a separate alphabetical index of all control agents and their targets. The list is complete to June 1985. The small section on introductions of pollinators lists 8 species of Apoidea, including *Apis mellifera* (in 1839) and 4 species of *Bombus*. A single dung-burying beetle has also been introduced to New Zealand. There are 8 pages of references. ADDITIONAL ABSTRACT: This is an annotated list of the invertebrate species that have been deliberately imported into New Zealand as biological control agents and pollinators. Agents

are listed first by primary target species (invertebrate pests (arranged alphabetically under orders and families), weeds (alphabetically under families), pollinators (8 species of bees in 4 families) and dung dispersal (with a single entry: the scarabaeid Copris incertus)). An alphabetical index of about 250 agents (cross-referred to their targets) is also provided.

Carreck, N. L. (2011). "Fifty years of the Journal of Apicultural Research." Journal of Apicultural Research 50(4): 249-256.

The Journal of Apicultural Research (JAR) was first published in 1962 under the Editorship of Dr Eva Crane, Director of the then Bee Research Association (BRA). The journal was envisaged as an international English language medium of refereed science dealing with all kinds of bee including: honey bees, stingless bees, bumble bees and solitary bees. The international nature of this journal and its parent journal Bee World were instrumental in the change of title of BRA to International Bee Research Association (IBRA). This paper, coming at the completion of the fiftieth volume of JAR, describes the origins and history of the journal, and discusses some of the most notable papers published within its pages.

Clemson, A. A. (1977). "Some notes relating to the N.S.W. Proclamation." Australasian beekeeper: 107-108.

Cook, V. A. (1967). "Facts about beekeeping in New-Zealand honey bees." Bee World 48(3): 88-100.

Davies, L. and W. Jones (1989). "Pollination pricing." Australian bee journal 70(11): 13-17.

A booklet issued by the New South Wales Agriculture and Fisheries Department is reprinted here. The advice, based on costing estimates for a business with 2000 hives, includes guidelines for setting pollination service charges and suggested charges per hive for 52 crops. Recommended hive densities are given. A pollination agreement between beekeeper and grower should cover several important points, which are summarized.

Davy, J. (1983). "Proposal for a market stabilisation scheme for the Australian Honey Industry." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 6-22.

Dawson, C. (1979). "Waitangi treaty had links with first beekeeper." New Zealand beekeeper 40(1): 19-22.

Mary Anna Bumby sailed from England to New Zealand, arriving in March 1839; she had with her some skeps of bees which were the first honeybees to be taken to New Zealand. This article, quoting from various diaries and biographies, gives some information about Mary Bumby's life, though none of the quotations mention her beekeeping. P. Walker

Dijk, J. v., et al. (2016). "Australian honey bee industry: 2014-15 survey results." ABARES Research Report(16.18): vii-pp.

In this report, data from the ABARES Australian Honey Bee Industry Survey are presented for 2014-15. Key performance measures for beekeeping businesses are presented, including analysis of pollination services, use of public lands, challenges facing the beekeeping industry and the extent to which research and information is sought and implemented. Over 13,000 registered beekeepers operate across Australia. The number of commercial beekeepers fell by 25 per cent over the 10 years to 2015-16. Most honey produced came from non-agricultural private land (39 per cent) or public land (39 per cent). 23 per cent was produced from agricultural land. Larger businesses were more likely to derive a greater proportion of total honey produced from public land. The majority of beekeeping cash receipts came from honey sales (85 per cent) in 2014-15. Cash receipts from paid pollination were the second largest component of receipts (11 per cent). Business cash income averaged $70 400 and was significantly higher in Tasmania, Victoria and New South Wales. Small operators had negative business profit and rate of return in 2014-15, while small-medium, medium and large operators experienced increasingly large positive rates

of return and business profit. Paid pollination was conducted by around 44 per cent of beekeepers in 2014-15. The proportion of beekeepers and the value of payments received were higher in areas that produced large amounts of bee-pollination dependent crops such as almonds and cherries. Drought was the most commonly cited challenge to honey production by beekeepers over the 5 years ending 2014-15 (70 per cent of beekeepers). Other challenges include the use of agricultural chemicals which have negatively impacted floral resources, and the presence of pests and diseases. Nearly three quarters of beekeeping businesses changed their management practices in 2014-15 as a result of research. Large businesses were more responsive to research findings than smaller operators.

Donovan, B. J. (1974). "Bees of the world. IV. Honey bees in New Zealand." New Zealand beekeeper: 45-48.

Dziadyk, A. (1993). "Beekeeping around the world: Australia. I." American bee journal. 133(5): 365-367.

Dziadyk, A. (1993). "Beekeeping around the world: Australia. II." American bee journal. 133(8): 571-572.

Dziadyk, A. (1993). "Beekeeping around the world: New Zealand." American bee journal. 133(4): 274-276.

Evans, S. (1984). "An economic survey of the honey industry in Victoria: 1980-81." Research Project, Department of Agriculture, Victoria(186): v-pp.

The survey was based on the operations of 30 of the 53 commercial beekeepers in Victoria (each managed 400 or more hives and received at least 60% of their income from honey and other products). Most were in central and north-east Victoria; on average they had been involved in beekeeping for 25 years or more. The beekeepers earned over 90% of their gross income from honey production; 95% of honey produced was sold to commercial packers. Direct transport costs and labour costs together accounted for 59% of the total costs; family labour costs (paid or imputed) represented, on average, 22% of total costs. From this small survey, average net operating profits and average investment figures are calculated. Most of the beekeepers would be prepared to borrow for profitable business expansion, but the actual level of borrowing (at 30 June 1981) was low.

Flottum, K. (2018). "Inner cover." Bee Culture 146(4): 18-19.

Fung, E., et al. (2018). "Co-occurrence of RNA viruses in Tasmanian-introduced bumble bees (*Bombus terrestris*) and honey bees (*Apis mellifera*)." Apidologie. 49(2): 243-251.

A number of bee RNA viruses, including Deformed wing virus (DWV), are so far unreported from Australia. These viruses can be introduced together with imported live honey bees (*Apis mellifera*) and their products, with other bee species, and bee parasites. Given that bee viruses have a profound impact on bee health, it is surprising that since the introduction of bumble bees (*Bombus terrestris*) onto Tasmania in 1992 from New Zealand, no work has been done to investigate which RNA viruses are associated with these bees. Consequently, we investigate the current prevalence of RNA viruses in *B. terrestris* and *A. mellifera* collected in south-eastern Tasmania. We did not find DWV in either *A. mellifera* or *B. terrestris*. However, both bee species shared Kashmir bee virus (KBV) and Sacbrood virus (SBV), but Black queen cell virus (BQCV) was detected only in *A. mellifera*. This reinforces the importance of ongoing strong regulation of the anthropogenic movement of live bees and their products.

Gill, R. A. (1983). "Honey industry market regulation: a discussion of alternative schemes." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 23-30.

Gill, R. A. (1989). "Pollination services: an overview." Australasian beekeeper 91(4): 168-187.

From a literature survey, over 60 tropical and temperate-zone crops are rated according to their degree of dependence on pollinating insects and to the effect of removing bees from them. The use of pollination services is illustrated by examples from the USA and New Zealand. The market in Australia is not as fully developed, but could be profitable for many commercial beekeepers.

Gill, R. A. (1989). "The value of pollination services in Australia." Australasian beekeeper 91(6): 256-275.

Gill, R. A. (1991). "The value of honeybee pollination to society." The Sixth International Symposium on Pollination, Tilburg, Netherlands, 27-31 August 1990.: 62-68.

Previous attempts to evaluate the benefits attributable to the pollinating activities of honeybees are reviewed and criticized, and a value for the relatively undeveloped pollination services market in Australia is derived and discussed.

Harman, A. (2009). "Manuka health." Bee Culture: 67-67.

The article reports that the Advertising Standards Authority of New Zealand has upheld a complaint over an advertisement by Manuka Health New Zealand Ltd. about the health benefits of Manuka honey. According to the authority's ruling, the advertisement breached a therapeutic products advertising code. Concern over the impact of the rush to harvest the medicinal Manuka honey on bees was expressed by beekeeping officials. The National Beekeepers' Association warns about the problem over the competition for access to Manuka bush.

Harman, A. (2009). "Manuka test passes." Bee Culture 137(9): 59-59.

The article reports that a global standard is being introduced to examine the manuka honey of New Zealand for its antibacterial activity. It mentions that the examination will render more accurate and reliable ratings of the antibacterial activity of manuka honey and will be released with its own trademark. It notes that the worldwide standard was made by the Honey Research Unit of Waikato University in Christchurch.

Harman, A. (2010). "Cheap imports -- sound familiar?" Bee Culture 138(9): 73-73.

The article reports on the ruling of the New Zealand Commerce Commission against retailers for selling internationally sourced royal jelly in capsule form with lower standards and active ingredients.

Harman, A. (2011). "...More on the way." Bee Culture 139(8): 75-75.

The article reports on the 1.7 million New Zealand dollar grant given to a manuka honey industry consortium in New Zealand which is headed by Manuka Research Partnership Ltd. and Comvita Ltd., to fund the research aimed to improve the production of medical grade manuka honey.

Harman, A. (2013). "Keep OZ bees out." Bee Culture 141(12): 83-83.

The article focuses on New Zealand that is facing a continuing challenge to allow imports from Australia because of the fear of new bee pests and disease and informs that the imports of Australian honey to New Zealand is down the track for some years.

Harman, A. (2013). "NZ honey." Bee Culture 141(5): 92-92.

The article reports that the production of honey crop in New Zealand in 2011/12 increased by 10 percent from 2010/2011.

Harman, A. (2015). "Manuka - more solo than made." Bee Culture 143(9): 92-93.

This article reports that New Zealand's Unique Manuka Factor Honey Association has appointed Brooks and New Zealand scientist Terry Braggins to develop a chemical fingerprint for manuka honey to prevent counterfeiting. It is reported that two or three times more manuka honey is being sold in international markets than the actual production. Meanwhile, Australia is reported to be a home to more than 80 different varieties of bushes from leptospermum family have been identified in Australia.

Harman, A. (2016). "OZ honey issues." Bee Culture 144(9): 91-91.

The article highlights a research published in the "Food Additives and Contaminants" journal that revealed all but five Australian honeys tested had more than contaminants than what is considered safe by the European Food Safety Authority, which comes after doubts over Australian beekeepers' practices and the lax Australian food safety standards.

Harman, A. (2017). "Aussie Manuka honey tied up in red tape." Bee Culture 145(9): 91-91.

Harman, A. (2017). "Manuka honey becomes political football." Bee Culture 145(7): 93-93.

Harpinder, S., et al. (2016). "Scarcity of ecosystem services: an experimental manipulation of declining pollination rates and its economic consequences for agriculture." PeerJ 4

Ecosystem services (ES) such as pollination are vital for the continuous supply of food to a growing human population, but the decline in populations of insect pollinators worldwide poses a threat to food and nutritional security. Using a pollinator (honeybee) exclusion approach, we evaluated the impact of pollinator scarcity on production in four brassica fields, two producing hybrid seeds and two producing open-pollinated ones. There was a clear reduction in seed yield as pollination rates declined. Open-pollinated crops produced significantly higher yields than did the hybrid ones at all pollination rates. The hybrid crops required at least 0.50 of background pollination rates to achieve maximum yield, whereas in open-pollinated crops, 0.25 pollination rates were necessary for maximum yield. The total estimated economic value of pollination services provided by honeybees to the agricultural industry in New Zealand is NZD $1.96 billion annually. This study indicates that loss of pollination services can result in significant declines in production and have serious implications for the market economy in New Zealand. Depending on the extent of honeybee population decline, and assuming that results in declining pollination services, the estimated economic loss to New Zealand agriculture could be in the range of NZD $295-728 million annually.

Harvey, S. (2019). "Comvita CEO Scott Coulter to step down as business review launched." Aroq - Just-Food.com (Global News): N.PAG-N.PAG.

The article announces a business review and the departure of chief executive Scott Coulter by Comvita, the New Zealand-based Manuka honey supplier. It discussed the review on an agreement with its China joint venture partners Comvita Food (China) Ltd. and Comvita China Limited, and highlights the China's distribution business profit.

Heersink, D. K., et al. (2016). "Quantifying the establishment likelihood of invasive alien species introductions through ports with application to honeybees in Australia." Risk Analysis 36(5): 892-903.

The cost of an uncontrolled incursion of invasive alien species (IAS) arising from undetected entry through ports can be substantial, and knowledge of port-specific risks is needed to help allocate limited surveillance resources. Quantifying the establishment likelihood of such an incursion requires quantifying the ability of a species to enter, establish, and spread. Estimation of the approach rate of IAS into ports provides a measure of likelihood of entry. Data on the approach rate of IAS are typically sparse, and the combinations of risk factors relating to country of origin and port of arrival diverse. This presents challenges to making formal statistical inference on establishment likelihood. Here we demonstrate how these challenges can be overcome with judicious use of mixed-effects models when estimating the incursion likelihood into Australia of the European (*Apis mellifera*) and Asian *(A. cerana*) honeybees, along with the invasive parasites of biosecurity concern they host (e.g., *Varroa destructor*). Our results demonstrate how skewed the establishment likelihood is, with one-tenth of the ports accounting for 80% or more of the likelihood for both species. These results have been utilized by biosecurity agencies in the allocation of resources to the surveillance of maritime ports.

Henry, L. (1980). "Structural change in the New South Wales honey industry." Commodity Bulletin, New South Wales Department of Agriculture, Division of Marketing and Economics 8(9): 29-34.

Honey Research, C. (1986). "Annual report."

Honeybee, R. and C. Development (1990). "Annual report."

Johnson, P. (2011). "The Financial Stability Of Sustainable Organisations." Journal of Business & Economics Research 9(10): 65-74.

Research by Avery and Bergsteiner (2010) has found that Honeybee organisations, those that practice the principles of Sustainable Leadership, tend to perform better financially than those purely focused on generating profit. Financial analysis applies the concept of risk to adjust returns for the risks the organisations were exposed to in order to achieve the returns. This study applied the idea of stability, being the opposite of volatility, to evaluate the financial performance of three pairs of comparable organisations that operate in different industry sectors where each pair consists of a Sustainable and a non-sustainable organisation as defined by DJSI index membership in 2010. In order to obtain a complete picture a mixture of internal and external financial measures was considered. This preliminary study found that Sustainable organisations are more financially stable and maintain a lower risk profile. [PUBLICATION ABSTRACT]

Langridge, D. and R. Goodman (1978). "Bees and the law: the Bees Act and regulations." Australasian beekeeper: 215-216.

Love, J. L. (1990). "SAC 89 toxic honey a New Zealand story." Analytical Proceedings 27(4): 87-89.

Love, J. L. (1990). "Toxic honey - a New Zealand story." Analytical Proceedings 27: 87-89.

Published information from studies of toxic New Zealand honey is summarized. After determination of the source as the honeydew produced by Scolypopa australis on Coraria species, the two toxins tutin and hyenanchin were identified in the toxic honey. Methods were then developed to assay honey for quantitative determination of the toxins. An HPLC method was developed which for tutin gives results comparable with those obtained by GLC, but for hyenanchin HPLC gives higher values than GLC.

Manning, R. (1996). "The effect of drawing wax foundation on honey production and the cost of production for export." Australasian beekeeper 98(3): 99-102.

The economics of using colonies to draw wax foundation were examined for colonies in a *Eucalyptus calophylla* area north of Perth, Western Australia. In the study period (51 days) 12 test colonies produced an average of 37.4 kg honey/colony compared with 62.3 g in 12 controls (given recently extracted combs). In this period 261 frames were drawn, each at a cost of $A1.38 (1.15 kg honey/frame). Calculations of other costs e.g. labour, freight, showed that it would be profitable to export drawn frames to beekeepers in countries where honey prices are much higher, such as Saudi Arabia, where the cost of drawing each foundation sheet is calculated to be about $A146. Australian-produced frames would cost Saudi beekeepers from $A8.46 to $A11.00 per frame.

Manning, R. (1996). "Packaged honey bees: the export market, package bee research and economics of the enterprise. A reference for Western Australian beekeepers." Miscellaneous Publication - Western Australian Department of Agriculture(17/96).

The first part of this publication gives a general background to the production of package bees. It covers structure and size of packages, health certification, export opportunities and costs, timing and supply, production sites, methods of extracting bees from hives, productive capacity of apiaries, supplementary feeding of colonies, supply problems, and factors involved in air transport of package bees. Four research studies carried out by Agriculture Western Australia, on specific aspects of package bee production, are then described in detail. The studies examined economic aspects of package bee production versus honey production, methods for increasing the yield of bees from hives, the effects of hatching virgin queens above the queen excluder after raising 3 brood frames into the super, and methods of extracting bees from hives. A reference list of 24 publications is given and an article on transport of live bees by air, by D. MacCulloch, previously published in Australasian Beekeeper (1993) 95(3) 122, 125-126, forms an appendix; there are 16 colour photographs. This publication is aimed at Western Australian beekeepers, but it will be of interest to any beekeeper seeking an in-depth analysis of the commercial aspects of package bee production.

Manning, R., et al. (1992). "Honey production, economic value and geographic significance of apiary sites in Western Australia."

Martin, S. (1982). "Beekeeping: honey and other hive products." Beekeeping: honey and other hive products.: 60-pp.

This study examines commercial aspects of the production and sale of hive products and pollination services in New Zealand. It concludes that although the majority of beekeeping operations in New Zealand are geared to honey production, the marketing of honey is in a state of flux as a result of the demise of the Honey Marketing Authority, and future price stability depends on the annual export of 1000-3000 t, or a significant increase in domestic consumption. A financial analysis, based on a number of assumptions, indicates that the profitability of producing and processing extracted honey is marginal. Slightly better returns can be made from comb honey production. Marketing prospects for beeswax appear sound, and pollen collection in home-apiaries, although management-intensive, can increase income by 50% per hive. Queen rearing, especially for export, offers very good prospects for groups of professional, highly experienced beekeepers. Propolis, royal jelly and bee venom production are at present of little significance to New Zealand's beekeeping industry. Hiring out colonies for pollination, especially of kiwifruit [*Actinidia chinensis*], can be lucrative, but the development of an artificial method for kiwifruit pollination would have serious effects.

Matheson, A. (1987). "The value of honey bees to New Zealand." New Zealand beekeeper(194): 29-29.

It is estimated that the value of pollination benefits is 113 times as much as the value of bees, honey and beeswax.

Matheson, A. (1997). "The world market in relation to tropical honey." Perspectives for honey production in the tropics: proceedings of the NECTAR symposium held in Utrecht, 18 December 1995.: 191-203.

Only about 17% of the world's honey is produced in the tropics. About the same proportion of the 250 000-300 000 t of honey traded internationally every year originates in the tropics, but the vast majority of this comes from only 2 countries: Australia and Mexico. Exports from other tropical countries are limited by the high local market prices often paid, the difficulties for small exporters to establish reliable markets, and quality problems. Opportunities do exist, though, for exporting particular types of honey into the niche markets in developed countries. The effects on the honey market of the sanitary and phytosanitary agreement recently concluded as part of the Uruguay Round of the General Agreement of Tariffs and Trade (GATT) are considered.

Matheson, A. G. and M. Schrader (1987). "The value of honey bees to New Zealand's primary production." The value of honey bees to New Zealand's primary production.: 5-pp.

This paper attempts, for the first time, a detailed analysis of the economic importance of honeybee pollination in New Zealand. The contribution made by honeybee pollination to New Zealand's primary production is made up of several components: nitrogen fixation by legumes which are dependent on bee pollination; fruit and vegetable crops which rely on bee pollination for economically viable production; and crops which require bee pollination to produce their seed. A conservative estimate of the value of the honeybee's contribution to New Zealand agriculture is NZ$2275 million per year (NZ$ 2255 million from pollination activities and nearly NZ$20 million from bees and hive products). Thus, in New Zealand, the honeybee's pollinating activities are worth approximately 113 times as much as the value of bees and bee products sold by beekeepers.

Monson, T. (1991). "Income supplemented by pollination." Australasian beekeeper 92(12): 511-513.

An Australian commercial beekeeper describes the practicalities and economics of preparing and hiring out honey bee colonies for pollination.

Morthorpe, K. J. (1991). "Pollination services agreements and pricing [Australia]." Australasian beekeeper 93(2): 71-81.

New, T. R. (1994). "Exotic insects in Australia." Exotic insects in Australia.

This book discusses insects introduced accidentally or on purpose to Australia. Relevant biological aspects are discussed, including arrival and dispersal, establishment and invasion, with reference to the characteristics of successful invaders. Beneficial exotic insects, in particular *Apis mellifera*, are discussed. Exotic pests and their control and the use of exotic insects for the control of weeds are considered in the next 2 chapters. Conservation issues arising from the establishment of exotic insects are outlined. Finally, the prediction and regulation of exotic pests

and the use of quarantine are described. Examples include Lucilia cuprina, various insects of medical importance, dung beetles, Sirex spp. and aphids. Some important insects not yet present in Australia are also discussed.

O'Brien, L. (1990). "Australian [honeybee] packages to Canada." Australasian beekeeper 91(12): 511-524.

Oldroyd, B. P. and M. Beekman (2015). "The XVIIth International Conference, Cairns Australia." Insectes Sociaux 62(1): 1-3.

The seventeenth International Congress of the International Union for the Study of Social Insects was held in Cairns, Australia, from 13 to 18 July 2014. The Congress was attended by 576 delegates from 38 countries. The venue for the conference was the magnificent Cairns Convention Centre, which set new standards in technical excellence for an IUSSI conference. There were 37 symposia, reflecting the diverse interests of IUSSI members. Nine distinguished scientists presented plenary talks. The Hamilton award, the Union's highest honour, was presented to Professor Mary-Jane West-Eberhard.

Papworth, E. (1992). "VAA Inc. Resources Committee report to the 93rd Annual Conference of the VAA Inc." Australian bee journal 73(8): 17-23.

In Victoria, Australia, forage for honey bees is being reduced as a result of some areas of "wilderness estate" being closed and entry to national parks being restricted. Proposed management plans for several areas are summarized and discussed in relation to beekeeping and to overall conservation aims.

Paust, G. (1975). "Income variation in the Western Australian beekeeping industry." Farm Policy 15(3): 85-89.

The main source of income variation was linked with revenue from honey sales, which in turn depended on the price of honey and the yield per hive. The number of hives owned was a factor in this variation; changes in honey yield and in the number of hives owned tended to be in the same direction, with the result that variations in income fluctuated widely from year to year. E. E. Crane ADDITIONAL ABSTRACT: The previous article outlines the Australian and Western Australian beekeeping industry. This article examines the variation over time of gross receipts from honey and beeswax in terms of price and quantity variation.

Paynter, Q., et al. (2006). "Predicting the economic benefits and costs of introducing new biological control agents for Scotch broom *Cytisus scoparius* into New Zealand: how much will biological control of broom harm the New Zealand beekeeping industry?" 15th Australian Weeds Conference, Papers and Proceedings, Adelaide, South Australia, 24-28 September 2006: Managing weeds in a changing climate: 659-662.

A recent estimate of the potential benefits and costs of introducing additional biological control agents against the European shrub Scotch broom *Cytisus scoparius* (L.) Link (Fabaceae), henceforth broom, into New Zealand predicted an annual net benefit of $10.13 million, should broom be completely controlled. However, costs may be incurred by beekeepers and from non-target attack to tagasaste (tree lucerne, *Cytisus proliferus* L.f.), an exotic relative of broom used as a minor fodder crop and, occasionally, for erosion control on marginal hill country. Due to uncertainties regarding these costs, a risk-averse approach was adopted by assuming non-target damage to tagasaste will be similar to damage to broom and that no pollen sources suitable for beekeeping will replace broom stands. Work to refine these estimates by determining the potential impact of reduced broom pollen availability on honeybees was conducted in New Zealand and preliminary results are reported here. Pollen availability varied considerably between sites. At two of the three sites, only a minority of broom flowers were pollinated, indicating that even large reductions in pollen availability (>60% reduction in flowers) should not adversely affect honeybees. However, at one site 80% of broom flowers were pollinated, indicating even a minor reduction (25%) in broom pollen might affect honeybees. Nevertheless, at all sites, other sources of pollen growing in close proximity to broom were utilised by honeybees. If these alternative pollen sources increase in abundance, should biologically control of broom succeed, this should mitigate the impacts of a reduction in broom pollen availability for honeybees. This study, therefore, indicates the potential impact of successful biological control of broom is likely to be less than previously supposed. Finally, the only species capable of pollinating broom flowers were introduced bees (mainly

honeybees), indicating that introduced pollinators are at least partially responsible for the invasiveness of broom in New Zealand.

Phillips, C. (2020). "Telling times: More-than-human temporalities in beekeeping." Geoforum 108: 315-324.

In this paper, I build on insights from temporal studies and more-than-human geographies to argue that there is need to delve more deeply into how, by whom, and to what ends the times in which we live become told. Empirically, the practice of beekeeping provides orientation for exploring intertwining temporalities and timescales as more-than-human accomplishments. Drawing on ethnographic research undertaken in Australia, three accounts are developed: the catastrophic futures related to calls to 'save the bees'; intimate, embodied tempos and negotiated timings of visiting a hive; and seasonal cycles and rhythms beyond but integral to the life of a colony. Employing the concept of 'telling times' enables a gathering of these three accounts and highlights not only the eco-social significance of the current times, but the ways in which time becomes experienced, shared, and resonates through more-than-human practices of time- and world-making. © 2019 Elsevier Ltd

Pyper, W. (2001). "Princes of bees. (Cover story)." Ecos(107): 18-18.

Reports on initiatives that have increased awareness of the need to conserve stingless bees in Australia. Establishment of a native bee rescue service; Design of suitable hives; Protection of the European honeybee, a major pollinator and honey producer, from a parasitic mite; Identification of a chemical signal released by the honeybee that stimulates mite reproduction. INSET: The bees' trees.

Pyper, W. (2001). "Six-legged friends. (Cover story)." Ecos(107): 16-16.

Reports on the species of stingless wild bees of Australia. Characteristics; Friendlier alternative to wild bees; Increasingly important source of honey and means of crop pollination in tropical areas.

Pyper, W. (2001). "The sting. (Cover story)." Ecos(107): 21-21.

Reports on efforts by Australian scientists to control the varroa mite, a major destroyer of the European honeybee. Biology and behaviour of the mite; Identification of effective control strategies.

Reid, G. M., et al. (1988). "Bibliography of New Zealand apiculture (1842-1986)." Bibliography of New Zealand apiculture (1842-1986).

Over 1350 items published in the period 1842-1986 are cited in this Bibliography. All research articles concerned with honeybees and beekeeping in New Zealand are included, and extension literature is also covered, except for material that has become completely outdated. Newspaper articles and most localized pamphlets have been excluded. Significant items on non-Apis bees and pollination are included. The full references are grouped under subject headings which follow the arrangement used in Apicultural Abstracts. Within each subject grouping publications are listed alphabetically by author, and those which have been mentioned in Apicultural Abstracts include the relevant AA reference number. There is an author index which lists articles under the name of the first author only, giving a page reference and a shortened form of the title for each article. This will be a valuable reference book for anyone interested in New Zealand beekeeping, particularly research workers, teachers, librarians and others needing access to the published literature

Rice, N. (1983). "Alternate income for beekeeping industry." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 31-34.

Rice, N. V. (1994). "Queens' land." Queens' land.

This autobiography of a large-scale commercial beekeeper, who specialized in queen rearing in Queensland, Australia, contains a wealth of useful advice and also provides an insight into how certain methods and equipment,

accepted as the norm today, came to be developed over the last 50 years or so. The author writes about 'reading' honey bee colonies, maintaining records, breeder queen management, queen mailing cages, nucleus colonies, package bees, marketing, instrumental insemination, marking queens, queen introduction, queen cell cup production, feeding colonies, pollen and pollen substitutes, processing honey and beeswax, hot wax treatment of wooden equipment, and many other topics. The book, which should be of interest to all beekeepers, both professional and hobbyist, is illustrated by over 40 photographs.

Rogers, K. M., et al. (2010). "Eliminating false positive C4 sugar tests on New Zealand Manuka honey." Rapid communications in mass spectrometry : RCM 24(16): 2370-2374.

Carbon isotope analyses (delta(13)C) of some New Zealand Manuka honeys show that they often fail the internationally recognised Association of Official Analytical Chemists sugar test (AOAC method 998.12) which detects added C(4) sugar, although these honeys are from unadulterated sources. Failure of these high value products is detrimental to the New Zealand honey industry, not only in lost export revenue, but also in brand and market reputation damage. The standard AOAC test compares the carbon isotope value of the whole honey and corresponding protein isolated from the same honey. Differences between whole honey and protein delta(13)C values should not be greater than +1.0 per thousand, as it indicates the possibility of adulteration with syrups or sugars from C(4) plants such as high fructose corn syrup or cane sugar. We have determined that during the standard AOAC method, pollen and other insoluble components are isolated with the flocculated protein. These non-protein components have isotope values which are considerably different from those of the pure protein, and can shift the apparent delta(13)C value of protein further away from the delta(13)C value of the whole honey, giving a false positive result for added C(4) sugar. To eliminate a false positive C(4) sugar test for Manuka honey, prior removal of pollen and other insoluble material from the honey is necessary to ensure that only the pure protein is isolated. This will enable a true comparison between whole honey and protein delta(13)C isotopes. Furthermore, we strongly suggest this modification to the AOAC method be universally adopted for all honey C(4) sugar tests. Copyright 2010 John Wiley & Sons, Ltd.

Scandrett, J. (2010). "A honey of a year." NZ Business 24(4): 16-16.

The article features the New Zealand Honey Co., the largest producer of specialty honeys based in Dunedin, New Zealand. It describes the growth of the company and the honours it received in the 2009 Deloitte FAST50 Awards. It also discusses the company's revenue growth in 2009, its production processes, the quality of its products, and its plan to expand export markets and boost export growth in 2012.

Sharell, R. (1971). "New Zealand insects and their story." New Zealand insects and their story.: 268-pp.

The subject is clearly set out and well-illustrated. In a chapter on bees, ants and wasps, it is recorded that in 1839 a Miss Burnby brought to North island 2 straw skeps of black bees from England. This was the first introduction of *Apis mellifera* to New Zealand.

Showler, K. (1978). "William Charles Cotton and the first bees in New Zealand." New Zealand beekeeper: 20-21.

Smith, J. (1979). "The value of honey bees." Alternative land uses in New Zealand : with emphasis on temperate tree crops : proceedings of a course held at Lincoln College, Canterbury, New Zealand, 8-10 February 1979. --: 193-197.

Smith, T. J., et al. (2016). "Honey bees: the queens of mass media, despite minority rule among insect pollinators." Insect Conservation & Diversity 9(5): 384-390.

Pollination is a critical ecosystem function with high ecological and economic value. Conservation initiatives aimed at protecting diverse pollinator communities in natural and agricultural habitats are essential, but the implementation and success of such initiatives often depends on public support., Mass media play an important role in building public awareness around environmental issues, and biased coverage can have damaging effects. Here, we present the first analysis of how Australian mainstream media present the 'pollinator' paradigm. We gathered insect

pollinator and pollination related articles from major Australian online newspapers published over a period of 9 years, and performed a qualitative content analysis using deductive coding to record information on the pollinator species or groups discussed in the story., We found 151 stories, and demonstrate that within these, there was a disproportionate focus on introduced European honey bees as the most important, or only, pollinator insect relevant to Australia. Only 15% of stories mentioned native bees as pollinators and 17% mentioned non-bee pollinators., There is potential that the trend we report here for pollinators may be indicative of a larger overall simplification and neglect of biodiversity concepts in mainstream media, both in Australia and globally. As public awareness of science and environmental issues partly depend on disseminating accurate information beyond the scholar network, it is imperative that the broader effects of inaccurate science communication are fully understood. [ABSTRACT FROM AUTHOR] Copyright of Insect Conservation & Diversity is the property of Wiley-Blackwell and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Stace, P. (1989). "Beekeeping on the north coast of N.S.W." Australasian beekeeper 90(10): 456-459.
Estimates future demand for colonies for fruit pollination, and provides a sample pollination contract.

Stace, P. (1990). "The submission presented to the Resources Assessment Commission on Australian forests and timber resources, re beekeepers' utilization of north east N.S.W. forests." Australasian beekeeper 92(4): 157-160.
NSW Agriculture and Fisheries, Wollongbar, NSW, Australia.

Stace, P. (1991). "Inverell and district - the home of a large honey producing industry." Australasian beekeeper 93(1): 8-20.
This area of New South Wales, Australia, has 24 000 honey bee colonies owned by some 120 beekeepers, producing from 1600 to 2400 t of honey per year and 26-35 t of beeswax. The average annual production is 70-100 kg honey/hive. Management methods, marketing, other hive products, bee forage, and tourism, are discussed.

Stevenson, B. (1991). "New Zealand's first beekeeper arrives home." New Zealand beekeeper(210): 10-12.
On 9-20 March 1991, a group of beekeepers marked the 150th anniversary of the arrival of honey bees in New Zealand (on 20 March 1839) by retracing the last stage of the voyage of the ship that carried two skeps of North European bees brought from England by Mary Anna Bumby. This article describes historical aspects of New Zealand beekeeping, including a record of the transport of skeps within New Zealand in early 1840.

Stevenson, B. (1996). "In search of Father Petitjean's bees: early history of New Zealand beekeeping." New Zealand beekeeper 3(4): 12-13.
This article discusses the introduction, by French Roman Catholic priests, of European honey bees to the Bay of Islands area, in the N. Island of New Zealand, in 1842.

Sutherland, M. D. (1992). "New Zealand toxic honey - the actual story." Analytical Proceedings 29(3): 112-115.
This review, with 35 references, covers mainly the chemical aspects of the history, nature and analysis of the toxins involved in the tutu [*Coriaria* spp.] sap/leaf hopper/toxic honeydew pathway to New Zealand toxic honey, from the isolation of the first toxin in 1945. Numerous errors and distortions which have accumulated in the literature, including a recent account by J. L. Love [Analytical Proceedings (1990) 27, 87-89], are corrected. These defects include not naming C. R. Paterson as the discoverer of the source of the toxicity in the 1945 honey sample from Pongakawa, the false claim that the discovery of the crystalline mellitoxin was guided by guineapig toxicity tests, the failure to accept the evidence which pointed to a third toxin not extractable from honey by acetone, the introduction of ethyl acetate extraction as the first step in the analysis of the honey without reporting the proportion of the toxicity remaining unextracted, the incorrect assertions (in 1965/6) that mellitoxin is identical with the

hyenanchin described by T. A. Henry [Journal of the Chemical Society (1920) 117, 1619], and the confusing change of the name mellitoxin to hyenanchin in 1966. The author suggests that the name hyenanchin should be replaced by hydroxytutin, or 8-hydroxytutin, in accordance with current chemical nomenclature. Current procedures for bioassay and chemical analysis exclude probably about half of the toxicity shown by whole honey in guineapig tests. The toxic substances not extracted by acetone (and probably not by ethyl acetate) are likely to be conjugates of tutin, hydroxytutin and other detoxication products with sulphate, sugars or amino acids, etc., and possible methods for detecting and analysing these substances are discussed.

Traynor, K. (2011). "Mossop's Honey Shoppe: A New Zealand family business." American bee journal. 151(1): 81-84.

Van Eaton, C. and R. Law (2000). "Marketing apitherapy products and the challenge of government regulation." Bee World 81(3): 109-115.

The marketing of apitherapy products offers significant potential for the further development of beekeeping industries worldwide. This article looks at the problems experienced in New Zealand and Australia with government regulations on selling apitherapy products and labelling of products. It also gives details of the New Zealand bee products industry response.

Victoria. Department of, A. (1937). "The story of honey."

Walton, G. M. (1977). "Weather factors influencing the production of white clover (*Trifolium repens* L.) honey in southern New Zealand." Proceedings of the XXVIth International Apicultural Congress, Adelaide.: 429-432.

Daily hive weights were recorded from November to March; this period included the full flowering period of T. repens, the major nectar source. Results for 1973-1977 are examined in relation to daily weather recordings. Average daily weight gain in January was 2.0 kg, but the range was -5.4 to +11.8 kg. The daily weight variation (Wv) in January was strongly and inversely correlated with wind force; Wv was usually also correlated with solar radiation, maximum temperature, temperature range and atmospheric pressure. Some additional correlations were found in some Januarys. Multiple correlations were derived between Wv and a combination of 8 meteorological variables. P. Walker

Weatherhead, T. (1986). "Boxes to bar hives: beekeeping history of Queensland." Boxes to bar hives: beekeeping history of Queensland.

This illustrated history of Queensland beekeeping begins with an account of the introduction of honeybees to Australia, and the introduction of honeybees of various races (Italian, Caucasian, Carniolan, Punic, Cyprian) to Queensland. Three chapters then describe early beekeeping to 1900, beekeeping from 1900 to 1930, and from 1930 to the present day. Short entries on beekeeping literature published in Queensland, the Royal National Association, and exhibiting bees and bee products are followed by histories of the Queensland Beekeepers Association and its 7 branches, 10 amateur groups, the Queensland Honey Producers Association, the Department of Primary Industries and Queensland Agricultural College. Finally, historical aspects of the following are discussed: honey flora, equipment manufacturers and suppliers, queen breeding, diseases and pests, bees exported from Queensland, marketing, beekeeping personalities. The book ends with a collection of information gleaned from letters received by the author and an 'intermission' (rather than a 'conclusion'). The book was written to coincide with the Centenary of the Queensland Beekeepers Association in 1986.^CENTREQUAD~D. G. Lowe.

Winn, R. A. (1983). "Apicultural acts in each state." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 1-4.

Wright, L. (2013). "Hives for humanity." Australian Geographic(112): 30-34.

The article reports that people in Melbourne, Victoria are installing hives for survival of honeybees. Vanessa Kwiatkowski, founder of the organization Melbourne City Rooftop Honey, which wants to bring back bees back to the

city, states that there are 300 people on the waiting list who want to bring back bees. Robert Redpath, owner of the store which sells beekeeping gear, Bee Sustainable, mentions that the movement is strong as people understand that they should consume food differently. INSET: THE BUZZ ABOUT BEES.

Zorbas, C., et al. (2020). "Do purchases of price promoted and generic branded foods and beverages vary according to food category and income level? Evidence from a consumer research panel." Appetite. 144(144).

Price is a key determinant of food choice, particularly for low-income households who may be more sensitive to price-lowering strategies such as price promotions and generic/retailer-owned brands. Price-lowering strategies may therefore represent important policy targets to improve population nutrition and reduce inequities. This study aimed to describe household purchasing patterns of price promoted and generic branded foods and beverages in New Zealand (2016-2017).One year of grocery purchase data from a national consumer research panel in New Zealand (n-=-1778 households) were analysed. Purchases were classified by processing level and food type. Linear mixed models were fitted to estimate the mean proportion of annual household purchases (unique items and volumes (kg/L)) that were price promoted or generic branded (overall and by food category), and to assess whether purchasing patterns were modified by income level. On average, price promoted products constituted 50% (95%CIs; 49,51) of all unique annual household grocery items purchased. Fifty-nine percent (95%CIs; 58,60) of processed, 55% (95%CIs; 54,56) of ultra-processed, 45% (95%CIs; 44,46) of unprocessed and 45% (95%CIs; 44,46) of ingredient purchases were price promoted. By volume, the proportion of purchases that were price promoted was highest for meat (65%[95%CIs; 64,66]), sugar-sweetened beverages (64%[95%CIs; 62,65]), dairy foods (64%[95%CIs; 63,66]), confectionary (64%[95%CIs; 63,66]), snack foods (63%[95%CIs; 61,64]), oils (61%[95%CIs; 60,62]) and non-sugar-sweetened beverages (60%[95%CIs; 58,62]), and lowest for dairy beverages (30%[95%CIs; 28,31]), sugar/honey (33%[95%CIs; 32,35]) and sauces/spreads (39%[95%CIs; 37,40]). On average, generic brands constituted 10% (95%CIs; 9,10) of all household purchases. Overall, a significantly greater proportion of purchases made by low and middle-income households were price promoted and generic branded compared to high-income households (p-<-0.001 for both), a pattern generally observed across food categories. This study supports recent calls to address unhealthy food and beverage price promotions in comprehensive policy strategies aiming to improve population diets and weight.

HONEYBEE PRODUCTS

Bee export

Harrison, B. (2005). "First Australian honey bee imports. III. Late summer 2005 update." American bee journal. 145(10): 797-799.

Harrison, B. (2005). "U.S. beekeepers make history with first Australian bee imports. I." American bee journal. 145(4): 287-289.

Harrison, B. (2006). "First Australian honey bee imports. 4. Early summer 2006 update." American bee journal. 146(8): 671-674.

Harrison, B. (2007). "Browns bees Australian honey bee imports." American bee journal. 147(12): 1029-1032.

Bee venom

Anonymous (2000). "Bee venom provides pain relief." Manufacturing Chemist 71(8): 11-11.

Bishop, D. G. and J. R. Kenrick (1980). "Melittin: an inhibitor of chloroplast photochemical reactions." Biochemical and Biophysical Research Communications 97(3): 1082-1090.

Melittin from honeybee venom inhibited photochemical reactions in chloroplasts isolated from peas, *Beta vulgaris*, maize and wheat. At concentrations of about 5 mu M, melittin acted as an uncoupler of photophosphorylation, and it abolished the 518-nm light-induced absorbance changes. At 30-50 mu M melittin abolished the light-induced photooxidation of cytochrome f and partially inhibited other reactions of photosynthetic electron transfer, without causing lysis of the membrane. The observed inhibitions appeared to be due to changes in the properties of the membrane lipid bilayer, caused by penetration of melittin molecules. [Chem.Abstr. 94 : 97579x (1981).] F. B. Wells

Farhat, E., et al. (2018). "Not as sweet as honey: A rare case of an apparent factor V "inhibitor" in association with bee sting anaphylaxis." American Journal of Haematology 93(7): 965-970.

Ford, R. M. (1980). "Honey bee immunotherapy." The Medical journal of Australia 1(10): 500-500.

Gupta, S., et al. (1988). "Management of bee-sting anaphylaxis." Medical Journal of Australia 149(11/12): 602-604.

A retrospective case analysis of 101 adverse reactions to bee-stings presenting at a medical centre in South Australia in 1978-86, and a prospective questionnaire analysis of the proposed management by medical practitioners and resident hospital staff members at 3 medical centres/hospitals in South Australia of 3 hypothetical bee-sting reactions, revealed that (a) understanding of the use of adrenaline in patients with reactions to bee envenomation is confused with regards to the indications for its use, dosage and route, (b) corticosteroid agents are used or are recommended too frequently, sometimes as the sole therapeutic agent, and (c) there is a lack of awareness of the need for volume replacement in hypotensive shocked patients. These conclusions highlight the urgent need in Australia for a greater understanding of the optimal forms of management for patients with acute anaphylactic reactions to bee envenomation. ADDITIONAL ABSTRACT: The management of bee-sting anaphylaxis is discussed following analysis of 101 cases of adverse reactions to stings and the results of a study in which questionnaires were circulated to general practitioners and hospital staff in Australia. The unnecessary use of adrenalin or incorrect route of its administration appeared to be the main area of confusion encountered. Corticosteroids were also frequently used although there is little factual evidence to support their use in acute bee-sting reactions. There was a general

lack of awareness for the need for intravenous volume replacement and additional oxygen in hypotensive shocked patients.

Han, S. M., et al. (2015). "The beneficial effects of honeybee-venom serum on facial wrinkles in humans." Clinical interventions in aging 10: 1587-1592.

Facial wrinkles are an undesirable outcome caused by extrinsic photodamage and intrinsic aging processes. Currently, no effective strategies are known to prevent facial wrinkles. We assessed the beneficial effects of bee-venom serum on the clinical signs of aging skin. Our results show that bee-venom serum treatment clinically improved facial wrinkles by decreasing total wrinkle area, total wrinkle count, and average wrinkle depth. Therefore, bee-venom serum may be effective for the improvement of skin wrinkles.

Han, S. M., et al. (2012). "Dermal and Ocular Irritation Studies of Honeybee (*Apis mellifera* L.) Venom." American Journal of Chinese Medicine 40(4): 795-800.

The aim of this study was to access the irritant properties of bee venom (BV) after its application to skin and eye mucous membranes of the rabbit. The animals were also observed for clinical signs and mortality after the application of the test material. Six animals were used for the skin irritation test and nine rabbits for the eye irritation test. The acute BV application to the rabbit skin revealed no appreciable clinical signs throughout the observation period of 72 h and there was no mortality seen. In the eye irritation test, eye reactions were read and graded 24, 48, 72, 96 and 168 h after BV treatment. No changes in the cornea, iris or conjunctivae were observed at all time points of observations. Based on the present findings, it can be concluded that the irritation potential of BV is negligible.

Harvey, P., et al. (1984). "Bee-sting mortality in Australia." Medical Journal of Australia 140: 209-211.

Death as a result of a bee sting is uncommon in Australia. During the 22 years from 1960 to 1981, 25 individuals have been recorded by the Australian Bureau of Statistics as having died shortly after a bee sting (a mortality incidence of 0.086/1 000 000 population per year). This may be an underestimate, as two additional fatalities are reported that did not appear in the records of the Bureau of Statistics. Fatalities have occurred predominantly in men over 40 years of age, which suggests that there may be other contributory risk factors, for example, coronary atherosclerosis. No deaths were reported in individuals aged from 6 to 19 years, the age group in which bee-sting anaphylaxis is particularly common. It thus appears that the prevention of death per se is not a strong rationale for routine venom immunotherapy in children and young adults.

Heddle, R., et al. (2019). "Randomized controlled trial demonstrating the benefits of delta inulin adjuvanted immunotherapy in patients with bee venom allergy." Journal of Allergy & Clinical Immunology 144(2): 504-513.

Background: Allergic reactions to Hymenoptera insect stings remain a major global clinical problem. Although effective, parenteral desensitization regimens require use of costly venom extracts and require frequent visits over extended periods of time. Objective: Adjuvants are commonly used to enhance the efficacy of infectious disease vaccines, and this study asked whether Advax (Vaxine Pty Ltd, Adelaide, Australia), a novel noninflammatory polysaccharide adjuvant, might provide similar benefits for allergy desensitization. Methods: A randomized, controlled phase 1/2 trial was undertaken in 27 adults with a history of rapid-onset systemic allergic reactions to honeybee stings and positive specific IgE levels to evaluate the safety and efficacy of honeybee venom immunotherapy (HBVIT) combined with Advax adjuvant. Venom immunotherapy (VIT) was administered monthly for 30 months after achievement of maintenance doses. Results: Advax-adjuvanted HBVIT was well tolerated. Around week 14 of VIT, specific IgG(4) responses peaked in both groups but increased earlier, peaked higher, and were better maintained through the end of the study in the Advax-adjuvanted arm. Several different patterns of serologic response to VIT were seen; some subjects had a dominant IgG(4) response, some had a combined IgG(4) and IgG(1) response, and some had an exclusively IgG(1) response. In some subjects specific IgE levels increased during the induction phase and then decreased, whereas in others specific IgE levels progressively decreased from the start of VIT. Conclusion: Advax adjuvant favourably enhanced the immunogenicity of HBVIT, with an early and prolonged switch to specific IgG(4) production. The ability of Advax adjuvant to enhance VIT efficacy warrants further study.

Houliston, L., et al. (2004). "Venom immunotherapy." New England Journal of Medicine 351(20): 2129-2130.

A retrospective analysis was performed of children from Western Australia, Australia who were sensitized to honeybee venom (mean age (+or-standard deviation), 9+or-3 years) and who had a history of moderate-to-severe

systemic reactions after bee stings [date not given]. The children received either slow bee-venom immunotherapy (n=18 children) or modified ultra-rush bee-venom immunotherapy (n=82). Ultra-rush immunotherapy in these children was as safe as the slow immunotherapy regimen. In addition, protective doses (50 micro g) were achieved more rapidly with the ultra-rush protocol than with the slow protocol. The incidence of systemic adverse effects was substantially lower than that reported for rush bee-venom immunotherapy in adults.

Houliston, L., et al. (2011). "Honeybee venom immunotherapy in children using a 50- micro g maintenance dose." Special Section: Commemorating 100 years of allergen immunotherapy. 127(1): 98-99.

This study identified 143 children who received venom immunotherapy (VIT) from either Princess Margaret Hospital for Children or Fremantle Hospital through a search of the Health Department of Western Australia database of patients admitted to the hospital between January 1987 and 2003. Of the 143 children identified, 110 were successfully contacted, and a further 25 were excluded, resulting in a response rate of 60%; 74% were male. During honeybee VIT, 34 subjects sustained 55 field stings with 7 mild-to-moderate systemic reactions. After completion of VIT, 44 subjects were stung 96 times (average of 2.2 stings per person stung), with 6 systemic reactions. All were of less severity than their initial reactions except one 8-year-old boy. He had angioedema and wheeze before VIT and then 3 episodes of systemic reactions requiring adrenaline during immunotherapy without a change in dose. After VIT was discontinued, he collapsed after a field sting and required adrenaline. His VIT should have been increased after the first systemic reaction to a field sting during VIT. A 50- micro g maintenance dose prevented systemic reactions in 86.4% (38 of 44) of children for 93.8% (90 of 96) of stings after honeybee VIT. When a systemic reaction occurred, it was of lesser severity than the initial reaction in all but one child.

Kheyri, H., et al. (2013). "Comparing the secretory pathway in honeybee venom and hypopharyngeal glands." Arthropod structure & development 42(2): 107-114.

We provide insights into the secretory pathway of arthropod gland systems by comparing the royal jelly-producing hypopharyngeal glands and the venom-producing glands of the honeybee, *Apis mellifera*. These glands have different functions and different product release characteristics, but both belong to the class 3 types of insect glands, each being composed of two cells, a secretory cell and a microduct-forming cell. The hypopharyngeal secretory cells possess an extremely elongate tubular invagination that is filled with a cuticular structure, the end-apparatus, anchored against the cell membrane by a conspicuous series of actin rings. In contrast, venom glands have no actin rings, but instead have an actin-rich brush border surrounding the comparatively short and narrow end-apparatus. We relate these cytoskeletal differences to the production system and utilisation of secretions; venom is stored in a reservoir whereas royal jelly and enzymes are produced on demand. Fluorescence-based characterisation of the actin cytoskeleton combined with scanning electron microscopy of the end-apparatus allows for detailed characterisation of the point of secretion release in insect class 3 glands.

Levick, N. R., et al. (2000). "Review of bee and wasp sting injuries in Australia and the USA." Hymenoptera: evolution, biodiversity and biological control. Fourth International Hymenoptera Conference, held in Canberra, Australia, in January 1999.: 437-447.

The extent of problems caused by bee and wasp stings in the USA and Australia is reviewed. The main species of medical importance are listed for both countries. The morphology, behaviour and venom chemistry of honey bees (*Apis mellifera*) and Vespula germanica is compared. Mortality and morbidity due to stings in the USA and Australia are discussed. Notes are given on envenomation versus allergy, injury prevention and control, and injury surveillance.

Lewis, N. and D. Racklyeft (2014). "Mass envenomation of a mare and foal by bees." Australian Veterinary Journal 92(5): 141-148.

Case report The clinical course of toxic envenomation of a mare and her foal after an attack by a swarm of bees in the Upper Hunter Valley of New South Wales is described. Early agitation and urticaria were followed by more severe systemic clinical signs within 18h. There was severe, generalised angioedema, rhabdomyolysis, hypovolaemia, gastrointestinal stasis and renal injury. A particular feature in the mare was almost maniacal behaviour during the first 48h. Clinical pathological examination showed evidence of haemoconcentration, intravascular haemolysis, thrombocytopenia, azotaemia, rhabdomyolysis and hypoproteinaemia. Symptomatic treatment was initiated using intravenous fluids, anti-inflammatory drugs, histamine antagonists, analgesia and

antibiotics. The foal responded within 12h, but management of the mare was complicated by severe pain, generalised oedema, intrauterine haemorrhage, renal injury and later, recurrent fever. The most severe, acute effects of mass envenomation lasted for 3-4 days. Neither mare nor foal suffered any known lasting systemic effects of envenomation, although localised dermal necrosis resulted in white hairs at some sting sites and deformed ear tips in the foal. Conclusion Early recognition of clinical signs and treatment of toxic envenomation with an understanding of the physiological effects of hymenoptera venom can lead to a favourable outcome in horses receiving a non-lethal dose. Further case reports of the treatment of affected horses are needed to expand knowledge of how best to approach this rare, but serious intoxication.

Lui, C. L., et al. (1995). "Bee venom hypersensitivity and its management: patients' perception of venom desensitisation." Asian Pacific Journal of Allergy and Immunology 13(2): 95-100.

A self-administered, 9 item questionnaire was sent to 219 patients who had undergone either inpatient or outpatient bee (*Apis mellifera*) venom immunotherapy at Flinders Medical Centre, Adelaide, Australia. The clinic records of these patients were also reviewed. The controls for the genetic study were sought from patients, staff and students at Flinders University and Flinders Medical Centre. 146 questionnaires (some incomplete and anonymous) were received. The female to male ratio was 1:2.5. The age at the time of the initial anaphylactic reaction to a bee sting ranged between 2 to 59 years, with 67% of patients being <20 years old. 40% of patients underwent venom immunotherapy for <2 years with only 11% maintaining therapy for the recommended period of 5 years or more. 33% of patients stopped therapy themselves. Bee stings occurring during bee venom immunotherapy (n = 56) were generally well tolerated except in 8 subjects, 7 of whom had not reached the maintenance dose. The reduction in systemic reactions to subsequent bee stings was significantly better in the study group receiving bee venom than in an historic control group treated with whole bee extract (P = 0.03). Fear of bee stings and restricted life styles were improved during or after venom immunotherapy. The frequency of a positive family history of systemic reactions to bee stings in the patient cohort was 31%, whereas in controls it was 15% (P = 0.013). Bee venom immunotherapy has dual benefits: patients are protected from subsequent sting anaphylaxis and there is reduced psychological morbidity. However, to be effective, venom immunotherapy requires a prolonged period of carefully supervised treatment and each venom injection can cause local and systemic side effects. Genetic factors appear to be present in those patients who develop immediate hypersensitivity to bee stings.

Nagaratnam, N., et al. (1988). "Electrocardiographic changes following bee-sting anaphylaxis." Journal of the Royal Society of Medicine 81(7): 420-421.

A case report is given of a 29-year-old man who developed widespread electrocardiographic changes following a bee [*Apis mellifera*] sting. An electrocardiogram performed soon after arrival in hospital revealed widespread T wave inversion predominantly in the inferolateral leads. Eight weeks later the T waves were less negative and by 12 weeks the T waves were upright. The electrocardiographic changes in the patient were related to the intravenous adrenaline treatment, to the direct action of the bee venom on the myocardium or possibly to some endocardial ischemia in the face of hypotension following the anaphylactic reaction.

Riches, K. J., et al. (2002). "An autopsy approach to bee sting-related deaths." Pathology 34(3): 257-262.

Although severe reactions to the sting of the common honey bee (*Apis mellifera*) are a common problem in Australia, reported deaths are uncommon, with the estimated mortality varying from one to four persons each year. The following study presents the post-mortem findings in three cases of bee sting fatality, including one in which no observable sting was found. An autopsy approach to such cases is detailed. Over-reporting of bee sting-related deaths may occur due to the inclusion of deaths unrelated to a reaction to bee venom, while under-reporting may be due to unexplained deaths where a history of a bee sting is not available or apparent at autopsy. A classification of bee sting-related deaths is proposed, which would allow more accurate reporting of bee sting-related fatalies. A serum tryptase and specific IgE to bee venom on serum obtained at autopsy can assist in confirming anaphylactic reaction to bee venom as the cause of death, particularly in the absence of observable stings. Although there are limitations to the usefulness of serum tryptase tests in the post-mortem situation, it may still be useful to confirm suspected anaphylaxis in autopsy cases with an undetermined cause of death.

Roberts-Thomson, P. J., et al. (1985). "Bee sting anaphylaxis in an urban population of South Australia." Asian Pacific Journal of Allergy and Immunology 3: 161-164.

The clinical manifestations and circumstances of bee sting anaphylaxis were studied retrospectively in 98 subjects. Most reactions occurred in children, but the most severe reactions were seen in adult males, of whom 7 lost consciousness and 2 required cardiopulmonary resuscitation. Most stings causing anaphylaxis occurred on unprotected feet when the subject was on the lawn in the afternoons in December, January and February when the maximum daily temperature was 20-30 degrees C. However, a significantly greater frequency of anaphylactic reactions occurred at higher temperatures when bees were less active, suggesting that high environmental temperature may predispose the individual to greater exposure to bees or possibly to anaphylactic reactions per se. The presence of atopy did not appear to predispose subjects to bee venom hypersensivity. Considerable anxiety and alteration in lifestyle were identified in some subjects. The alleviation of this anxiety is considered an appropriate indication for bee venom immunotherapy.

Southcott, R. V. (1973). "Survey of injuries to man by Australian terrestrial arthropods." Survey of injuries to man by Australian terrestrial arthropods.: 165-pp.

This review of the literature on injuries to man by arthropods in Australia includes the results of questionnaires sent out by the author. The arthropods causing fatalities in man are stated for practical purposes to be honey bees (*Apis mellifera* L.), social wasps of the genera Polistes and Vespula, Ixodes holocyclus Neum., the Sydney funnel web spider (Atrax robustus P.-Camb.) and possibly other species of Atrax, and Latrodectus mactans (F.) (hasseltii Thorell). Only two fatalities have been attributed to scorpions, and the cause of death was apparently not proved in either. The arthropods that cause injury are dealt with in some detail.

Stuckey, M., et al. (1982). "Bee venom hypersensitivity in Busselton." Lancet 2(8288): 41-41.

Of 3679 persons completing a questionnaire in the Busselton Health Survey in Western Australia, only 7% admitted to a previous reaction of any type to venom of bees [*Apis mellifera* L.]. However, when 3439 of this group were subsequently examined using the radioallergosorbent test (RAST), a positive result was obtained for 16% of the total population and for 46% of those with a previous reaction. The evidence indicated that the nature of the reaction (severe or local) was not important in relation to specific IgE antibody; the findings suggest that at least 15% of the population will have IgE antibodies to bee sting at any given time. The high frequency of previous reactions in the RAST-negative group might be explained as a decline in antibody with time. The authors consider it is reasonable to assume that a much larger proportion of the population will have been sensitised at one time or another. Since bee stings are seldom fatal, the predictive value of a positive history and/or test will be very low if only fatal reactions are considered.

Tibballs, J. (2017). "Envenomation by Australian Hymenoptera: ants, bees, and wasps." Clinical toxicology in Australia, Europe, and Americas: 253-277.

The venoms of the order Hymenoptera, comprising ants, bees, and wasps, contain numerous toxic substances including a vast array of peptides, which serve to cause cell lysis and disrupt intracellular processes. Australia has numerous indigenous species of all Hymenoptera, but the imported European honeybee (*Apis mellifera*) and the European wasp (Vespula germanica) have added significantly to the burden of allergic reactions expected principally from stings by members of the indigenous ant genus Myrmecia. Although Hymenoptera toxins from multiple stings may damage organs and tissues especially muscle, hepatic, and renal and disrupt coagulation, a large number of toxins are allergenic and share significant homology between species and between bees and wasps. The overwhelming clinical effects of humans are allergic reactions varying from minor local inflammation to life-threatening IgE-mediated anaphylaxis which tends to progress with repeated venom exposures. However, a state of immune tolerance may be achieved by regimens of repeated exposure to small quantities of venoms or recombinant allergens (venom immunotherapy). The diagnosis, monitoring, and prediction of the immunoreactivity of individual allergic victims are major difficulties in clinical management but facilitated with wider adoption of serum tryptase measurement and new techniques of in vitro basophil activation testing.

Wanstall, J. C. and I. S. d. l. Lande (1974). "Fractionation of bulldog ant venom." Toxicon 12(6): 649-655.

Sephadex-gel filtration of the venom of an Australian bulldog ant, Myrmecia pyriformis F.Sm., yielded an enzyme-free fraction which possessed smooth muscle stimulant, red-cell lysing and histamine-releasing activities and resembled the main peptide melittin in the venom of bees [*Apis mellifera* L.].

Westall, G. P., et al. (2001). "Adverse events associated with rush Hymenoptera venom immunotherapy." Medical Journal of Australia 174(5): 227-230.

A retrospective descriptive case study was conducted to determine the incidence and nature of adverse events associated with the induction of rush Hymenoptera venom immunotherapy. The study was conducted at the asthma and allergy unit of a major metropolitan teaching hospital in Melbourne, Victoria in Australia, between 1 January 1989 and 30 June 1999. Participants included all patients with anaphylaxis to stings of Hymenoptera insects who received rush venom immunotherapy as inpatients. Outcome measures were hypersensitivity reactions to venom administration, including angioedema, skin rashes, hypotension and asthma, as well as any other adverse events related to the inpatient stay. 68 venom-allergic patients received 73 courses of rush immunotherapy; 89% were desensitized to honey bee venom, 10% to yellow jacket wasp venom, and one to paper wasp venom. Hypersensitivity reactions occurred after 36 subcutaneous injections (3.8% of all injections given) in 26 patients (38%). In our cohort, immunotherapy was accompanied by a high incidence of adverse systemic events during the induction phase. Immunotherapy should only be given by experienced staff in centres where there are facilities for resuscitation.

Wilson, J. D. and S. D. Somerfield (1981). "Desensitisation for bee sting reactions." New Zealand Medical Journal 93(686): 430-431.

Evidence is presented from a review of investigations in various countries that there is no advantage for bee [*Apis mellifera* L.] body extracts for desensitisation for bee sting reactions in man.

Honey

(1976). "Honey, a comprehensive survey."608pp.

This book covers the whole subject of honey: its plant sources, production, composition, marketing, legislations, world production and trade, manifold uses and its consumption throughout history, each aspect being treated by an expert in the field. The most important exporters of honey are Argentina, Mexico, People's Republic of China, Australia and the USA, while the largest importers are West Germany, Switzerland, the UK, France, Italy, Belgium, the Netherlands and Japan. However, tariffs and import regulations are obstacles to the further development of international trade in honey, and it is felt that more co-operation between exporters and importers is desirable.

Albietz, J. M. and L. M. Lenton (2015). "Standardised antibacterial Manuka honey in the management of persistent post-operative corneal oedema: a case series." Clinical & experimental optometry 98(5): 464-472.

BACKGROUND: Corneal oedema is a common post-operative problem that delays or prevents visual recovery from ocular surgery. Honey is a supersaturated solution of sugars with an acidic pH, high osmolarity and low water content. These characteristics inhibit the growth of micro-organisms, reduce oedema and promote epithelialisation. This clinical case series describes the use of a regulatory approved Leptospermum species honey ophthalmic product, in the management of post-operative corneal oedema and bullous keratopathy., METHODS: A retrospective review of 18 consecutive cases (30 eyes) with corneal oedema persisting beyond one month after single or multiple ocular surgical procedures (phacoemulsification cataract surgery and additional procedures) treated with Optimel Antibacterial Manuka Eye Drops twice to three times daily as an adjunctive therapy to conventional topical management with corticosteroid, aqueous suppressants, hypertonic sodium chloride five per cent, eyelid hygiene and artificial tears. Visual acuity and central corneal thickness were measured before and at the conclusion of Optimel treatment., RESULTS: A temporary reduction in corneal epithelial oedema lasting up to several hours was observed after the initial Optimel instillation and was associated with a reduction in central corneal thickness, resolution of epithelial microcysts, collapse of epithelial bullae, improved corneal clarity, improved visualisation of the intraocular structures and improved visual acuity. Additionally, with chronic use, reduction in punctate epitheliopathy, reduction in central corneal thickness and improvement in visual acuity were achieved. Temporary stinging after Optimel instillation was experienced. No adverse infectious or inflammatory events

occurred during treatment with Optimel., CONCLUSIONS: Optimel was a safe and effective adjunctive therapeutic strategy in the management of persistent post-operative corneal oedema and warrants further investigation in clinical trials. Copyright © 2015 The Authors. Clinical and Experimental Optometry © 2015 Optometry Australia.

Albietz, J. M. and K. L. Schmid (2017). "Randomised controlled trial of topical antibacterial Manuka (*Leptospermum* species) honey for evaporative dry eye due to meibomian gland dysfunction." Clinical & experimental optometry 100(6): 603-615.

BACKGROUND: The aim was to evaluate the efficacy of standardised Manuka (Leptospermum species) antibacterial honey as adjunctive twice daily treatment to conventional therapy (warm compresses, lid massage and preservative-free lubricant), in participants with evaporative dry eye due to moderate to advanced meibomian gland dysfunction., METHODS: This prospective, open-label study involved 114 participants. After two weeks of conventional therapy participants were randomised to one of three treatment groups: Optimel Antibacterial Manuka Eye Gel (98 per cent Leptospermum species honey) plus conventional therapy (n = 37), Optimel Manuka plus Lubricant Eye Drops (16 per cent Leptospermum species honey) plus conventional therapy (n = 37) and a control (conventional therapy) (n = 40). Clinical evaluations performed at baseline and Week 8 included: symptom scores (Ocular Surface Disease Index, Ocular Comfort Index), daily lubricant use, tear assessments (break-up time, secretion, osmolarity and InflammaDry), corneal sensation, ocular surface staining, meibomian gland secretion quality and expressibility, bulbar conjunctival, limbal and lid marginal redness and eyelid marginal bacterial cultures and colony counts., RESULTS: Significant improvements ($p <= 0.05$) occurred at Week 8 in symptoms, tear break-up time, staining, tear osmolarity, meibum quality and bulbar, limbal and lid margin redness for all treatments. Improvement in staining was significantly greater with Optimel 16 per cent drops ($p = 0.035$). Significant improvements ($p < 0.05$) in meibomian gland expressibility and InflammaDry occurred for both Optimel treatments. Optimel 98 per cent gel was significantly more effective in improving meibum quality ($p = 0.005$) and gland expressibility ($p = 0.042$). Total eyelid marginal bacterial colony counts reduced significantly with Optimel 16 per cent drops ($p = 0.03$) but not the other treatments. Staphylococcus epidermidis counts reduced significantly with Optimel 16 per cent drops ($p = 0.041$) and Optimel 98 per cent gel ($p = 0.027$). Both Optimel treatments significantly reduced the need for lubricants, with Optimel 16 per cent drops decreasing lubricant use most ($p = 0.001$). Temporary redness and stinging were the only adverse effects of Optimel use., CONCLUSIONS: Optimel antibacterial honey treatments are effective as adjunctive therapies for meibomian gland dysfunction. Copyright © 2017 Optometry Australia.

Allan, L. F. (1994). "Consumers expect their food to be safe. A food handlers' guide for beekeepers." Australasian beekeeper 95(11): 463-469.

The implementation of the Hazard Analysis and Critical Control Point (HACCP) system to honey production and processing is described, giving for each operation the potential hazards, monitoring procedures (Critical Control Points) and suitable preventative measures. The HACCP system is a form of quality assurance used in the wider food industry, and its use is recommended for beekeepers wishing to comply with new food hygiene regulations in Western Australia.

Allen, K. L. and P. C. Molan (1997). "The sensitivity of mastitis-causing bacteria to the antibacterial activity of honey." New Zealand Journal of Agricultural Research 40(4): 537-540.

Seven mastitis pathogens (*Actinomyces pyogenes, Klebsiella pneumoniae, Nocardia asteroides, Staphylococcus aureus, Streptococcus agalactiae, S. dysgalactiae* and *S. uberis*) of cows were tested for their sensitivity to the antibacterial activity of honey. The growth of all pathogens was completely inhibited by Rewarewa honey (*Knightia excelsa*, with antibacterial activity attributed to its content of hydrogen peroxide) at a concentration of 10% (v/v) in agar plates, and 2 were inhibited by 5% Rewarewa honey. Six species were completely inhibited by Manuka honey (*Leptospermum scoparium*, with antibacterial activity attributed to its content of a non-peroxide component) at a concentration of 5% (v/v). Only 1 species was inhibited by 10% (v/v) artificial honey (containing sugars and gluconic acid as in natural honey). It is concluded that as honey is harmless to tissues and leaves no undesirable residues in milk, it may be of interest for us in clinical mastitis therapy.

Allen, K. L., et al. (1991). "A survey of the antibacterial activity of some New-Zealand honeys." Journal of Pharmacy and Pharmacology 43(12): 817-822.

To assess the variation in antibacterial activity of honey a survey was carried out on 345 samples of unpasteurized honey obtained from commercial apiarists throughout New Zealand. Most of the honeys were considered to be mono-floral, from 26 different floral sources. The honeys were tested against *Staphylococcus aureus* in an agar well diffusion assay, with reference to phenol as a standard. Antibacterial activity was found to range from the equivalent of < 2% (w/v) phenol to 58% (w/v) phenol, with a median of 13.6 and a standard deviation of 12.5. Neither the age of the honey samples nor whether they had been processed by the apiarist was associated with lower activity. However, the difference between floral sources in the antibacterial activity was very highly significant. Kanuka (*Kunzea ericoides* (A. Rich.) J. Thompson. Family: Myrtaceae), manuka (*Leptospermum scoparium* J. R. et G. Forst. Family: Myrtaceae), ling heather (*Calluna vulgaris* (L.) Hull. Family: Ericaceae) and kamahi (*Weinmannia racemosa* Linn. f. Family: Cunoniaceae) were shown to be sources likely to give honey with high antibacterial activity. When antibacterial activity was assayed with catalase added to remove hydrogen peroxide, most of the honeys showed no detectable antibacterial activity. Only manuka and vipers bugloss (*Echium vulgare* L. Family: Boraginaceae) honeys showed this type of activity in a significant proportion of the samples. The high antibacterial activity of manuka honey was in many cases due entirely to this non-peroxide component.

Allsopp, K. A. and J. C. Brand Miller (1996). "Honey revisited: the role of honey in pre-industrial diets." Proceedings of the Nutrition Society of Australia 20: 97-97.

Anand, S., et al. (2019). "*Agastache* honey has superior antifungal activity in comparison with important commercial honeys." Scientific Reports 9: 14-14.

There is an urgent need for new effective antifungal agents suitable for the treatment of superficial skin infections, since acquired resistance of fungi to currently available agents is increasing. The antifungal activity of mono-floral *Agastache* honey and commercially available honeys were tested against dermatophytes (*T. mentagrophytes* and *T. rubrum*) and *C. albicans* (ATCC 10231 and a clinical isolate) by agar well diffusion and micro-dilution (AWD and MD). In AWD and MD assays, *Agastache* honey was effective at 40% concentration against dermatophytes (zone diameter, 19.5-20 mm) and *C. albicans* with the same MIC and MFC values indicating fungicidal activity. Tea tree honey was effective at 80% concentration (zone diameter, 14 mm) against dermatophytes and at 40% concentration against *T. mentagrophytes* and *C. albicans*. Manuka was effective at 80% concentration only against *T. mentagrophytes* (zone diameter, 12 mm) and at 40% against *T. rubrum* and *C. albicans* with fungistatic activity. Similar to the AWD results, Jelly bush, Super Manuka, and Jarrah showed no activity against dermatophytes but showed some activity against *C. albicans*. Headspace volatiles of six honeys were isolated by SPME and identified by GC-MS. The characteristic chemical markers for each honey were as follows: Agastache- Phenol, 2,4-bis(1,1-dimethylethyl) and Estragole; Manuka and Tea-tree-Acetanisole and Methyl 3,5-dimethoxybenzoate; Jelly bush-Linalool and Nonanal; Super Manuka-Methyl 3,5-dimethoxybenzoate and Nonanal; Jarrah- Isophorone and Nonanoic acid. Overall, analysis of the bioactive compound content and antifungal activity of Agastache honey indicated possible use as an antifungal agent for management of superficial fungal infections.

Anand, S., et al. (2018). "Characterization of Physico-Chemical Properties and Antioxidant Capacities of Bioactive Honey Produced from Australian Grown *Agastache rugosa* and its Correlation with Colour and Poly-Phenol Content." Molecules (Basel, Switzerland) 23(1).

The antioxidant and antimicrobial components of honey vary based on sourced of nectar. Medicinal plants with the therapeutic value have potential to produce honey with greater bioactivity. The aim of the present study was to characterize the physico-chemical and antioxidant capacities of *Agastache* honey produced from *Agastache rugosa* and compare them with other popular commercial honeys sold in Australia. The total phenolics, total flavonoids, moisture content, colour, pH, protein content and antioxidant capacity were evaluated for Agastache, Manuka, Jelly bush, Tea tree, Super manuka and Jarrah honeys. The results reveal that the moisture content ranged from 17-21%, pH ranged from 3.8-4.3 and estimated protein content ranged from 900-2200 microg/g. The DPPH*, ABTS*+, ORAC and FRAP methods were used to measure the antioxidant capacity of the honey samples. The DPPH*

% inhibition, ABTS*+, ORAC and FRAP values for Agastache honey were 9.85 (+/-1.98 micromol TE/g), 26.88 (+/-0.32 micromol TE/g), 19.78 (+/-1.1 micromol TE/g) and 3.61 (+/-0.02 micromol TE/g) whereas the highest antioxidant capacity values obtained were 18.69 (+/-0.9 micromol TE/g), 30.72 (+/-0.27 micromol TE/g), 26.95 (+/-0.9 micromol TE/g) and 3.68 (+/-0.04 micromol TE/g), respectively. There was a positive correlation between colour, total phenolic content and DPPH* scavenging activity for most of the honeys except Tea tree honey. However, there was no clear correlation with ABTS*+, ORAC and FRAP values. The measured antioxidant capacity of samples varied with the assays used. The DPPH* assay clearly indicated that the phenolic compounds contribute to the scavenging activity of the honeys. Nevertheless, all assays confirm that Agastache honey has significant antioxidant capacity. Therefore, Agastache honey can be important to human nutrition and health.

Anonymous (2001). "Australian honey-based product is effective against resistant bacteria." Manufacturing Chemist 72(5): 11-11.

Anonymous (2014). "Manuka Honey Labelling Guide: "Positive Step for NZ"." World Food Regulation Review 24(3): 10-10.

The Interim Labelling Guide for Manuka Honey released on July 31 by the Ministry for Primary Industries (MPI) is a positive step for the New Zealand industry, according to Food Safety Minister, Nikki Kaye. The Guide provides clarification on what constitutes manuka-type honey, and aims to ensure that New Zealand is producing quality manuka honey that is labelled correctly and meets the expectations of overseas regulators, along with consumers here and overseas, said Kaye. The MPI says it will be working with honey companies to help them comply with the new Guide.

Anonymous (2017). "MPI "Taking More Time" to Finalise Manuka Honey Definition." World Food Regulation Review 27(3): 14-15.

The Ministry for Primary Industries (MPI) is pausing its finalisation of the definition for manuka honey until the end of the year. They have decided to take more time to fully consider the alternative definition industry provided during consultation, said Director Systems Audit, Assurance and Monitoring, Allan Kinsella. They will ask the industry to provide all the data and methodology that supports the definition they are proposing so it can be fully considered. MPI's focus has always been on ensuring the rules for exporting of manuka honey are based on a robust and accurate scientific definition.

Anonymous (2018). "Consultation Opens on Whether Domestic Manuka Honey Should Meet Export Standard." World Food Regulation Review 28(2): 22-22.

The New Zealand Government said July 23 that it wants to hear from manuka honey producers and consumers on whether the honey produced and sold in New Zealand should meet similar requirements to exported manuka honey. Agriculture and Food Safety Minister, Damien O'Connor, opened the consultation at the Apiculture New Zealand conference and trade exhibition in Blenheim the same day. In December 2017, the Ministry for Primary Industries introduced a robust scientific definition for exported New Zealand manuka honey to safeguard the industry from cowboy operators and protect New Zealand's trade reputation.

Anonymous (2018). "New Information Leads to a Small Change in Manuka Honey Definition." World Food Regulation Review 27(8): 20-21.

The New Zealand Ministry for Primary Industries (MPI) has reissued the General Requirements for Bee Products Export Notice. The revised Notice adjusts the level of a chemical marker known as 2'-MAP from greater than or equal to 5 mg/kg, to greater than or equal to 1 mg/kg for the definition for multifloral manuka honey. There is no change to the definition for monofloral manuka honey, which remains at equal or greater than 5mg/kg for 2'-MAP. The implementation date of the notice remains Feb 5, 2018. The change means that the legal claim challenging the definition by New Zealand Beekeeping has been resolved.

Arbuckle, J. (2017). "Severe allergic rhinitis, perennial sinusitis and antihistamine dependence resolved with naturopathic treatment: A case study and short literature review." Australian Journal of Herbal Medicine 29(4): 142-148.

Allergic rhinitis is very common in Australia, and 20% of those who suffer from this also have perennial sinusitis. Histamine release is what causes inflammation and the commonly experienced symptoms of nasal congestion, runny nose, sneezing, itchy nose, throat and palate, as well as watery, itchy and red eyes. There is a small amount of clinical evidence for the use of honey in these cases; however, a low histamine diet may also improve patients' symptoms and little research has been done to confirm the effectiveness of naturopathic interventions. This paper presents a case of severe allergic rhinitis, perennial sinusitis and antihistamine dependence where naturopathically prescribed nutritional supplements, herbal medicines, honey and a low histamine diet had an improvement on the patient's symptoms and pharmaceutical antihistamine reliance sustained for at least two years.

Armitage, M. (2015). "Manuka honey trademark options." Grocer: 22-22.

The article reports on the legal dispute between New Zealand makers of manuka honey and others around the world over the manuka honey trademark amid claims that some are producing it without the nectar of *Leptospermum scoparium*, a manuka bush native to New Zealand.

Astwood, K., et al. (1998). "Oligosaccharides in New Zealand honeydew honey." Journal of agricultural and food chemistry. 46(12): 4958-4962.

A series of oligosaccharides based upon successive addition of glucose (1 leads to 4) to the glucopyranosyl residue of sucrose and another series similar to the first but with the final residue linked (1 leads to 6) have been isolated from New Zealand honeydew honey and fully characterized. Because the trisaccharide in this series is erlose, it is inferred that the honeydew of the indigenous scale insect, *Ultracoelostoma assimile*, which lives upon the Southern beech, *Nothofagus* spp., is of the erlose type. These oligosaccharides and others have been quantified by GC and LC in six New Zealand honeydew honeys.

Balan, P., et al. (2016). "Synergistic and additive antimicrobial activities of curcumin, Manuka honey and Whey proteins." Journal of Food Biochemistry 40(5): 647-654.

Antimicrobial activity of curcumin, Manuka honey (MH, *Leptospermum scoparium*) and Whey protein isolate (WPI) and their synergistic and/or additive effects were tested against various Gram positive and negative bacterial strains for development of functional foods. Curcumin and MH each displayed 100% inhibition against all the tested strains of bacteria. The minimum inhibitory concentration values of curcumin and honey against different strains ranged from 100 to 250 mg/mL and 5-20% respectively. Except *Bacillus subtilis*, all other tested pathogens were completely inhibited by the mixture of subinhibitory concentrations of curcumin and MH. At these levels, the mixture of MH and WPI was more effective against *Streptococcus pyogenes, Shigella soneii* and *Proteus vulgaris*. Mixture of curcumin and WPI completely inhibited the growth of Listeria monocytogenes and Staphylococcus aureus. Combinations of curcumin, MH and WPI had additive and/or synergistic antimicrobial activities and various combinations could be used in food formulations and pharmacological applications. PRACTICAL APPLICATIONS Turmeric, honey and whey proteins are widely consumed all over the world, and have been associated with multiple health benefits. Synergistic and/or additive antimicrobial effects of curcumin, Manuka honey (MH) and whey protein isolate (WPI) were tested against various Gram positive and negative bacterial strains for development of functional foods. Curcumin and MH each showed complete inhibition against all the tested bacterial strains. These in vitro investigations demonstrate that combinations of curcumin, MH and WPI have potent antibacterial activities. To our knowledge, this is the first of such outcomes to be reported. The implication of the results of this study is that Curcumin, MH and WPI in various combinations could be used as a food supplement and also in pharmacological applications.

Bale, M. D. (1967). "A study of the marketing of New Zealand honey." Disc. Pap. Dep. Agric. Econ. Fm Mgmt., Massey Univ. Palmerston North, N. Z.(48): 71-pp.

About 80 per cent. of New Zealand's honey is sold privately, and the remainder by the Honey Marketing Authority (HMA), which has sole export rights. The HMA is also induced to compete on the domestic market by the higher internal market price; this tends to lower real returns within New Zealand and reduce export earnings. It is suggested then that the HMA opt out of the local market and concentrate on bulk exports to the UK. Through liaison with a major New Zealand board honey might be sold as a quality commodity; exports to the rest of the world and comb honey exports would then be left open to licenced private packers. The HMA could also operate in this capacity, while retaining its function of setting a " floor price " and continuing to collect a deals levy for financing industry promotion.

Balick, M. J. (2011). "Manuka Honey." Organic Gardening 58(4): 32-34.

The article discusses the value of manuka honey, which comes from the manuka tree native to New Zealand and southeast Australia, in treating infected wounds. The University of Waikato's Honey Research Unit in New Zealand had discovered that manuka honey contains high levels of non-peroxide antibacterial compounds, which allow it to heal wounds better than honeys with low levels of hydrogen peroxide. The Waikato Honey Research Unit had also developed the Unique Manuka Factor (UMF) scale for measuring antibacterial activity in manuka honey.

Bang, L. M., et al. (2003). "The effect of dilution on the rate of hydrogen peroxide production in honey and its implications for wound healing." Journal of Alternative and Complementary Medicine 9(2): 267-273.

Objective: Honey is an effective antiseptic wound dressing, mainly the result of the antibacterial activity of hydrogen peroxide that is produced in honey by the enzyme glucose oxidase. Because the rate of production of hydrogen peroxide is known to vary disproportionately when honey is diluted, and dilution of honey dressings will vary according to the amount of wound exudate, it is important to know more about the production of hydrogen peroxide at different concentrations of honey. Design: The rates of hydrogen peroxide production by honey with respect to honey dilution were measured in eight different samples of honey from six different floral sources. Settings: Honey Research Unit, Waikato University, Hamilton, New Zealand. Main Results: The maximum levels of accumulated hydrogen peroxide occurred in honey solutions diluted to concentrations between 30% and 50% (v/v) with at least 50% of the maximum levels occurring at 15-67% (v/v). This is equivalent to a 10x10 cm dressing containing 20 ml of honey becoming diluted with 10 to 113 ml of wound exudate. Maximum levels of hydrogen peroxide reached in the diluted honeys were in the range of 1-2 mmol/litre. Conclusion: Significant antibacterial activity can be maintained easily when using honey as a wound dressing, even on a heavily exuding wound. Concentrations of hydrogen peroxide generated are very low in comparison to those typically applied to a wound; thus cytotoxic damage by hydrogen peroxide is very low.

Batt, P. J. and A. Liu (2012). "Consumer behaviour towards honey products in Western Australia." British Food Journal 114(2): 285-297.

Purpose - This paper aims to explore the factors impacting and influencing the consumer's decision to purchase honey in a retail store. Design/methodology/approach - Data were collected from shopping mall intercepts in Perth, Western Australia, using a structured questionnaire. Exploratory factor analysis was used to identify the principal constructs which most influence the consumer's decision to purchase. On the basis of the ways in which honey was consumed within the household, cluster analysis was utilised to group the respondents into meaningful segments. Findings - In Perth, Western Australia, honey is primarily consumed as a spread or a sweetener on breakfast cereals and porridge. However, honey is also used as a marinade, in cakes and cookies and as a beverage. According to the way in which honey is consumed in the household, five clusters were identified. In purchasing honey from a retail store, exploratory factor analysis revealed three principal constructs which were most influential in the consumer's decision to purchase: brand reputation, origin and value for money. Ethnicity was found to have a significant influence on the way in which honey was consumed in the household and the importance of the three

constructs extracted. Originality/value - This is one of the few studies that find a significant difference between Anglo Saxon and Asian consumers of honey.

Beasley, D. M. (2008). "A recent outbreak of honey poisoning linked to the Tutu plant (*Coriaria arborea*)." Clinical Toxicology 46(7): 617-618.

Background: The Tutu plant (*Coriaria arborea*) of New Zealand contains tutin, similar to picrotoxin in structure and toxicity. This involves antagonism of inhibitory gamma-aminobutyric acid (GABA) receptors, with resultant CNS stimulation causing seizures amongst other effects. Direct human poisoning is sporadic, but can occur from uninformed consumption by hikers including tourists. There is also recognised risk of secondary poisoning. The "vine hopper" (Scolypopa australis) feeds on tutu and deposits a "honey dew", rich in the metabolite hydroxytutin (hyenanchin). With drought conditions (and inappropriately located hives), bees are drawn to this source, with risk of producing contaminated honey. One teaspoonful may be toxic. Case Report: An outbreak (mid-March 2008) of "toxic honey" poisoning occurred in one area, due to the interplay of these factors. This is being investigated and managed by the relevant authorities, and some data including full clinical reports are not yet available. The source has been linked to one apiary, which has withdrawn its honey from sale. Three index cases developed vomiting and two (including a young child) later had seizures requiring treatment By month's end, at least twenty people had become ill. Questions were raised regarding the kinetics of tutin, its possible effects in pregnancy, and fitness for driving of those having seizures. Case Discussion: This appears a relatively small outbreak. There is very limited data on the kinetics of tutin, even experimentally, but its elimination seems prompt. Earlier reports suggest its more obvious effects typically last no more than a few days, and that appears borne out by this episode. "One-off" toxin-induced seizures should not be subject to the same degree of restriction as that for epilepsy in general, but case-by- case assessment is indicated. Fetal exposures will be followed up. Conclusion: This outbreak illustrates that even quite well-known environmental hazards can resurface when climatic risk factors increase and/or controls lapse slightly. The impending clinical reports should provide more insight into the features of tutin (and hyenanchin) poisoning, including the range of effects, times to onset and duration of symptoms, and clinical course and prognosis.

Beasley, M., et al. (2018). "Poisoning due to tutin in honey - a report of an outbreak in New Zealand." New Zealand Medical Journal 131(1473): 59-66.

AIM: In autumn 2008, an outbreak of toxic honey poisoning was identified. The outbreak was not recognised initially until three cases from one family group presented to hospital, with a common factor of recent consumption of locally produced honey. The aim of this study was to investigate potential cases of this honey poisoning and determine which toxin was involved. METHOD: The incident was investigated retrospectively by Waikato District Health Board's Population Health unit and the New Zealand Food Safety Authority (NZFSA). Identified patients were followed up by questionnaire to gather case information. HortResearch (now Plant and Food Research) tested honey samples for toxins. RESULTS: The causative agent was identified as tutin, which comes from the New Zealand native plant tutu (*Coriaria arborea*) which has long been known as a potential source of contamination of honey produced in the warmer parts of New Zealand. Retrospective case investigation identified a total of 22 possible or probable cases, based on a clinical case definition. The spectrum of toxic effects reported were broadly similar to those previously described for tutin, derived either directly from the plant itself or indirectly from honey. There were 13 samples of honey, linked to symptomatic individuals, which were available for testing. Of these, 10 were positive for tutin and its hydroxy metabolite hyenanchin (hydroxytutin) and one was positive for hyenanchin alone. CONCLUSION: Toxic honey production is a significant risk in parts of New Zealand. Beekeepers and health professionals need to be informed of this risk and know how best to manage it. Due to this poisoning incident, public and professional awareness of honey poisoning has been substantially enhanced. This incident led to development of new food safety standards for New Zealand honey.

Beckh, G. and C. Lullmann (1998). "Phenol as a natural component in New Zealand honeydew honeys." Phenol - ein naturlicher Bestandteil neuseelandischen Waldhonigs? 94(5): 149-152.

Many different phenolic substances are known as characteristic components of honey responsible for the honey-specific or source-specific flavour and taste. Phenol itself is generally considered as a residue of bee repellents. Maximum limits for phenol in honey are discussed between experts and the trade. In New Zealand honeydew honeys produced by the beech scale insect, *Ultracoelostoma assimile* on *Nothofagus* sp., phenol can be found at concentrations up to 0.2 ppm. Phenol in small amounts (<0.2 ppm) should be considered as a natural component of this type of honey. The origin of phenols in honeys are discussed.

Beiranvand, S., et al. (2020). "Use of kinetic data to model potential antioxidant activity: Radical scavenging capacity of Australian *Eucalyptus* honeys." Food Chemistry: 128332-128332.

Antioxidant activity of honeys may be beneficial in wound healing processes by protecting cells against lipid oxidation. The DPPH assay assesses the efficacy of antioxidant molecules to reduce DPPH* to DPPHH. Studies determining EC50 are limited by single time-point determinations of antioxidant effect and can miss vital information about the rate of antioxidant response. Acquisition of kinetic data allows determination of the radical scavenging capacity (RSC) of honeys. The purpose of this study was to determine the RSC of 53 honeys from 16 species of Australian *Eucalyptus* trees and four samples of New Zealand manuka (Leptospermum scoparium) honey. Whereas honeys could not be differentiated based on EC50 values, significant differences were observed for RSC, supporting collection of kinetic data for honey analysis. The greatest RSC was observed for New Zealand manuka (4.6 +/- 0.3 x 10-5 mg.mL-1.min-1), grey ironbark (E. paniculate; 3.4 +/- 0.2 x 10-5 mg.mL-1.min-1) and river red gum honeys (*E. camaldulensis*; 3.2 +/- 0.2 x 10-5 mg.mL-1.min-1).

Beitlich, N., et al. (2014). "Differentiation of manuka honey from kanuka honey and from jelly bush honey using HS-SPME-GC/MS and UHPLC-PDA-MS/MS." Journal of Agricultural and Food Chemistry 62(27): 6435-6444.

In the present study, pollen-identical pure manuka and kanuka honeys and an Australian jelly bush honey were analysed for the non-volatiles by UHPLC-PDA-MS/MS and for the volatiles by HS-SPME-GC/MS. A chromatographic profile matchup by means of characteristic marker compounds achieved a clear discrimination between manuka, kanuka, and jelly bush honey. UHPLC-PDA profiles of manuka honey show leptosin, acetyl-2-hydroxy-4-(2-methoxyphenyl)-4-oxobutanate, 3-hydroxy-1-(2-methoxyphenyl)-penta-1,4-dione, kojic acid, 5-methyl-3-furancarboxylic acid, and two unknown compounds as prominent, kanuka honey was characterized by 4-methoxyphenyllactic acid, methyl syringate, p-anisic acid, and lumichrome. 2-Methylbenzofuran, 2'-hydroxyacetophenone, and 2'-methoxyacetophenone were markant volatiles for manuka honey, whereas kanuka honey was characterized by 2,6,6-trimethyl-2-cyclohexene-1,4-dione, phenethyl alcohol, p-anisaldehyde, and an unknown compound in HS-SPME-GC/MS. The jelly bush honey differed from the manuka honey by higher contents of 2-methoxybenzoic acid and an individual unknown substance in the PDA profile and by lower intensities of 2'-methoxyacetophenone, higher concentrations of cis-linalool oxide, and 3,4,5-trimethylphenol in the HS-SPME-GC/MS profile.

Beitlich, N., et al. (2016). "Fluorescent pteridine derivatives as new markers for the characterization of genuine monofloral New Zealand manuka (Leptospermum scoparium) honey." Journal of Agricultural and Food Chemistry 64(46): 8886-8891.

New Zealand manuka honey is well-known for its unique antibacterial activity. Due to its high price and limited availability, this honey is often subject to honey fraud. Two pteridine derivatives, 3,6,7-trimethyl-2,4(1H,3H)-pteridinedione and 6,7-dimethyl-2,4(1H,3H)-pteridinedione, have now been identified in New Zealand manuka honey. Their structures were elucidated by LC-QTOF-HRMS, NMR, and single-crystal X-ray diffraction after isolation via semipreparative HPLC. Their marker potential for authentic manuka honey was proved as both substances were detectable in neither the pollen-identical kanuka honey nor the nine other kinds of monofloral New Zealand honey analysed (clover, forest, kamahi, pohutukawa, rata, rewarewa, tawari, thyme, and vipers bugloss). The fluorescence property of the pteridine derivatives can be used as an easy and fast TLC screening method for the authentication of genuine manuka honey. 6,7-Dimethyl-2,4(1H,3H)-pteridinedione has been described for the first time.

Beitlich, N. and K. Speer (2017). "Manuka honey authentication via fingerprinting and statistics." Abstracts of Papers American Chemical Society 254: 182-182.

Belton, M. (1979). "Beech scale insect: the place of the beech scale insect (*Ultracoelostoma assimile*) in the ecology of mountain beech forest." Apiarist(8): 4-6.

The distribution of *U. assimile* particularly in northern South Island, New Zealand, and its effect in draining sap from the tree, are discussed. The theoretical standing crop of honeydew can be calculated; under dry conditions, removal of honeydew droplets by birds and insects increases the rate of flow. In some forest areas it is possible to introduce 10 colonies of honeybees/ha, and to harvest at least 60 kg honey/colony. In forests where honeydew flow is restricted to a small area, introduction of many hives might deprive birds and local insects of their main energy source. P. Walker

Bhandari, B., et al. (1999). "Rheology of selected Australian honeys." Journal of food engineering. 41(1): 65-68.

The viscosity property of seven varieties of commercial Australian honeys (yellow box, tea tree, leatherwood, red gum, iron bark, strawberry clover and creamed) were analysed over a range of temperatures (4-30 degrees C). All of these honey varieties exhibited Newtonian behaviour. The temperature effect on the viscosity followed an Arrhenius-type relationship. The activation energy ranged from approx. 1250-1850 J/g mole.

Bischofberger, A. S., et al. (2011). "A preliminary study on the effect of Manuka honey on second-intention healing of contaminated wounds on the distal aspect of the forelimbs of horses." Veterinary Surgery 40(7): 898-902.

Objective: To determine the effect of manuka honey on second-intention healing of contaminated, full-thickness skin wounds in horses. Study Design: Experimental. Animals: Adult Standardbred horses (n = 8). Methods: One wound was created on the dorsomedial aspect of the third metacarpus in both forelimbs, contaminated with feces, and bandaged for 24 hours. Bandages were removed and wounds rinsed with isotonic saline solution. Wounds on 1 limb had manuka honey applied daily (n = 8) whereas wounds on the contralateral limb received no treatment (n = 8). Bandages were replaced and changed daily for 12 days, after which treatment stopped, bandages were removed, leaving wounds open to heal. Wound area was measured 24 hours after wound creation (day 1), then weekly for 8 weeks. Overall time for healing was recorded. Wound area and rate of healing of treated and control wounds were compared statistically. Results: Treatment with manuka honey decreased wound retraction and treated wounds remained significantly smaller than control wounds until day 42; however, there was no difference in overall healing time between treatment and control wounds. Conclusions: Treatment with manuka honey reduced wound area by reducing retraction but did not affect overall healing time of full-thickness distal limb wounds using this wound-healing model.

Bischofberger, A. S., et al. (2013). "The effect of short- and long-term treatment with Manuka honey on second intention healing of contaminated and noncontaminated wounds on the distal aspect of the forelimbs in horses." Veterinary Surgery 42(2): 154-160.

Objectives To compare the effects of manuka honey and manuka honey gel on second intention healing of noncontaminated distal limb wounds and those contaminated with feces. Study Design Experimental study. Animals Standardbred horses (n = 10). Methods Five full-thickness wounds (2 x 2 cm) were created on both metacarpi. Wounds on 1 forelimb were covered with horse feces for 24 hours. Wounds on the contralateral limb were left uncontaminated. Wounds were assigned to the following 5 different treatments: manuka honey, manuka honey gel or gel applied for 12 days, manuka honey gel applied throughout healing and untreated control. Wound area was measured on day 1 then weekly until day 42 and time to complete healing was recorded. Results Wounds treated with manuka honey gel throughout healing healed faster than all other wounds ($P < .05$). Wounds treated with manuka honey and manuka honey gel for 12 days healed faster than gel control and untreated control wounds ($P < .05$). Wounds treated with manuka honey and manuka honey gel for 12days and throughout healing were smaller than gel control and untreated control wounds until day 35 ($P < .05$). Wounds contaminated with feces had greater retraction for 7 days, but healed faster than noncontaminated wounds ($P < .05$). Conclusions Treatment of wounds

with manuka honey and manuka honey gel reduced wound retraction and overall healing time compared with gel and untreated control wounds.

Blair, S. E., et al. (2009). "The unusual antibacterial activity of medical-grade Leptospermum honey: antibacterial spectrum, resistance and transcriptome analysis." European Journal of Clinical Microbiology & Infectious Diseases 28(10): 1199-1208.

There is an urgent need for new, effective agents in topical wound care, and selected honeys show potential in this regard. Using a medical-grade honey, eight species of problematic wound pathogens, including those with high levels of innate or acquired antibiotic resistance, were killed by 4.0-14.8% honey, which is a concentration that can be maintained in the wound environment. Resistance to honey could not be induced under conditions that rapidly induced resistance to antibiotics. Escherichia coli macroarrays were used to determine the response of bacterial cells to a sub-lethal dose of honey. The pattern of gene expression differed to that reported for other antimicrobial agents, indicating that honey acts in a unique and multifactorial way; 78 (2%) genes were upregulated and 46 (1%) genes were downregulated more than two-fold upon exposure to the medical-grade honey. Most of the upregulated genes clustered into distinct functional regulatory groups, with many involved in stress responses, and the majority of downregulated genes encoded for products involved in protein synthesis. Taken together, these data indicate that honey is an effective topical antimicrobial agent that could help reduce some of the current pressures that are promoting antibiotic resistance.

Bong, J., et al. (2017). "Leptosperin is a distinct and detectable fluorophore in Leptospermum honeys." Food chemistry. 214(214): 102-109.

New Zealand manuka (*Leptospermum scoparium*) honey exhibits two unique fluorescence signatures that distinguish it from other honey types. One of these is the MM1 fluorescence marker (270-365nm excitation-emission) which we show is due to a Leptospermum nectar-derived compound, leptosperin. Synthetic or honey-purified leptosperin not only displayed an identical fluorescence spectrum, but supplementation of leptosperin into clover or artificial honeys generated the MM1 fluorescence signature. There was a quenching effect of the honey matrix on leptosperin fluorescence but otherwise leptosperin was chemically stable over prolonged storage at 37AdegreeC. Leptosperin was also present in the woody-fruited Australian Leptospermum species at elevated concentrations but virtually absent in *Leptospermum subtenue* suggesting its elevated expression developed following the mid-Miocene separation of the genus. These findings suggest that fluorescence spectroscopy could offer a rapid and high-throughput screening method for identification of Leptospermum honeys using the MM1 fluorescence marker.

Bong, J., et al. (2016). "Fluorescence markers in some New Zealand honeys." Food chemistry. 192(192): 1006-1014.

The fluorescence characteristics of various New Zealand honeys were investigated to establish if this technique might detect signatures unique to manuka (*Leptospermum scoparium*) and kanuka (*Kunzea ericoides*) honeys. We found unique fluorescence profiles for these honeys which distinguished them from other New Zealand honey floral types. Two excitation-emission (ex-em) marker wavelengths each for manuka and kanuka honeys were identified; manuka honey at 270-365 (MM1) and 330-470 (MM2) nm and kanuka honey at 275-305 (KM1) and 445-525 (KM2) nm. Dilution of manuka and kanuka honeys with other honey types that did not possess these fluorescence profiles resulted in a proportional reduction in fluorescence signal of the honeys at the marker wavelengths. By comparison, rewarewa (*Knightia excelsa*), kamahi (*Weinmannia racemosa*), and clover (*Trifolium* spp.) honeys did not exhibit unique fluorescence patterns. These findings suggest that a fluorescence-based screening approach has potential utility for determining the monoflorality status of manuka and kanuka honeys.

Bong, J., et al. (2018). "New approach: chemical and fluorescence profiling of NZ honeys." Food chemistry. 267(267): 355-367.

New Zealand manuka (*Leptospermum scoparium*) and kanuka (*Kunzea ericoides*) honeys contain a unique array of chemical markers useful for chemical fingerprinting. We investigated the presence of 13 potential marker compounds in nectars of the major honey crop species. We confirmed that leptosperin, lepteridine, 2--

methoxyacetophenone, and 2-methoxybenzoic acid are exclusive to manuka nectar whereas lumichrome is unique to kanuka nectar. 3-Phenyllactic acid and 4-hydroxyphenyllactic acid are present in manuka and kanuka nectars. Leptosperin, lepteridine, 3-phenyllactic acid, and 4-hydroxyphenyllactic acid are chemically stable over prolonged storage, but not 2-methoxybenzoic acid and 2--methoxyacetophenone. Accordingly, leptosperin and lepteridine are definitive chemical markers for authentication of manuka honey. An optimal concentration cut-off was established for the floral source-specific markers: leptosperin (94mg/kg), lepteridine (2.1mg/kg), 2--methoxyacetophenone (2.0mg/kg) for manuka honey, and lumichrome (4.5mg/kg) for kanuka honey. The use of leptosperin and lepteridine as fluorescence markers for manuka honey authentication is reinforced.

Boontaganon, P., et al. (2011). "Characterisation of manuka honey produced in New Zealand based on pollen analysis, peroxide content and antioxidant activities." Australasian Medical Journal 4(12): 760-760.

Background New Zealand manuka honey is recognised for its highly effective antimicrobial activity due to its hydrogen peroxide and antioxidant content. To be classified as a manuka honey it should contain more than 70% manuka pollen, unfortunately many honey brands sold in New Zealand do not reach this minimum standard. Objective To investigate the hydrogen peroxide content, antioxidant activity and other characteristics of manuka honey produced in New Zealand. To compare composition of manuka honey to clover honey. Design Seventy-four honey samples produced in New Zealand were analysed for pollen, moisture, total acidity, total phenols, peroxide, glucose, fructose, HMF contents, pH, colour, conductivity value and antioxidant activities. Outcomes Thirty-nine honey samples were labelled as pure manuka, 9 samples were labelled as manuka blends, while the remaining samples were clover (25) and tawari. From the pollen counts, only 17 samples could be classified as manuka honey. The pollen in 35 of the remaining samples was predominantly manuka pollen but this was less than 70%. Twenty-two samples were clover. For all of the parameters measured, there was no significant difference ($P<0.01$) between the true manuka honeys and the blends containing manuka. Peroxide values ranged from 1.2-11.7 mug/g/h and antioxidant activity (ORAC) ranged from 3.6-14.5 mumol trolox equivalent/g. The total phenolic content of manuka honey was significantly ($P<0.0001$) correlated to both the ORAC activity ($r=0.672$) and colour ($r=0.874$). Total phenolics and peroxide content in true manuka honey was significantly different to those in clover honey ($P<0.01$) whereas there was no significant difference in antioxidant activity and other parameters between these honeys. Conclusion The labelling of manuka honey is often poor. Honeys with greater than 70% manuka pollen did not significantly differ from manuka blends (<70%) in the chemical parameters that were measured here. Manuka honey had significantly higher total phenolics and peroxide content than clover honey.

Bouzo, D., et al. (2020). "Characterizing the Mechanism of Action of an Ancient Antimicrobial, Manuka Honey, against *Pseudomonas aeruginosa* Using Modern Transcriptomics." MSystems 5(3).

Manuka honey has broad-spectrum antimicrobial activity, and unlike traditional antibiotics, resistance to its killing effects has not been reported. However, its mechanism of action remains unclear. Here, we investigated the mechanism of action of manuka honey and its key antibacterial components using a transcriptomic approach in a model organism, *Pseudomonas aeruginosa*. We show that no single component of honey can account for its total antimicrobial action, and that honey affects the expression of genes in the SOS response, oxidative damage, and quorum sensing. Manuka honey uniquely affects genes involved in the explosive cell lysis process and in maintaining the electron transport chain, causing protons to leak across membranes and collapsing the proton motive force, and it induces membrane depolarization and permeabilization in P. aeruginosa. These data indicate that the activity of manuka honey comes from multiple mechanisms of action that do not engender bacterial resistance. IMPORTANCE The threat of antimicrobial resistance to human health has prompted interest in complex, natural products with antimicrobial activity. Honey has been an effective topical wound treatment throughout history, predominantly due to its broad-spectrum antimicrobial activity. Unlike traditional antibiotics, honey-resistant bacteria have not been reported; however, honey remains underutilized in the clinic in part due to a lack of understanding of its mechanism of action. Here, we demonstrate that honey affects multiple processes in bacteria, and this is not explained by its major antibacterial components. Honey also uniquely affects bacterial membranes, and this can be exploited for combination therapy with antibiotics that are otherwise ineffective on their own. We argue that honey should be included as part of the current array of wound treatments due to its effective antibacterial activity that does not promote resistance in bacteria.

Brady, N. (1997). "Report on the research project: finding New Zealand honeys with outstanding antibacterial and antifungal activity." New Zealand beekeeper 4(10): 20-26.

During 1995-1997, 179 samples of unifloral honeys from 27 different plant sources (other than manuka, *Leptospermum scoparium*) were collected from throughout New Zealand. They were tested for antimicrobial activity against *Staphylococcus aureus, Escherichia coli, Candida albicans* and *Trichophyton mentagrophytes* var. *mentagrophytes*, using agar well diffusion assay or a turbidimetric assay. No honey showed any non-peroxide antimicrobial activity, but 3 types showed outstanding hydrogen peroxide antibacterial properties: pennyroyal, *Mentha pulegium* (Lamiaceae), rewarewa, *Knightia excelsa* (Proteaceae) and honeydew honey from *Nothofagus solandri* (Fagaceae). The possible use of such honeys for therapeutic purposes is discussed.

Brady, N., et al. (2004). "A survey of non-manuka New Zealand honeys for antibacterial and antifungal activities." Journal of apicultural research. 43(2): 47-52.

Braithwaite, I., et al. (2015). "Randomised controlled trial of topical kanuka honey for the treatment of rosacea." BMJ Open 5(6): e007651-e007651.

Objective: To investigate the efficacy of topical 90% medical-grade kanuka honey and 10% glycerine (Honevo) as a treatment for rosacea. Design Randomised controlled trial with blinded assessment of primary outcome variable. Setting: Outpatient primary healthcare population from 5 New Zealand sites. Participants: 138 adults aged >=16, with a diagnosis of rosacea, and a baseline blinded Investigator Global Assessment of Rosacea Severity Score (IGA-RSS) of >=2. 69 participants were randomised to each treatment arm. 1 participant was excluded from the Honevo group, and 7 and 15 participants withdrew from the Honevo and control groups, respectively. Interventions: Participants were randomly allocated 1:1 to Honevo or control cream (Cetomacrogol), applied twice daily for 8 weeks. Main outcome measures The primary outcome measure was the proportion of participants who had a >=2 improvement in the 7-point IGA-RSS at week 8 compared to baseline. Secondary outcomes included change in IGA-RSS and subject-rated visual analogue score of change in severity (VAS-CS) on a 100 mm scale (0 mm 'much worse', 100 mm 'much improved') at weeks 2 and 8. Results 24/68 (34.3%) in the Honevo group and 12/69 (17.4%) in the control group had a >=2 improvement in IGA-RSS at week 8 compared to baseline (relative risk 2.03; 95% CI 1.11 to 3.72, p=0.020). The change in IGA-RSS for Honevo compared to control at week 2 minus baseline was -1 (Hodges-Lehman estimate, 95% CI -1 to 0, p=0.03), and at week 8 minus baseline was -1 (Hodges-Lehman estimate, 95% CI -1 to 0, p=0.005). The VAS-CS at week 2 was 9.1 (95% CI 3.5 to 14.7), p=0.002, and at week 8 was 12.3 (95% CI 5.7 to 18.9), p<0.001 for Honevo compared to control. Conclusions: Honevo is an effective treatment for rosacea.

Briscoe, D. A. (1979). "Toxic honeydew of the North Island [New Zealand]." Apiarist(7): 3-5.

From the plant *Coriaria arborea*.

Broom, S. J., et al. (1992). "Synthesis of (+/-)-E-4-(1,2,4-trihydroxy-2,6,6-trimethylcyclohexyl)-but-3-en-2-one: a novel degraded carotenoid isolated from New Zealand thyme (Thymus vulgaris) honey." Tetrahedron letters. 33(22): 3197-3200.

A racemic synthesis of the title compound is described starting from beta-ionone. The key steps involve selective hydroboration of a triene, followed by molybdenum mediated epoxidation of the resulting homoallylic alcohol with subsequent ring opening of the epoxide to give the title compound.

Broom, S. J., et al. (1992). "Isolation and structural characterization of Kamahine C: an unusual spiroketal found in a native New Zealand honey." Tetrahedron letters. 33(41): 6201-6204.

The diethyl ether extract of honey from the flowers of the New Zealand native tree Kamahi (Weinmannia racemosa) has been found to contain three diastereoisomers of an unusual degraded carotenoid with a 14 carbon skeleton. After acetylation, one of the isomers, 1b, was fully characterised by multidimensional (1)H and (13)C NMR

spectroscopy and single crystal X-ray crystallography, showing that the parent alcohol (Kamahine C, 1a) was 4,5-dihydro-1',5-dihydroxy-2', 4,8',8'-tetramethylspiro[furan-2(3)H,7'[6]oxabicyclo-[3.2.1] oct[2]ene]-4'-one.

Bryant, T. G. (1977). "Thyme honey - liquid gold." New Zealand Journal of Agriculture 135(2): 19-21.

Over 600 colonies on the verge of starvation were moved from Southland to an area of Thymus vulgaris in Otago in spring, when beekeepers in Southland usually feed sugar to their colonies to build them up for the white clover flow. They produced a thyme honey surplus of 17 kg per colony, even after some honey had been taken to feed other colonies that remained in Southland. Thyme honey has a strong dominant flavour, so it was removed and stored in the comb, to be fed back to colonies later in place of sugar. This enabled all the (more commercially valuable) white clover honey to be extracted. The marketing of thyme honey is being contemplated. J. M. Gedye

Budgar, L. (2010). "Postcard from New Zealand." Natural Foods Merchandiser 31(5): 20-21.

The article features New Zealand, a country ready to break onto the natural products scene. It emphasizes the less intervention of New Zealand's products in their production. It also outlines seven reasons why these islands might just be the next natural products treasure trove including its dairy products, the manuka honey and the lambs.

Burke, J. (2012). "Pack it in!" Food Magazine: 13-13.

The article discusses a process developed by family-owned Australian business Maya Sunny Honey wherein authentic honey is created inside the jar it is sold in. The company uses a system in which bees create honeycombs in empty jars placed upside down on top of a beehive. The jars are then sealed and sold in supermarkets. The layer of the natural antibiotic propolis on top of the honey is described. The work done by the husband and wife team of Andrew and Joanna Wyszynski is also discussed.

Burns, D. T., et al. (2018). "A Critical Review of the Factors Available for the Identification and Determination of Manuka Honey." Food Analytical Methods 11(6): 1561-1567.

Methods for the determination of the authenticity of samples of manuka honey are reviewed. Suggestions are made as to how to authenticate, or otherwise, the label claims for a given sample of manuka honey.

Butcher, C. F. (1986). "Life history of *Ultracoelostoma assimile* (Maskell) (Margarodidae)." Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri 43(suppl.): 143-147.

The life history of a New Zealand margarodid is described. These insects are found in cysts on the bark of *Nothofagus* species, and produces "honey dew" used by bees to make "forest honey" which is becoming an important New Zealand export. There are four female stages and five male stages. Comparisons are made with other margarodid life histories.

Campbell, D. J., et al. (2017). "Infection prophylaxis in peritoneal dialysis patients: results from an Australia/New Zealand survey." Peritoneal Dialysis International 37(2): 191-197.

Background: Clinical practice guidelines aim to reduce the rates of peritoneal dialysis (PD)-related infections, a common complication of PD in end-stage kidney disease patients. We describe the clinical practices used by Australian and New Zealand nephrologists to prevent PD-related infections in PD patients. Methods: A survey of PD practices in relation to the use of antibiotic and antifungal prophylaxis in PD patients was conducted of practicing nephrologists identified via the Australia and New Zealand Society of Nephrology (ANZSN) membership in 2013. Results: Of 333 nephrologists approached, 133 (39.9%) participated. Overall, 127 (95.5%) nephrologists prescribed antibiotics at the time of Tenckhoff catheter insertion, 85 (63.9%) routinely screened for nasal S. aureus carriage, with 76 (88.4%) reporting they treated S. aureus carriers with mupirocin ointment. Following Tenckhoff catheter insertion, 79 (59.4%) prescribed mupirocin ointment at the exit site or intranasally, and 93 (69.9%) nephrologists routinely prescribed a course of oral antifungal agent whenever their PD patients were given a course

of antibiotics. Conclusions: Although the majority of nephrologists prescribe antibiotics at the time of Tenckhoff catheter insertion, less than 70% routinely prescribe mupirocin ointment and/ or prophylactic antifungal therapy. This variation in practice in Australia and New Zealand may contribute to the disparity in PD-related infection rates that is seen between units.

Cao, Y., et al. (2013). "Persistence of echimidine, a hepatotoxic pyrrolizidine alkaloid, from honey into mead." Journal of Food Composition and Analysis 29(2): 106-109.

Honey produced by bees foraging on *Echium plantagineum* is known to contain dehydropyrrolizidine alkaloids characteristic of the plant. Following a prolific growth of *E. plantagineum* in the wake of Australian bushfires, two samples of mead, a fermented drink made from honey, and the honey used to prepare the mead were analyzed for the presence of Echium-related dehydropyrrolizidine alkaloids. HPLC-esiMS and MS/MS analysis of the alkaloidal fractions obtained using strong cation exchange, solid phase extraction unequivocally confirmed the presence of echimidine, a major hepatotoxic dehydropyrrolizidine alkaloid produced by *E. plantagineum*, in the honey (780 ng/g) and in the subsequent mead samples (236-540 ng/mL). The results from this limited, and specifically targeted sample set, while not indicative of the extent of the presence of echimidine (or other dehydropyrrolizidine alkaloids) in meads, reinforce the need for a wider survey and perhaps subsequent routine monitoring to determine the potential contribution to long-term, low-level or intermittent exposure to these toxic alkaloids and consequent chronic disease development.

Carpinelli de Jesus, M., et al. (2019). "Pyrrolizidine Alkaloids of Blue Heliotrope (*Heliotropium amplexicaule*) and their Presence in Australian Honey." Journal of agricultural and food chemistry. 67(28): 7995-8006.

Blue heliotrope (*Heliotropium amplexicaule*) is an invasive environmental weed that is widely naturalized in eastern Australia and has been implicated as a source of pyrrolizidine alkaloid (PA) poisoning in livestock. Less well-documented is the potential of such carcinogenic alkaloids to contaminate honey from bees foraging on this plant species. In this study, the PA profile of H. amplexicaule plant material, determined by HRAM LC-MS/MS, revealed the presence of nine PAs and PA-N-oxides, including several PAs and PA-N-oxides of the indicine class, which have not previously been reported. The predominant alkaloid, indicine, represents 84% of the reduced PA content, with minor alkaloids identified as intermedine and the newly reported helioamplexine, constituting 7 and 9%, respectively. NMR analysis confirmed the identity of helioamplexine as a previously unreported indicine homologue. This is the first report of the isolation of intermedine, helioamplexine, and 3--O-angelylindicine from H. amplexicaule. Also described is the identification of N-chloromethyl analogues of the major alkaloids as isolation-derived artifacts from reactions with dichloromethane. Analysis of regional-market honey samples revealed a number of honey samples with PA profiles analogous to that seen in H. amplexicaule, with measured PA contents of up to 2.0 I1/4g of PAs per gram of honey. These results confirm the need for honey producers to be aware of H. amplexicaule as a potential PA source, most particularly in products where honey is sourced from a single location.

Carson, C. F. and T. V. Riley (2003). "Non-antibiotic therapies for infectious diseases." Antimicrobial resistance in Australia 27(Supplement): S143-S146.

The emergence of multiple antibiotic resistant organisms in the general community is a potentially serious threat to public health. The emergence of antibiotic resistance has not yet prompted a radical revision of antibiotic utilization. Instead it has prompted the development of additional antibiotics. Unfortunately, this does not relieve the underlying selection pressure that drives the development of resistance. A paradigm shift in the treatment of infectious disease is necessary to prevent antibiotics becoming obsolete and, where appropriate, alternatives to antibiotics ought to be considered. There are already several non-antibiotic approaches to the treatment and prevention of infection including probiotics, phages and phytomedicines. There is some evidence that probiotics such as Lactobacillus spp. or Saccharomyces boulardii are useful in the prevention and treatment of diarrhoea, including Clostridium difficile-associated diarrhoea that can be difficult to treat and recurs frequently. Bacteriophages have received renewed attention for the control of both staphylococcal and gastrointestinal infections. Phytomedicines that have been utilized in the treatment of infections include artesunate for malaria, tea

tree oil for skin infections, honey for wound infections, mastic gum for Helicobacter pylori gastric ulcers and cranberry juice for urinary tract infections. Many infections may prove amenable to safe and effective treatment with non-antibiotics.

Casey, G. and A. v. Rij (1997). "Manuka honey and leg ulcers." New Zealand Medical Journal 110(1045): 216-216.

In response to a paper by B. Wood et al. [New Zealand Medical Journal, 110, 107 (1997)] on the use of Manuka [Leptospermum] honey as a dressing for leg ulcers, the authors question several issues: the desirability of any topical antimicrobial in the care of chronic wounds; the possible damage to cells in the granulation tissue and delay in healing from the reputed acidity, hydrogen peroxide and hyperosmolarity of Manuka honey; the lack of control groups to compare the course or rate of healing of Manuka honey with other dressings; and failure to address the underlying aetiologies of the ulcers.

Chan, C. W., et al. (2013). "Analysis of the flavonoid component of bioactive New Zealand manuka (*Leptospermum scoparium*) honey and the isolation, characterisation and synthesis of an unusual pyrrole." Food Chemistry 141(3): 1772-1781.

The flavonoid components of New Zealand manuka (Leptospermum scoparium) honey have been quantified in a series of 31 honeys of varying non-peroxide antibacterial activity to clarify discrepancies between previous studies reported in the literature. Total flavonoid content was 1.16 mg/100 g honey. The principal flavonoids present were pinobanksin, pinocembrin, luteolin and chrysin and together these represented 61% of the total flavonoid content. 1, 2-formyl-5-(2-methoxyphenyl)-pyrrole, which was weakly correlated with the non-peroxide antibacterial activity, was isolated from the flavonoid fraction and separately synthesised. 1 did not display inhibitory activity against Staphylococcus aureus in vitro and thus the origin of the correlation, which is still unknown, is not a direct contribution.

Chancellor, A. M. (2013). "A bitter-sweet tale from the land of milk and honey." Practical Neurology (BMJ Publishing Group) 13(3): 185-187.

Chandler, B. V. (1977). "Quality of Australian honeys." CSIRO Food Research Quarterly 37(1): 1-9.

Summary of AA 845/75.

Chandler, B. V., et al. (1974). "Composition of Australian honeys." Technical Paper, Division of Food Research, CSIRO, Australia(38): 39-pp.

Chemical analyses were conducted on 99 Australian honeys, 60 from eucalypt flora, 18 from non-eucalypt Australian flora, and 21 from exotic flora. The samples were drawn from all the major honey-producing regions in Australia and represented over 60 floral sources. Less complete analyses were carried out on 58 commercial samples of blended and pure Australian honeys and on 32 samples of imported honeys. Results are given for individual samples. The pure honeys in each of the floral source categories showed general uniformity in chemical composition; honeys from indigenous sources (mainly tree flora) resembled each other more than they resembled the honeys from exotic sources (mainly ground flora). Marked similarities were noted in the composition of Australian and USA honeys from ground flora. It is thought that very few eucalypt honeys would have difficulty meeting the quality standards of importing countries, although honeys from *Eucalyptus scabra*, *E. leucoxylon* and *E. melliodora* may be discriminated against because of their high sucrose contents. Non-eucalypt honeys from *Xanthorrhoea preissii*, *Banksia grandis*, *Banksia menziesii* and *Calothamnus sanguineus* could also be rejected by overseas markets because of their unusual carbohydrate composition. Three exotic honeys did not satisfy quality standards. J.M. Gedye

Chen, C., et al. (2012). "The effect of standard heat and filtration processing procedures on antimicrobial activity and hydrogen peroxide levels in honey." Frontiers in Microbiology 3.

There is increasing interest in the antimicrobial properties of honey. In most honey types, antimicrobial activity is due to the generation of hydrogen peroxide (H2O2), but this can vary greatly among samples. Honey is a complex product and other components may modulate activity, which can be further affected by commercial processing procedures. In this study we examined honey derived from three native Australian floral sources that had previously been associated with H2O2-dependent activity. Antibacterial activity was seen in four red stringybark samples only and ranged from 12 to 21.1% phenol equivalence against Staphylococcus aureus. Antifungal activity ranged from MIC values of 19-38.3% (w/v) against *Candida albicans*, and all samples were significantly more active than an osmotically equivalent sugar solution. All honey samples were provided unprocessed and following commercial processing. Processing was usually detrimental to antimicrobial activity, but occasionally the reverse was seen and activity increased. H2O2 levels varied from 0 to 1017 mu M, and although samples with no H2O2 had little or no antimicrobial activity, some samples had relatively high H2O2 levels yet no antimicrobial activity. In samples where H2O2 was detected, the correlation with antibacterial activity was greater in the processed than in the unprocessed samples, suggesting other factors present in the honey influence this activity and are sensitive to heat treatment. Antifungal activity did not correlate with the level of H2O2 in honey samples, and overall it appeared that H2O2 alone was not sufficient to inhibit *C. albicans*. We conclude that floral source and H2O2 levels are not reliable predictors of the antimicrobial activity of honey, which currently can only be assessed by standardized antimicrobial testing. Heat processing should be reduced where possible, and honey destined for medicinal use should be retested post-processing to ensure that activity levels have not changed.

Chen, L., et al. (2014). "Development of research on quality evaluation of Manuka honey." Journal of Food Safety and Quality 5(10): 2967-2971.

Manuka honey is a kind of valuable honey, which exists uniquely in New Zealand. Because of it has unique non-peroxide antibacterial activity, the nutritional and health functions are powerful, Manuka honey has occupied an increasingly large proportion in the honey imported into China. But the research on manuka honey in China is very few. This will severely affect the supervision on imported Manuka honey. Manuka honey is quality evaluated and graded according to the antibacterial activity, thus the prices of different graded Manuka honey are very different. Recently, the events about Manuka honey adulteration are reported more often. Such as the false labeling of the antibacterial activity grade, even there is no antibacterial activity in "Manuka honey". This suggests that the research on Manuka honey is needed and the criterion should been worked out. In this paper, the research on non-peroxide antibacterial activity and methylglyoxal, which are the key parameters used in quality evaluation of Manuka honey, is reviewed. Moreover, the determination of carbon-4 plant sugars in honey and the screening of characteristics markers in Manuka honey for adulteration identification are discussed.

Chen, L., et al. (2014). "[Determination of methylglyoxal in Manuka honey of New Zealand by high performance liquid chromatography]." Se pu = Chinese journal of chromatography 32(2): 189-193.

An HPLC method was developed for the determination of methylglyoxal in Manuka honey of New Zealand. The honey sample was dissolved in water and mixed with o-phenylenediamine solution for derivatization. After the reaction for at least 8 h in the dark at room temperature, the solution was filtered with 0.22 microm membrane and injected into an HPLC system for analysis. The separation was carried out on a Kromasil reversed phase column with gradient elution. The mobile phases were methanol and 0. 1% (v/v) acetic acid aqueous solution. The detection wavelength was 318 nm. The external standard method was used for quantitation. The linear range of methylglyoxal was 1-50 mg/L with a correlation coefficient of 0. 999 9. The LOD (S/N = 3) and LOQ (S/N = 10) were 0.02 mg/L and 0.06 mg/L, respectively. The recoveries at the spiked levels of 50, 100, 200 mg/kg were 98.3%-101.5% and the RSDs (n = 5) were less than 5%. The derivative of methylglyoxal was stable within 24 h. The results showed that the pretreatment of this method is simple and the sensitivity, the recovery and repeatability are good. This method can be used for the quality control of Manuka honey of New Zealand, and also for the detection of methylglyoxal in Chinese honey.

Chen, M., et al. (2014). "Quantitative Analysis of Neonicotinoid Insecticide Residues in Foods: Implication for Dietary Exposures." Journal of agricultural and food chemistry. 62(26): 6082-6090.

This study quantitatively measured neonicotinoids in various foods that are common to human consumption. All fruit and vegetable samples (except nectarine and tomato) and 90% of honey samples were detected positive for at least one neonicotinoid; 72% of fruits, 45% of vegetables, and 50% of honey samples contained at least two different neonicotinoids in one sample, with imidacloprid having the highest detection rate among all samples. All pollen samples from New Zealand contained multiple neonicotinoids, and five of seven pollens from Massachusetts detected positive for imidacloprid. These results show the prevalence of low-level neonicotinoid residues in fruits, vegetables, and honey that are readily available in the market for human consumption and in the environment where honeybees forage. In light of new reports of toxicological effects in mammals, the results strengthen the importance of assessing dietary neonicotinoid intakes and the potential human health effects.

Chepulis, L. and E. Francis (2013). "The glycaemic index of Manuka honey." e-SPEN, the European e-journal of clinical nutrition and metabolism. 8(1): e21-e24.

BACKGROUND & AIMS: Rates of obesity and diabetes are increasing in Western populations, and it is suggested that these diseases can be moderated, in part, by consuming foods that produce a low blood sugar response. Anecdotally honeys are thought to be comparable to simple sugars for sweetness and glycaemic response, although little is currently known about the medically beneficial Manuka honey from New Zealand. The aim of this study was to measure the glycaemic index (GI) of five samples of Manuka honey from different geographic origins. METHODS: Five high methylglyoxal (460667pmg/kg) Manuka honey samples were selected from different geographical locales around the North Island of NZ and tested for GI in 10 healthy volunteers in a single-blinded, randomised study. Participants were fed honey containing 25pg of available carbohydrate in 200pml water and the blood glucose responses measured (incremental area under the curve; IAUC) and compared to that of 25pg of available carbohydrate from glucose. RESULTS: All five honey samples were shown to have moderate GI values (5459), although variation amongst the group was high. CONCLUSIONS: The GI of five Manuka honeys tested was in the moderate range, being 5459. This study is registered under Clinical Trials.gov Identifier number NCT01615588.

Chernyshev, A. and T. Braggins (2020). "Investigation of Temporal Apparent C4 Sugar Change in Manuka Honey." Journal of Agricultural & Food Chemistry 68(14): 4261-4267.

New Zealand manuka honeys are known for their propensity to increase apparent C4 sugar content during storage. Depending on the particular storage regime and the initial content of dihydroxyacetone (DHA) in honey, the ready-to-market product often fails the C4 sugar test because of the above phenomenon. We have used DHA labeled with a radioactive C-14 isotope in a set of honeys subject to an incubation experiment. These honeys were analyzed for DHA, methylglyoxal (MG), hydroxymethylfurfural (HMF), apparent C4 sugars, and C-14 scintillation counts over a period of 18 months. The major conclusion of this experiment is that neither DHA nor MG is responsible for the delta C-13 shift in the honey protein extract. There must be some other yet unknown substance of manuka honey, which binds to the protein and causes negative delta C-13 shift. One identified candidate for such a binding is carbon dioxide.

Clemons, R. (2015). "Sugar, by any other name." Choice: 5-5.

The article discusses the recommendations on improving added sugar labelling in the nutrition information panel (NIP) of food ingredients in Australia. Topics discussed include several names used for added sugar such as dextrose, maltose, and honey, the proposal of the U.S. Food and Drug Administration (FDA) to include an added sugar percentage-of-daily-intake value in the NIP, and the technical advice provided by the governmental body Food Standards Australia New Zealand to ministers.

Clinch, P. G. and J. C. Turner (1975). "Estimation of tutin and hyenanchin in honey. Part 3. Toxicity of honey samples from test hives." New Zealand Journal of Science 18(3): 323-328.

Cokcetin, N. N., et al. (2016). "The Antibacterial Activity of Australian *Leptospermum* Honey Correlates with Methylglyoxal Levels." PLoS One 11(12): e0167780-e0167780.

Most commercially available therapeutic honey is derived from flowering *Leptospermum scoparium* (manuka) plants from New Zealand. Australia has more than 80 Leptospermum species, and limited research to date has found at least some produce honey with high non-peroxide antibacterial activity (NPA) similar to New Zealand manuka, suggesting Australia may have a ready supply of medical-grade honey. The activity of manuka honey is largely due to the presence of methylglyoxal (MGO), which is produced non-enzymatically from dihydroxyacetone (DHA) present in manuka nectar. The aims of the current study were to chemically quantify the compounds contributing to antibacterial activity in a collection of Australian Leptospermum honeys, to assess the relationship between MGO and NPA in these samples, and to determine whether NPA changes during honey storage. Eighty different Leptospermum honey samples were analysed, and therapeutically useful NPA was seen in samples derived from species including *L. liversidgei* and *L. polygalifolium*. Exceptionally high levels of up to 1100 mg/kg MGO were present in *L. polygalifolium* honey samples sourced from the Northern Rivers region in NSW and Byfield, QLD, with considerable diversity among samples. There was a strong positive relationship between NPA and MGO concentration, and DHA was present in all of the active honey samples, indicating a potential for ongoing conversion to MGO. NPA was stable, with most samples showing little change following seven years of storage in the dark at 4 degrees C. This study demonstrates the potential for Australian Leptospermum honey as a wound care product, and argues for an extension of this analysis to other Leptospermum species.

Cook, V. A. (1973). "Potential for honey production." New Zealand Journal of Agriculture 126(5): 53-54.

Honey production in S. Island, New Zealand, increased from 11 800 tons in 1963-1967 to 13 700 tons in 1968-1972. There might be scope for 20 000 additional hives, producing 800 tons, largely by increasing the size of existing apiaries. Yields in the Canterbury area have decreased recently, but a new market is being now established with beech honeydew honey. J.M. Gedye

Cook, V. A. (1981). "New Zealand honeydew from beech [*Nothofagus*]." Bee World 62(1): 20-22.

At present 10 000 colonies work this flow, but it is still much underexploited.

Cooke-Yarborough, R. E. (1963). "The honey industry in New South Wales." Review of Marketing and Agricultural Economics 31(1): 5-39.

Australia is one of the leading honey producers and exporters in the world, with the second highest yield per hive. This report analyzes 207 questionnaires returned out of the 576 sent to commercial beekeepers in a postal survey about production and marketing practices. It has been possible to determine the type of sites used; the type and range of apiary equipment; the manner in which honey is extracted and prepared for marketing; and the type of containers and outlets used by beekeepers when disposing of their honey. U.N.E.

Craig, J. P., et al. (2020). "Randomized masked trial of the clinical efficacy of MGO Manuka Honey microemulsion eye cream for the treatment of blepharitis." The ocular surface 18(1): 170-177.

PURPOSE: To assess the clinical efficacy of a novel MGO Manuka Honey microemulsion (MHME) eye cream for the management of blepharitis., METHODS: Fifty-three participants (32 females, 21 males; mean +/- SD age, 60 +/- 12 years) with clinical signs of blepharitis were enrolled in a prospective, investigator-masked, randomized, paired-eye trial. The MHME eye cream (Manuka Health New Zealand) was applied to the closed eyelids of one eye (randomized) overnight for 3 months. Visual acuity, ocular surface characteristics, symptoms and tear film parameters were assessed at baseline, day 30, and day 90. Eyelid swab microbiology cultures were evaluated at baseline and day 90., RESULTS: Baseline measurements did not differ between treated and control eyes (all $p > 0.05$). Significant reductions in SANDE and SPEED symptomology scores were detected in treated eyes on days 30 and 90 (all $p < 0.05$), while clinical improvements in non-invasive tear film breakup time, lipid layer thickness, and inferior lid

wiper epitheliopathy were observed on day 90 (all p < 0.05). Following the 3-month treatment period, ocular Demodex, Corynebacterium macginleyi, Propionibacterium acnes, and Staphylococcus epidermidis load decreased significantly in treated eyes (all p <= 0.001). There were no changes in visual acuity during the 90-day period (all p > 0.05), and no major adverse events were reported., CONCLUSION: Topical overnight application of the MHME eye cream effected significant improvements in ocular surface symptomology, tear film stability and lipid layer thickness, and reduced lid margin staining, ocular Demodex and bacterial load. The favourable clinical efficacy and tolerability profile suggests promise for the MHME eye cream as a treatment for blepharitis management., TRIAL REGISTRATION NUMBER: ACTRN12616000539437.

Craig, J. P., et al. (2014). "In vivo rabbit tolerability and safety of a Manuka honey-based eye preparation for blepharitis." IOVS 55(13): 3668-3668.

Purpose: Methylglyoxal (MGO) derived from New Zealand's native Manuka honey (MH), demonstrates antibacterial properties that may be beneficial in the treatment of blepharitis. MH complexed with a-cyclodextrin increases bioavailability of the active ingredient (Manuka Honey CycloPower (TM) (MHCP), Manuka Health, NZ). With safety previously confirmed in vitro, this project sought to undertake in vivo safety testing of a novel formulation designed for topical eyelid application, containing MHCP in a microemulsion (ME) base. Methods: Six male NZ white rabbits were administered 20 mu l of 10% MHCP (100MGO) in ME to the right eye, (diluted 1: 10 in PBS as estimate of potential tear film contamination), and 20 mu l of saline (0.9% NaCl) to the left eye, instilled directly into the conjunctival sac daily, on 5 consecutive days. Tear film and ocular surface characteristics were compared before and after instillation, daily. Lipid layer grade, tear evaporation rate, osmolarity and production were assessed as well as ocular surface fluorescein staining, conjunctival hyperemia and corneal clarity. Subsequently, following washout, 20 mu l of undiluted formulation was instilled into one eye of each rabbit to confirm safety, and the ocular surface evaluated on the same day, after 0.5, 5 and 10 min. Results: No statistically or clinically significant changes in lipid grade, tear production, evaporation rate, fluorescein staining or hyperemia were observed in either eye, across the 5 days (Repeated measures ANOVA/Friedman, p>0.05). Mean osmolarity decreased following instillation of formulation and control drops, but excepting Day 1 for MHCP (p=0.027), differences were not statistically significant (p>0.05). Bulbar hyperemia and lowered tear osmolarity induced by the undiluted formulation returned to baseline levels within 10 min. Conclusions: Instilled at a concentration as high as 10% on 5 consecutive days, the MHCP formulation showed no significant adverse immediate or cumulative effects. Exposure to the tear film and ocular surface is unlikely to reach such high levels clinically when the preparation is applied topically to the eyelids. Instillation of the undiluted preparation, simulating accidental in-eye application, was transient and not associated with significant discomfort. The novel MHCP formulation appears safe and thus continues to show potential for development as a preparation for managing blepharitis.

Cramb, J. (1997). "Climatic influences on honey production." Australasian beekeeper 98(10): 406-412.

A graph shows average annual honey production per colony in Western Australia for the period from 1950 to 1992; values vary between 30 and 120 kg/colony. The low production in some years can be explained by climatic conditions and/or bush fires. Long-term records (1910-1989) show an overall decrease in rainfall. The effect of this trend and of possible future climatic changes are discussed.

Craymer, L. (2016). "New Zealand, Australia Fight Over Manuka Honey Pot." Wall Street Journal - Online Edition: 1-1.

Creasey, S. (2014). "Will new guidelines rein in manuka honey cowboys?" Grocer 237(8167): 16-16.

The article reports developments in the food industry in New Zealand as of early August 2014, particularly in the manuka honey segment. It cites the issuance by the New Zealand Ministry for Primary Industries (MPI) of new voluntary guidelines for manuka honey labelling called the Interim Labelling Guideline for Manuka Honey to set quality standards for manuka products. The opinions of Minerva Scientific's David Hoyland and Simon Kingston of New Zealand Honey Shop on the developments are cited.

Creasey, S. (2015). "Manuka honey: a murky mire. (cover story)." Grocer 238(8203): 26-32.

The article discusses the move by the journal in June 2014 to investigate whether the manuka honey products sold in Great Britain are authentic due to claims that some producers and retailers are engaging in food fraud. In the investigation, the journal commissioned honey testing laboratories Minerva Scientific to do the test. Also cited is the move by the New Zealand's Ministry for Primary Industries (MPI) to issue Interim Labelling Guidelines (ILG) to resolve labelling issues of manuka honey.

Creasey, S. (2016). "Manuka honey: why haven't New Zealand's guidelines worked?" Grocer: 24-27.

The article discusses whether the New Zealand Ministry for Primary Industries' (MPI) interim labeling guidelines have been successful in fighting the sale of fraudulent manuka honey worldwide. Topics discussed include the adoption of different abbreviations on manuka honey labels, industry members' claim that the guidelines are ineffective particularly in Great Britain, and non-compliance in the labeling guidelines.

Crozier, L. R. (1981). "Beech honeydew forest produce." New Zealand Journal of Forestry 26(2): 200-209.

New Zealand beech honeydew is a viscous, sugary substance excreted by a soft scale insect (Ultracoelostoma assimile), which commonly feeds on the sap of the New Zealand beeches (Nothofagus spp.). Honeydew nourishes sooty mold fungi, insects and nectar feeding birds, and is the source of honeydew honey, a readily saleable export commodity. Heavy infestations of scale insects occur on beech trees in the northern half of the South Island, decline with increasing altitude and are lower on the southern aspect of trees. Honeydew honey is distinguished from floral honey by its darker color, distinctive flavor and composition. There is potential for an increase in the production of honeydew honey which would enable the present level of export to Europe to be raised.

Culvenor, C. C. J., et al. (1981). "Pyrrolizidine alkaloids in honey from *Echium plantagineum* L." Journal of Agricultural and Food Chemistry 29(5): 958-960.

Honey produced from stands of *Echium plantagineum* [*E. lycopsis*] (Paterson's Curse or Salvation Jane) in NSW, Australia, contained pyrrolizidine alkaloids at levels between 0.27 and 0.95 ppm. The main alkaloid present was echimidine, with smaller amounts of 7-acetyllycopsamine, 7-acetylintermedine, echiumine, uplandicine, lycopsamine, intermedine, and a new alkaloid which is probably acetylechimidine. Author

Da Abel, S., et al. (2018). "Honey reduces the metastatic characteristics of prostate cancer cell lines by promoting a loss of adhesion." PeerJ.

Honey has been shown to have a range of therapeutic effects in humans, with anti-inflammatory and anti-bacterial effects among those previously characterised. Here, we examine the possibility of New Zealand thyme, manuka and honeydew honeys, and their major sugar and phenolic components, reducing the development of metastatic cancer. Their activity was examined in vitro, in PC3 and DU145 prostate cancer cell lines, through measuring the compounds' effects on the metastatic characteristics of migration, invasion and adhesion. First, the phenolic compounds gallic acid, caffeic acid, quercetin, kaempferol and chrysin were quantified in the honeys using high performance liquid chromatography, and found in nanomolar concentrations. In a Boyden chamber-based migration assay, non-toxic concentrations of thyme and honeydew honeys reduced cell migration by 20%, and all phenolic compounds except caffeic acid also lowered migration, although a mixture of only the sugars found in honey had no effect. All of the honeys, phenolics and the sugar-only mixture reduced invasive movement of cells through extracellular matrix by up to 75%. Most notably, each of the three honeys and the sugar-only mixture reduced cell adhesion to collagen I by 90%. With the exception of quercetin, phenolic compounds did not reduce adhesion. Therefore, honey and its sugar and phenolic components can lower the metastatic properties of cancer

cells, and may do this by preventing effective cell adhesion to the extracellular matrix. The sugars and phenol compounds of honey are much more effective in combination than individually.

Daher, S. and F. O. Gulacar (2010). "Identification of new aromatic compounds in the New Zealand manuka honey by gas chromatography-mass spectrometry." E-Journal of Chemistry 7(S1): S7-S14.

Analysis of aromatic compounds in the New Zealand manuka honey was carried out by solid phase microextraction followed by gas chromatography-mass spectrometry. A total of 38 compounds were detected. Seven of them such as; 1,4-bis(x-methoxyphenyl)-but-2-en-1-one, 1,5-bis(x-methoxyphenyl)- pent-3-en-1-one, 1,4-bis(x-methoxyphenyl)-1-pentanone, 1,6- bis(x-methoxyphenyl)-3-heptene, 1,6-bis(x-methoxyphenyl)-hex-2(3 or 4)-en- 1-one and 2(3, 4 or 5)-hydroxy-1,6-bis(x-methoxyphenyl)-1-hexanone, had never before been identified as natural products. Their structures were deduced from the mass spectral data. Seven other compounds; 2,3-dimethoxynaphthalene, 4-(x-methoxyphenyl)-1-phenyl-1-butanone, desoxyanisoin, 2,6-dimethoxybenzoic acid benzyl ester, 4,4'-dimethoxystilbene, 3,3,4,5,5,8-hexamethyl-2,3,5,6- tetrahydro-s-indacene-1,7-dione and 1,5-bis(4-methoxyphenyl)-pentane-1,5-dione, were found in honey for the first time. Methyl syringate, orthomethoxyacetophenone and 3-phenyllactic acid were the most abundant components.

Dalefield, R. R., et al. (2016). "A 28-day oral toxicity study of echimidine and lasiocarpine in Wistar rats." Regulatory toxicology and pharmacology : RTP 81: 146-154.

Pyrrolizidine alkaloids (PAs) are a class of naturally-occurring plant toxins. Echimidine is one of the predominant PAs found in honeys produced in Australia and New Zealand. There is a lack of information on the oral toxicity of echimidine on which to base regulatory decisions concerning the risk to humans of these honeys. This GLP study was conducted to assess the subchronic dietary toxicity of echimidine to rats compared to that of lasiocarpine as a positive control. Wistar rats, 10/sex, were fed diets containing 0, 0.6, 1.2 or 2.5 mg/kg bw echimidine. Positive control groups, 10/sex, were fed diets containing 0.6, 1.2 or 2.5 mg/kg bw lasiocarpine. Neither PA had any effect on survival, food consumption, clinical signs, gross lesions, or histopathology. Consumption of lasiocarpine, but not echimidine, decreased bodyweight gain in males at >= 1.2 mg/kg bw, and in females at 2.5 mg/kg bw. Slight alterations in white cell counts and serum ALT concentrations at 2.5 mg/kg bw of both PAs were not clinically significant, had no histological correlates, and were considered to be of equivocal relevance. In conclusion, the subchronic No Observed Adverse Effect Level (NOAEL) for echimidine is 2.5 mg/kg bw/day, whereas, on the basis of a treatment-related decrease in bodyweight gain in males at 1.2 mg/kg bodyweight, the NOAEL for lasiocarpine is 0.6 mg/kg bw/day. Crown Copyright A© 2016. Published by Elsevier Inc. All rights reserved.

Dalzell, K. W. and W. A. Singers (1975). "A survey of some South Island honeydew honeys." New Zealand Journal of Science 18(3): 329-332.

Of 8 samples, 2 complied fully with both the Japanese standard and European Codex (CAC). Two samples conformed except for marginally high acidity in one, and high water-insolubles content in the other. Of 4 samples with a high sucrose content, 3 (with 6-8%) conformed with the CAC but not with the Japanese standard; the other had 13% sucrose and failed both standards. P. Walker ADDITIONAL ABSTRACT: Eight representative samples of honeydew honey contained total sugar 64 to 70, apparent reducing sugars as invert sugar 52 to 66, sucrose 1 to 13, fructose 33.2 to 41.2, moisture 12.9 to 19.0, water-soluble solids 0.01 to 0.31, ash 0.61 to 0.90% and acidity 13 to 41 mequiv/kg. Only 2 samples complied with the Japanese and European (Codex Alimentarius Commission) standards.

Daniels, B. J., et al. (2016). "Isolation, Structural Elucidation, and Synthesis of Lepteridine From Manuka (*Leptospermum scoparium*) Honey." Journal of Agricultural and Food Chemistry 64(24): 5079-5084.

Manuka honey, made from the nectar of Leptospermum scoparium, has garnered scientific and economical interest due to its nonperoxide antibacterial activity. Biomarkers for genuine manuka honey are increasingly in demand due to the presence of counterfeit manuka honey. This work reports the identification of a compound previously unreported in manuka honey by HPLC, and determination of the structure of the as 3,6,7-

trimethyllumazine using NMR, MS, IR, and UV/vis spectroscopy. This assignment was confirmed by total synthesis. The natural product, renamed lepteridine, was only observed in manuka honeys and could potentially serve as a biomarker for genuine manuka honey.

Darcy, B. R., et al. (1997). "Composition of Australian honey extractives .1. Norisoprenoids, monoterpenes, and other natural volatiles from blue gum (*Eucalyptus leucoxylon*) and yellow box (*Eucalyptus melliodora*) honeys." Journal of Agricultural and Food Chemistry 45(5): 1834-1843.

Chemical fingerprinting of Australian honey requires information on the composition of natural honey volatiles if it is to be useful as a honey-sourcing method. The naturally occurring volatiles of Australian blue gum (*Eucalyptus leucoxylon*) and yellow box (*Eucalyptus melliodora*) honeys were isolated by solvent (ethyl acetate) extraction. Compounds in the extracts were analyzed by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). These procedures have permitted the identification of 55 compounds that include norisoprenoids, monoterpenes, benzene derivatives, aliphatic compounds, and Maillard reaction: products. The following 13 compounds were quantitatively identified for the first time in honey: four isomeric 3,4-dihydro-3-oxoactinidols; 8,9-dehydrotheaspirone; two isomeric 3-oxoretro-alpha-ionols; megastigm-4-ene-3,9-dione; 1-phenylbutane-2,3-diol; 1-phenylbutane-2,3-dione; 18-hydroxyoleic acid lactone; 3,5-dihydroxy-2-methyl-4H-pyran-4-one and 2,5-dimethyl-2,4-dihydroxy-3(2H)-furanone. The nature of the volatiles and semivolatiles in these two Australian honeys suggests that Australian honeys are quite distinctive relative to the other honeys that have been chemically studied by GC-MS.

Dart, A. J., et al. (2015). "A review of research into second intention equine wound healing using manuka honey: Current recommendations and future applications." Equine Veterinary Education 27(12): 658-664.

In addition to the generic properties of honey, manuka honey has a nonperoxide antimicrobial activity largely attributed to methylglyoxal. Commercially, manuka honey is graded against a standard antiseptic, phenol, to provide a measure of antimicrobial activity referred to as the unique manuka factor (UMF). The higher the UMF, the greater the antimicrobial activity. However, more recently, there is evidence that manuka honey can also modulate the initial inflammatory response through activation of toll-like receptor 4 on monocytes to enhance production of cytokines important in tissue repair and regeneration. Recent studies investigating the effects of manuka honey on second intention healing of lower limb wounds in horses have shown that wounds treated with UMF 20 manuka honey retracted less and healed faster than untreated wounds. Using this wound healing model, the primary effects of manuka honey appeared to be associated with the modulation of the initial inflammatory reaction rather than its antimicrobial effects. Based on the current knowledge, treatment with manuka honey should be instituted as soon as possible after injury. Where bacterial contamination is substantial, manuka honey with a UMF >= 15 should be used. While bandages will improve the contact between the honey and the wound and may be indicated in the early stages of wound healing, prolonged bandaging may lead to the production of excessive granulation tissue. If topical treatment without a bandage is to be used, more honey is not necessarily better. Using a thin film combined with regular application, contact times may be optimised. Application 2-3 times daily to open wounds may improve efficacy. Manuka honey should be applied for at least 21 days after wounding but there may be beneficial effects if it is applied until wound healing is almost complete.

Eaton, C. v. and R. Law (2000). "Marketing apitherapy products and the challenge of government regulation." Bee World 81(3): 109-115.

The marketing of apitherapy products offers significant potential for the further development of beekeeping industries worldwide. Royal jelly produced in China is distributed to many countries, and propolis production is a major industry in both China and Brazil. A substantial trade also exists in bee pollen, with countries as diverse as Canada, Australia, Mexico, Argentina and Spain supplying the world market. Manuka honey from New Zealand has gained an international reputation for its unique antibacterial properties. All of these products, as well as a number of others, are raw materials used in apitherapy.

Ede, R. M., et al. (1993). "Novel nor-sesquiterpenoids in New Zealand honeys. II. Isolation and structural characterisation of meliracemoic acid." Tetrahedron letters : the international organ for the rapid publication of preliminary communications in organic chemistry. 34(42): 6795-6798.

Meliracemoic acid, a novel nor-sesquiterpenoid isolated from the honey of the New Zealand native tree kamahi (Weinmannia racemosa), has been shown to possess a substituted 2,5-methano-hexahydro-1,3-benzodioxolane skeleton. The structure was determined principally by 1D and 2D NMR analysis of the corresponding methyl ester.

Emma, P., et al. (2012). "Manuka honey mouthwash does not affect oral mucositis in head and neck cancer patients in New Zealand." Journal of Radiotherapy in Practice 11(4): 249-256.

Oral mucositis is an unavoidable side effect of radiation therapy to the head and neck, which can compromise patient health and quality of life. This study investigates the effect of manuka honey on the extent of oral mucositis in head and neck patients in New Zealand. A total of 28 patients were recruited; 10 patients received standard care and 18 patients were given additional manuka honey. Honey was used three times a day; assessment included: extent of oral mucositis using a multi-site mucositis scoring system, weight and quality of life. The first six patients, randomised to the honey arm, used undiluted honey and pulled out in the first week because of extreme nausea, vomiting and stinging sensations in the mouth. The next 12 honey patients used a honey mouthwash (diluted 1:3). Six of these patients completed the trial and four more completed the first 4 weeks of the trial. Eight control patients completed the trial. In contrast to previous honey trials in Malaysia, Egypt, Iran and India, diluted manuka honey did not decrease the extent and onset of radiation-induced oral mucositis but did appear to ameliorate radiation-induced weight loss and increase quality of life in the absence of cisplatin chemotherapy.

Faraji-Haremi, R. (1978). "Colour and chemical composition of honeys from known floral sources." Colour and chemical composition of honeys from known floral sources.

Colour and chemical composition of 6 unifloral Australian honeys, together with effects of accelerated storage trials, were studied. Analyses (methods given) included colour, moisture, ash, total nitrogen, pH, acidity, metals, sugars, free amino acids, organic acids and volatile components. Results include identification of 17 amino acids, detection of 7 sugars (6 identified), 15 elements and 18 organic acids (10 identified), and identification of 16 honey volatiles (12 not previously reported). Accelerated storage at 50 deg C produced significant darkening of all honeys. There were no significant changes in total nitrogen or total acidity, but two honeys showed significant decreases in pH while four showed little change. Sucrose, melezitose and apparent total sugars decreased, but turanose increased; levels of maltose, fructose and glucose varied with honey type. Total free amino acids decreased (with one exception), but some individual amino acids increased in some honeys. Flavour and colour showed serious deterioration during storage at 50 deg , together with loss of aroma compounds, and large increases of hydroxymethylfurfural. Honey processors should therefore avoid high processing temperatures. [See also Wootton, M. et al., AA 1158, 1159/76; 1079/79.]

Fauzi Noor, A., et al. (2014). "High-Pressure Processing of Manuka Honey: Improvement of Antioxidant Activity, Preservation of Colour and Flow Behaviour." Food and Bioprocess Technology 7(8): 2299-2307.

Manuka honey in New Zealand is known for its superior antimicrobial and antioxidant properties. However, these valuable properties are known to be compromised when raw honey goes through conventional thermal processing, thus reducing its final quality. As such, this present work is undertaken to assess the effect of high-pressure processing on quality of honey, namely, the antioxidant activity, colour and viscosity. The honey was subjected to different pressures (200–600 MPa) at ambient temperatures (25 to 33 °C) and combined with moderate temperatures (53 to 74 °C) for holding times (10 to 30 min). Thermal processing (49 to 70 °C) was also carried out for comparison purpose. In the absence of heat, the antioxidant activity of high-pressure processing (HPP)-treated samples (600 MPa, 10 min) was found to increase by about 30 % with no colour changes detected. The shear-thinning behaviour of the honey was also retained after HPP at ambient temperature, whereas for combined HPP–thermal treatment, no added benefit in antioxidant activity was observed particularly at higher temperature. Colour was significantly degraded when processed for ≥15 min at 70 °C and the flow behaviour was brought about from

shear thinning to Newtonian. Thus, it can be concluded that the quality of honey can be enhanced by using high-pressure processing at ambient temperature.

Fearnley, L., et al. (2012). "Compositional analysis of manuka honeys by high-resolution mass spectrometry: Identification of a manuka-enriched archetypal molecule." Food Chemistry 132(2): 948-953.

Manuka honey is used medicinally as a wound-healing dressing and possesses antibacterial bioactivities. It also possesses immunomodulating properties, comprising both anti-inflammatory and immune stimulating activities. At present its active components have not been identified. Given the importance of manuka honey as a therapeutic, we performed high-resolution Fourier-transform mass spectrometry analysis, in order to gain an insight into its complex make-up, as well as examining other honeys derived from different floral origins and storage conditions. Our analyses show that manuka-derived honeys contain unique compounds, particularly in the high molecular weight range, compared to other honeys from other floral species. Storage conditions also directly impact on the molecular composition. An archetypal mother molecule specific to manuka honey was identified that may serve as a precursor store for free 3,4,5-trimethoxybenzoic acid and provide a means of fingerprinting manuka honeys. (C) 2011 Elsevier Ltd. All rights reserved.

Fidaleo, M., et al. (2009). "Methylglyoxal: A new weapon against *Staphylococcal* wound infections?" Chemistry Letters 39(4): 322-322.

Methylglyoxal (MG), a phytochemical present in some New Zealand honeys, was found to possess bactericidal activity against S. aureus and a methicillin-resistant strain of S. epidermidis. The MIC and MBC values were 1.05 and 2.11 mM, respectively. Inclusion of MG in a hydrogel resulted in an active and stable preparation suitable for treating wound or burn infections.

Fields, B. A., et al. (2014). "Human pharmacokinetic study of tutin in honey; a plant-derived neurotoxin." Food & Chemical Toxicology 72: 234-241.

Over the last 150 years a number of people in New Zealand have been incapacitated, hospitalised, or died from eating honey contaminated with tutin, a plant-derived neurotoxin. A feature of the most recent poisoning incident in 2008 was the large variability in the onset time of clinical signs and symptoms of toxicity (0.5-17 h). To investigate the basis of this variability a pharmacokinetic study was undertaken in which 6 healthy males received a single oral dose of tutin-containing honey giving a tutin dose of 1.8 mu g/kg body weight. The serum concentration-time curve for all volunteers exhibited two discrete peaks with the second and higher level occurring at approximately 15 h post-dose. Two subjects reported mild, transient headache at a time post-dose corresponding to maximum tutin concentrations. There were no other signs or symptoms typical of tutin intoxication such as nausea, vomiting, dizziness or seizures. Pharmacokinetic analysis using a two-site absorption model resulted in a good fit to the observed concentration data. A novel analytical method subsequently revealed the presence of glycoside conjugates of tutin in addition to unconjugated tutin in honey. These pharmacokinetic data will be important to better define a safe maximum tutin concentration in honey. Crown Copyright (C) 2014 Published by Elsevier Ltd. All rights reserved.

Fingleton, J., et al. (2014). "Randomised controlled trial of topical kanuka honey for the treatment of cold sores." Advances in Integrative Medicine 1(3): 119-123.

Fingleton, J., et al. (2013). "Topical kanuka honey for the treatment of rosacea." Focus on Alternative and Complementary Therapies 18(4): 221-222.

Fingleton, J., et al. (2014). "Topical kanuka honey for the treatment of nappy rash." Focus on Alternative & Complementary Therapies 19(1): 50-51.

Floyd, B. (1996). "Some highlights from honey marketing file." New Zealand beekeeper 3(3): 20-23.
This article includes New Zealand honey marketing strategies and objectives for 1996.

Frederikson, B. (2004). "A sticky business." Consumer(433): 5-8.
Tests different brands of manuka honey in New Zealand. Difference between clover honey and manuka honey; Key factors that affect the availability of manuka honey; Requirements for a honey to be classified as "monofloral"; Curative properties of honey; Antibacterial action in manuka and "active" honey.

Frew, R., et al. (2013). "Modified sugar adulteration test applied to New Zealand honey." Food Chemistry 141(4): 4127-4131.
The carbon isotope method (AOAC 998.12) compares the bulk honey carbon isotope value with that of the extracted protein; a difference greater than 1 per mil suggesting that the protein and the bulk carbohydrate have different origins. New Zealand Manuka honey is a high value product and often fails this test. It has been suggested such failures are due to the pollen in the Manuka honey and an adaptation of the method to remove pollen prior to testing has been proposed. Here we test 64 authentic honey samples collected directly from the hives and find that a large proportion (37%) of Manuka honeys fail the test. Of these 60% still fail the adapted method. These honey samples were collected and processed under stringent conditions and have not been adulterated post-harvest. More work is required to ascertain the cause of these test failures.

Fuss, J. (1983). "Upper south east--South Australia honey production potential." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 295-298.

Gannabathula, S., et al. (2017). "Correlation of the immunostimulatory activities of honeys with their contents of identified bioactives." Food chemistry. 221(221): 39-46.
Honeys with unique compositions and properties are worth studying for their health-promoting effects. In order to correlate bioactive content with immunostimulatory activity we compared the abilities of seventy eight New Zealand and non-New Zealand honeys to stimulate blood monocytes to release tumour necrosis factor (TNF)-I+/-, and examined the compositions of selected honeys that had widely varying activities. All the honeys, except for a Malaysian -Amber honey- stimulated the release of TNF-I+/- from monocytes. However, the honeys differed greatly in their immunostimulatory activity, even within the same honey type. They differed in their contents of immunostimulatory components, including apalbumins, arabinogalactan proteins, and apisimin, whose levels did not correlate exactly with immunostimulatory activities. We suggest that the immunostimulatory properties of honey may be influenced by other factors, including unidentified immunostimulatory bioactives and immunosuppressive components; the bioavailability of some bioactives may depend on unidentified factors.

Gannabathula, S., et al. (2015). "Honeybee apisimin and plant arabinogalactans in honey costimulate monocytes." Food chemistry. 168(168): 34-40.
Here we determined whether immunostimulatory plant-derived arabinogalactan proteins (AGPs) and the honeybee-derived protein apisimin are present in varieties of New Zealand honey. Apisimin is a protein of unknown function secreted from the glands of honeybees into Royal Jelly, forming a complex with apalbumin1 capable of stimulating lymphocyte proliferation. AGPs were abundant in kanuka honey with lesser amounts in manuka, kowhai and clover honeys, but absent from Royal Jelly. Apisimin was present in all honeys, as well as Royal Jelly. We report that apisimin shares with honey AGPs the ability to stimulate the release of TNF-I+/- from blood monocytes. Further, it synergizes with AGPs to enhance the release of TNF-I+/-, via a mechanism not involving the formation of a complex with AGPs. In summary, this study provides evidence that AGPs and apisimin are commonly present in different floral varieties of honey, and hence contribute to their immunostimulatory properties.

Gannabathula, S., et al. (2012). "Arabinogalactan proteins contribute to the immunostimulatory properties of New Zealand honeys." Immunopharmacology & Immunotoxicology 34(4): 598-607.

Context: Factors in honey that improve wound healing are poorly understood, but are thought to include lipopolysaccharide (LPS), apalbumin-1 and -2, and a 5.8 kDa component that stimulate cytokine release from macrophages. Objective: To characterize the ability of New Zealand honeys to elicit the release of tumor necrosis factor-alpha (TNF-alpha) from monocytic cell lines as a model for early events within a wound site. Materials and methods : The ability of kanuka (*Kunzea ericoides*), manuka (Leptospermum scoparium), and clover (Trifolium spp.) honeys to stimulate the release of TNF-alpha from monocytic cell lines THP-1 and U937 was assayed by ELISA. Results: All three honeys stimulated TNF-alpha release from THP-1 cells, with kanuka honey being the most active. The activity of kanuka honey was associated with a high molecular weight (> 30 kDa) component that was partially heat labile and inhibitable with polymyxin B. LPS concentrations in the honeys were too low to adequately explain the level of immunostimulation. The contribution of type II arabinogalactan proteins (AGPs) we recently identified in kanuka honey was tested, as AGPs are known immunostimulators. AGPs purified from kanuka honey stimulated the release of TNF-alpha from THP-1 and U937 cells. Discussion: Here we demonstrated that AGPs we recently identified in kanuka honey have immunostimulatory activity. We propose that the immunostimulatory properties of individual honeys relate to their particular content of LPS, apalbumins, the 5.8 kDa component and AGPs. Conclusion: The immunostimulatory activity of kanuka honey may be particularly dependent on AGPs derived from the nectar of kanuka flowers.

Goebel, R. (1983). "Honey - colour grades." Australasian beekeeper 84(8): 156-156.

Gordon, L. (1989). "Quantitative determination of oxytetracycline in honey by cylinder plate microbioassay." Australian journal of agricultural research. 40(4): 933-940.

Graddon, A. D., et al. (1979). "Volatile constituents of some unifloral Australian honeys." Journal of Agricultural and Food Chemistry 27(4): 832-837.

Using a gas chromatograph, a mass spectrometer and a computer, the extracts of honey volatiles were shown to be complex mixtures of 100 compounds. A large range of hydrocarbons and oxygenated compounds was present, some of which may be unique to the floral sources concerned. [Chem.Abstr. 91 : 54734q (1979).] F. B. Wells

Grainger, M. N. C., et al. (2017). "Kinetics of conversion of dihydroxyacetone to methylglyoxal in New Zealand mal"nuka honey: Part IV - Formation of HMF." Food chemistry. 232(232): 648-655.

During a study of the conversion of dihydroxyacetone (DHA) to methylglyoxal (MGO) in maturing New Zealand mal"nuka honey, the kinetics of formation of 5-(hydroxymethyl)furfural (HMF) was studied at temperatures from 4 to 37AdegreeC. Formation of HMF was first-order during an induction period and zero-order thereafter indicating that the mechanism includes the formation of certain critical intermediates and that these require time to build up; the duration of the induction period depended primarily upon temperature.The zero-order rate constant at 37AdegreeC was the same for mal"nuka honey and clover honey doped with 2000 or 10,000mg/kg DHA and for artificial honey with 2000mg/kg of DHA and either alanine or proline and alanine added. Zero-order rate constants for artificial honey with added amino acids were less than for a control without amino acids.A simulation was created to predict the formation of HMF over time at 37AdegreeC in mal"nuka honey.

Grainger, M. N. C., et al. (2016). "Kinetics of conversion of dihydroxyacetone to methylglyoxal in New Zealand mal"nuka honey: Part I - Honey systems." Food chemistry. 202(202): 484-491.

The kinetics of conversion of dihydroxyacetone (DHA) to methylglyoxal (MGO) were investigated in maI"nuka honeys and DHA-doped clover honeys stored between 4 and 37AdegreeC. Both the disappearance of DHA and appearance of MGO were confirmed as overall, first order reactions, albeit probably composites of multiple reactions. Increasing the storage temperature accelerated the rate of DHA loss and the initial rate of formation of MGO, but better conversion efficiency was observed at lower temperature. At 37AdegreeC, more MGO was lost at later times in maI"nuka honey compared to DHA-doped-clover honey. Thirty-seven New Zealand maI"nuka honeys and four clover honeys were analysed for various chemical and physical properties; comparison of rate constants and these parameters identified some positive correlations.

Grainger, M. N. C., et al. (2016). "Kinetics of conversion of dihydroxyacetone to methylglyoxal in New Zealand maI"nuka honey: Part III - A model to simulate the conversion." Food chemistry. 202(202): 500-506.

A kinetic model for the conversion of dihydroxyacetone (DHA) to methylglyoxal (MGO) in honey is proposed; a building block approach was used to create the model. Artificial honeys doped with DHA and individual perturbants were fitted first, then multiple perturbants (alanine, proline and iron, and combinations of these) were fitted before comparing the simulation to real honey samples (doped clover and maI"nuka honey). The main responses in the prediction model were DHA, MGO, proline, primary amino acids, acidity, 3-phenyllactic acid and 4-methoxyphenyllactic acid. Three temperatures (20, 27 and 37AdegreeC) were studied and the conversion of DHA to MGO was monitored over at least 1year. Differences in the conversion between clover doped with DHA and maI"nuka honey were observed. The simulation fitted well for the honeys tested.

Grainger, M. N. C., et al. (2016). "Kinetics of the conversion of dihydroxyacetone to methylglyoxal in New Zealand maI"nuka honey: Part II - Model systems." Food chemistry. 202(202): 492-499.

The irreversible dehydration reaction of dihydroxyacetone (DHA) to methylglyoxal (MGO) in a honey model system has been examined to investigate the influence of added perturbant species on the reaction rate. The secondary amino acid proline, primary amino acids (alanine, lysine and serine), and iron, or combinations of these perturbants, were added to artificial honey with either DHA or MGO and stored at 20, 27 and 37AdegreeC. These systems were monitored over time. A 1:1 conversion of DHA to MGO was not observed in any system studied, including the control system with no added perturbants. Addition of proline to the matrix increased consumption of DHA but did not produce any more MGO than the control sample. Lysine and serine behaved similarly. Alanine enhanced the conversion of DHA to MGO and had the best efficiency of conversion of DHA to MGO for the amino acids studied. An iron II salt enhanced the conversion of DHA to MGO, even in the presence of proline.

Grainger, M. N. C., et al. (2014). "Effect of high-pressure processing on the conversion of dihydroxy acetone to methylglyoxal in New Zealand manuka (Leptospermum scoparium) honey and models thereof." Food Chemistry 153: 134-139.

The effect of high-pressure processing (HPP) on the conversion of dihydroxyacetone (DHA) to methylglyoxal (MGO) was examined in New Zealand manuka honey and models thereof. The objective was to confirm that previously reported increases of MGO with HPP treatment originated from conversion of DHA. RP-HPLC was used to quantify DHA, MGO and hydroxymethylfurfural (HMF) after derivatisation with O-(2,3,4,5,6-pentafluorobenzyl)hydroxylamine hydrochloride (PFBHA) or (in the case of MGO) separately with o-phenylenediamine (OPD). Fresh and stored manuka honey, clover honey with DHA added and artificial 26 honey with DHA added were subjected to nine different pressures and holding times and compared to untreated samples. There was no consistent trend of decrease in DHA or increase in MGO for any of the samples with any treatment. Samples showed random change generally within 5-10% of an untreated sample for MGO, DHA and HMF. HPP does not accelerate the conversion of DHA to MGO in honey.

Griffin, C. T., et al. (2015). "Development of a fast isocratic LC-MS/MS method for the high-throughput analysis of pyrrolizidine alkaloids in Australian honey: Part A. Chemistry, Analysis, Control, Exposure & Risk Assessment." Food Additives and Contaminants 32(2): 214-214.

Honey samples originating from Australia were purchased and analysed for targeted pyrrolizidine alkaloids (PAs) using a new and rapid isocratic LC-MS/MS method. This isocratic method was developed from, and is comparable with, a gradient elution method and resulted in no loss of sensitivity or reduction in chromatographic peak shape. Isocratic elution allows for significantly shorter run times (6 min), eliminates the requirement for column equilibration periods and, thus, has the advantage of facilitating a high-throughput analysis which is particularly important for regulatory testing laboratories. In excess of two hundred injections are possible, with this new isocratic methodology, within a 24-h period which is more than 50% improvement on all previously published methodologies. Good linear calibrations were obtained for all 10 PAs and four PA N-oxides (PANOs) in spiked honey samples (3.57-357.14 ...g l...; R2 ≥ 0.9987). Acceptable inter-day repeatability was achieved for the target analytes in honey with % RSD values (n = 4) less than 7.4%. Limits of detection (LOD) and limits of quantitation (LOQ) were achieved with spiked PAs and PANOs samples; giving an average LOD of 1.6 ...g kg... and LOQ of 5.4 ...g kg.... This method was successfully applied to Australian and New Zealand honey samples sourced from supermarkets in Australia. Analysis showed that 41 of the 59 honey samples were contaminated by PAs with the mean total sum of PAs being 153 ...g kg.... Echimidine and lycopsamine were predominant and found in 76% and 88%, respectively, of the positive samples. The average daily exposure, based on the results presented in this study, were 0.051 ...g kg... bw day... for adults and 0.204 ...g kg... bw day... for children. These results are a cause for concern when compared with the proposed European Food Safety Authority (EFSA), Committee on Toxicity (COT) and Bundesinstitut fur Risikobewertung (BfR - Federal Institute of Risk Assessment Germany) maximum daily PA intake limit of 0.007 ...g kg... bw day.... (ProQuest: ... denotes formulae/symbols omitted.)

Gulliford, R. B. (1995). "A layman's look over (ISO) AS/9002 and quality assurance/certification in the honey industry." Australasian beekeeper 96(8): 320-334.

The Australian standard AS/9002 (formerly ISO/9002) was adopted on 1 September 1994. (The honey standard AS/3902, which was very similar, was effectively eliminated.) The standard and its implications are discussed.

Hammond, J. (1976). "Honey poisoning." Journal of the New Zealand Dietetic Association 30(1): 27-28.

Honey poisoning in New Zealand has occurred when the small tree or shrub tutu (Cariara arborea) has grown near an apiary, and when hot dry weather has favoured the passion vine hopper (Scolypopa australis). The plant toxin tutin in young shrubs, on which the hoppers feed, may be converted to the main honey toxin, mellitoxin or hyenanchin, by the hopper and excreted in honeydew. In hot dry weather when nectar is not available, bees collect the honeydew. The Ministry of Agriculture and Fisheries can require the removal of hives from areas where tutu and hopper are abundant, at times when conditions favour production of toxic honey.

Harman, A. (2010). "70 tons of manuka honey lost in 10-hour fire." Bee Culture 138(4): 75-75.

The article reports on the destruction of 70 tons of high grade manuka honey in a 10-hour fire in New Zealand.

Harman, A. (2014). "Standardize Manuka honey labeling." Bee Culture 142(5): 101-101.

The article focuses on a warning issued by a New Zealand (NZ) scientist Merilyn Manley-Hanis on the Radio NZ about how fraudulent honey products can damage the country's intemational reputation while asking the NZ government to set up a system for standardized labelling of honey.

Harman, A. (2016). "Manuka Honey Thefts In New Zealand." Bee Culture 144(10): 78-79.

The article discusses the issue of manuka honey thefts in New Zealand (NZ) as of October 2016. Topics include the government and a consortium of private sector companies' aim to boost the value of the manuka honey industry by 2028, comments from Apiculture NZ chief executive Daniel Paul on the escalation of the crime, and the financial impact of such crime on apiarists across the country.

Harris, W. F. and D. W. Filmeb (1947). "A recent outbreak of honey poisoning. 6. Botanical investigation of pollen and nectar flora." New Zealand Journal of Science and Technology, Section A 29: 134-143.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Hobbs, R. H. B. D. A. B. C. L. (1974). "Honey: its production, processing, packaging and promotion. Beekeepers' seminar, 13-15 August 1974, Taupo." Honey: its production, processing, packaging and promotion. Beekeepers' seminar, 13-15 August 1974, Taupo.: 137-pp.

This full report includes a number of papers that are of interest to beekeepers in the world at large.Aspects of honey houses include: design, by G.M. Walton (pp. 18-22); flooring, by R.H. Hobbs (23-26); shifting (moving heavy weights) by D.A. Briscoe (27-30); hygiene and the Health Department, by C.L. Barber (43-48).Aspects of honey disposal include: marketing (70-77), within New Zealand (78-89), and overseas (90-99); packaging and labelling (100-101), and the housewife's action and reaction to the honey pack (102-110).Special problems covered include: utilizing bush areas (49-56), handling manuka honey (57-64), and toxic honeys (122-125).E.E. Crane

Hollderna-Kedzia, E., et al. (2008). "Estimation of antibiotic activity of New Zealand manuka honey by the method of serial dilutions in liquid medium." Ocena aktywnosci antybiotycznej nowozelandzkiego miodu manuka metoda rozcienczen seryjnych w podlozu plynnym. 9(2): 70-75.

This study analysed the antibacterial activities of 50 manuka honey samples from New Zealand and Australia, using the serial dilution method. The samples were divided into 5 groups: group A, 13 samples with undetermined UMF value; group B, 13 samples with a UMF value of 5+; group C, 12 samples with a UMF value of 10+; group D, 7 samples with a UMF value of 15+; and group E, 5 samples with a UMF value of 20+. The mean inhibitory values obtained were 2.7 (group A), 3.0 (group B), 3.1 (group C), 3.5 (group D), and 3.8 (group E). An analysis of these results is presented.

Holt, S. (2015). "A New Zealand topical kanuka honey product can treat rosacea and reduce antibiotic resistance." Advances in Integrative Medicine 2(3): 141-142.

Holt, S., et al. (2012). "New Zealand Kanuka honey has high levels of methylglyoxal and antimicrobial activity." Journal of Alternative and Complementary Medicine 18(3): 203-204.

This study was carried out to examine the basic physicochemical and antimicrobial properties of New Zealand kanuka (Kunzea ericoides) honey. Samples of both raw honey and medical-grade honey were tested, the latter being prepared in a 2-stage process of filtration and gamma irradiation. The antimicrobial properties of honey samples were determined using the Kirby-Bauer disk diffusion method. New Zealand kanuka honey samples showed significant in vitro activities against methicillin-resistant and -susceptible Staphylococcus aureus, and Trichophyton mentagrophytes strains. For several samples, the pH was ~3.6, with no difference between raw and medical-grade honey. Honey samples also had high levels of methylglyoxal, which is suggested to be responsible for the antimicrobial activity of honey. These results indicate the therapeutic potential of New Zealand kanuka honey, and clinical trials are warranted.

Honey Research, C. (1986). "Annual report."

Hornitzky, M. and A. Ghalayini (2006). "Honey produced from genetically modified canola (*Brassica napus*) nectar will not need to be labelled as a GM food under current Australian guidelines." Australian Journal of Experimental Agriculture 46(8): 1101-1104.

Food or ingredients labelled as genetically modified (GM) contain either new genetic material or protein as a result of genetic modification. In Australia, a 1% threshold, below which labelling is not required, exists for the unintended presence of GM material in non- GM foods. The canola pollen content by dry weight in a range of canola honey samples from diverse geographical areas in Australia was determined to be 0.2 +/- 0.12%, well below the 1% threshold. Two GM canola honey samples sourced from Canada contained 0.19 and 0.24% of canola pollen. This work indicates honey derived from GM canola crops will not need to be labelled as a GM food.

Hungerford, N. L., et al. (2019). "Analysis of pyrrolizidine alkaloids in Queensland honey: using low temperature chromatography to resolve stereoisomers and identify botanical sources by UHPLC-MS/MS." Toxins 11(12): 726-726.

Pyrrolizidine alkaloids (PAs) are a diverse group of plant secondary metabolites with known varied toxicity. Consumption of 1,2-unsaturated PAs has been linked to acute and chronic liver damage, carcinogenicity and death, in livestock and humans, making their presence in food of concern to food regulators in Australia and internationally. In this survey, honey samples sourced from markets and shops in Queensland (Australia), were analysed by high-resolution Orbitrap UHPLC-MS/MS for 30 common PAs. Relationships between the occurrence of pyrrolizidine alkaloids and the botanical origin of the honey are essential as pyrrolizidine alkaloid contamination at up to 3300 ng/g were detected. In this study, the predominant alkaloids detected were isomeric PAs, lycopsamine, indicine and intermedine, exhibiting identical MS/MS spectra, along with lesser amounts of each of their N-oxides. Crucially, chromatographic UHPLC conditions were optimised by operation at low temperature (5 degrees C) to resolve these key isomeric PAs. Such separation of these isomers by UHPLC, enabled the relative proportions of these PAs present in honey to be compared to alkaloid levels in suspect source plants. Overall plant pyrrolizidine alkaloid profiles were compared to those found in honey samples to help identify the most important plants responsible for honey contamination. The native Australian vines of Parsonsia spp. are proposed as a likely contributor to high levels of lycopsamine in many of the honeys surveyed. Botanical origin information such as this, gained via low temperature chromatographic resolution of isomeric PAs, will be very valuable in identifying region of origin for honey samples.

Hungerford, N. L., et al. (2020). "Mineral and trace element analysis of Australian/Queensland *Apis mellifera* honey." International Journal of Environmental Research and Public Health 17(17).

Honey is an extensively utilized sweetener containing sugars and water, together with small quantities of vitamins, minerals, fatty acids, amino acids and proteins. Naturally produced by honeybees (*Apis mellifera*) from floral nectar, honey is increasingly sold as a health food product due to its nutritious features. Certain honeys are retailed as premium, trendy products. Honeybees are regarded as environmental monitors, but few reports examine the impact of environment on Australian honey trace elements and minerals. In higher density urban and industrial environments, heavy metals can be common, while minerals and trace elements can have ubiquitous presence in both agricultural and urban areas. Honey hives are traditionally placed in rural and forested areas, but increasingly the trend is to keep hives in more urban areas. This study aimed to determine the levels of 26 minerals and trace elements and assess elemental differences between honeys from various regional Queensland and Australian sources. Honey samples (n = 212) were acquired from markets, shops and supermarkets in Queensland while urban honeys were purchased online. The honey samples were classified into four groups according to their regional sources: urban, rural, peri-urban and blend honey. Elemental analyses of honey were performed using ICP-MS and ICP-OES after microwave and hot block digestion. Considerable variations of essential trace elements (Co, Cu, Cr, Fe, Mn, Mo and Zn) and mineral levels (Ca, K, Mg, Na and P) were found in honeys surveyed. There were significant differences ($p < 0.05$) between urban and rural honey samples for B, Na, P, Mn, K, Ca and Cu. Significant differences

($p < 0.05$) were also found between blend and urban honey samples for K, Cu, P, Mn, Sr, Ni, B and Na. Peri-urban versus urban honeys showed significant differences in P, K and Mn. For rural and peri-urban honeys, the only significant difference ($p < 0.05$) was for Na. Toxic heavy metals were detected at relatively low levels in honey products. The study revealed that the Queensland/Australian honey studied is a good source of K and Zn and would constitute a good nutritional source of these elements.

Irish, J., et al. (2011). "The antibacterial activity of honey derived from Australian flora." PLoS One 6(3): e18229-e18229.

Chronic wound infections and antibiotic resistance are driving interest in antimicrobial treatments that have generally been considered complementary, including antimicrobially active honey. Australia has unique native flora and produces honey with a wide range of different physicochemical properties. In this study we surveyed 477 honey samples, derived from native and exotic plants from various regions of Australia, for their antibacterial activity using an established screening protocol. A level of activity considered potentially therapeutically useful was found in 274 (57%) of the honey samples, with exceptional activity seen in samples derived from marri (*Corymbia calophylla*), jarrah (*Eucalyptus marginata*) and jellybush (*Leptospermum polygalifolium*). In most cases the antibacterial activity was attributable to hydrogen peroxide produced by the bee-derived enzyme glucose oxidase. Non-hydrogen peroxide activity was detected in 80 (16.8%) samples, and was most consistently seen in honey produced from *Leptospermum* spp. Testing over time found the hydrogen peroxide-dependent activity in honey decreased, in some cases by 100%, and this activity was more stable at 4 degrees C than at 25 degrees C. In contrast, the non-hydrogen peroxide activity of *Leptospermum* honey samples increased, and this was greatest in samples stored at 25 degrees C. The stability of non-peroxide activity from other honeys was more variable, suggesting this activity may have a different cause. We conclude that many Australian honeys have clinical potential, and that further studies into the composition and stability of their active constituents are warranted.

Jervis-Bardy, J., et al. (2011). "Methylglyoxal-infused honey mimics the anti-Staphylococcus aureus biofilm activity of Manuka honey: potential implication in chronic rhinosinusitis." Laryngoscope 121(5): 1104-1107.

Objectives/Hypothesis: Low pH, hydrogen peroxide generation, and the hyperosmolarity mechanisms of antimicrobial action are ubiquitous for all honeys. In addition, manuka honey has been shown to contain high concentrations of methylglyoxal (MGO), contributing the relatively superior antimicrobial activity of manuka honey compared to non-MGO honeys. In high concentrations, manuka honey is effective in killing Staphylococcus aureus biofilms in vitro. Lower concentrations of honey, however, are desirable for clinical use as a topical rinse in chronic rhinosinusitis in order to maximize the tolerability and practicality of the delivery technique. This study, therefore, was designed to evaluate the contribution of MGO to the biofilm-cidal activity of manuka honey, and furthermore determine whether the antibiofilm activity of low-dose honey can be augmented by the addition of exogenous MGO. Study Design: In vitro microbiology experiment. Methods: Five S. aureus strains (four clinical isolates and one reference strain) were incubated to form biofilms using a previously established in vitro dynamic peg model. First, the biofilm-cidal activities of 1) manuka honey (790 mg/kg MGO), 2) non-MGO honey supplemented with 790 mg/kg MGO, and 3) MGO-only solutions were assessed. Second, the experiment was repeated using honey solutions supplemented with sufficient MGO to achieve concentrations exceeding those seen in commercially available manuka honey preparations. Results: All honey solutions containing a MGO concentration of 0.53 mg/mL or greater demonstrated biofilm-cidal activity; equivalent activity was achieved with > 1.05 mg/mL MGO solution. Conclusions: MGO is only partially responsible for the antibiofilm activity of manuka honey. Infusion of MGO-negative honey with MGO, however, achieves similar cidality to the equivalent MGO-rich manuka honey.

Jesus, M. C. d., et al. (2019). "Pyrrolizidine alkaloids of blue heliotrope (*Heliotropium amplexicaule*) and their presence in Australian honey." Journal of Agricultural and Food Chemistry 67(28): 7995-8006.

Blue heliotrope (Heliotropium amplexicaule) is an invasive environmental weed that is widely naturalized in eastern Australia and has been implicated as a source of pyrrolizidine alkaloid (PA) poisoning in livestock. Less well-documented is the potential of such carcinogenic alkaloids to contaminate honey from bees foraging on this plant species. In this study, the PA profile of H. amplexicaule plant material, determined by HRAM LC-MS/MS, revealed the

presence of nine PAs and PA-N-oxides, including several PAs and PA-N-oxides of the indicine class, which have not previously been reported. The predominant alkaloid, indicine, represents 84% of the reduced PA content, with minor alkaloids identified as intermedine and the newly reported helioamplexine, constituting 7 and 9%, respectively. NMR analysis confirmed the identity of helioamplexine as a previously unreported indicine homologue. This is the first report of the isolation of intermedine, helioamplexine, and 3'-O-angelylindicine from H. amplexicaule. Also described is the identification of N-chloromethyl analogues of the major alkaloids as isolation-derived artifacts from reactions with dichloromethane. Analysis of regional-market honey samples revealed a number of honey samples with PA profiles analogous to that seen in H. amplexicaule, with measured PA contents of up to 2.0 micro g of PAs per gram of honey. These results confirm the need for honey producers to be aware of H. amplexicaule as a potential PA source, most particularly in products where honey is sourced from a single location.

Johnson, D. W., et al. (2014). "Antibacterial honey for the prevention of peritoneal-dialysis-related infections (HONEYPOT): a randomised trial." The Lancet. Infectious diseases 14(1): 23-30.

BACKGROUND: There is a paucity of evidence to guide the best strategy for prevention of peritoneal-dialysis-related infections. Antibacterial honey has shown promise as a novel, cheap, effective, topical prophylactic agent without inducing microbial resistance. We therefore assessed whether daily application of honey at the exit site would increase the time to peritoneal-dialysis-related infections compared with standard exit-site care plus intranasal mupirocin prophylaxis for nasal carriers of Staphylococcus aureus., METHODS: In this open-label trial undertaken in 26 centres in Australia and New Zealand, participants undergoing peritoneal dialysis were randomly assigned in a 1:1 ratio with an adaptive allocation algorithm to daily topical exit-site application of antibacterial honey plus standard exit-site care or intranasal mupirocin prophylaxis (only in carriers of nasal S aureus) plus standard exit-site care (control group). The primary endpoint was time to first infection related to peritoneal dialysis (exit-site infection, tunnel infection, or peritonitis). The trial is registered with the Australian New Zealand Clinical Trials Registry, number 12607000537459., FINDINGS: Of 371 participants, 186 were assigned to the honey group and 185 to the control group. The median peritoneal-dialysis-related infection-free survival times were not significantly different in the honey (16.0 months [IQR not estimable]) and control groups (17.7 months [not estimable]; unadjusted hazard ratio 1.12, 95% CI 0.83-1.51; p=0.47). In the subgroup analyses, honey increased the risks of both the primary endpoint (1.85, 1.05-3.24; p=0.03) and peritonitis (2.25, 1.16-4.36) in participants with diabetes. The incidences of serious adverse events (298 vs 327, respectively; p=0.1) and deaths (14 vs 18, respectively; p=0.9) were not significantly different in the honey and control groups. 11 (6%) participants in the honey group had local skin reactions., INTERPRETATION: The findings of this trial show that honey cannot be recommended routinely for the prevention of peritoneal-dialysis-related infections., FUNDING: Baxter Healthcare, Queensland Government, Comvita, and Gambro.

Johnson, D. W., et al. (2009). "The honeypot study protocol: a randomized controlled trial of exit-site application of medihoney antibacterial wound gel for the prevention of catheter-associated infections in peritoneal dialysis patients." Peritoneal dialysis international : journal of the International Society for Peritoneal Dialysis 29(3): 303-309.

OBJECTIVES: The primary objective of this study is to determine whether daily exit-site application of standardized antibacterial honey (Medihoney Antibacterial Wound Gel; Comvita, Te Puke, New Zealand) results in a reduced risk of catheter-associated infections in peritoneal dialysis (PD) patients compared with standard topical mupirocin prophylaxis of nasal staphylococcal carriers., DESIGN: Multicenter, prospective, open label, randomized controlled trial., SETTING: PD units throughout Australia and New Zealand., PARTICIPANTS: The study will include both incident and prevalent PD patients (adults and children) for whom informed consent can be provided. Patients will be excluded if they have had (1) a history of psychological illness or condition that interferes with their ability to understand or comply with the requirements of the study; (2) recent (within 1 month) exit-site infection, peritonitis, or tunnel infection; (3) known hypersensitivity to, or intolerance of, honey or mupirocin; (4) current or recent (within 4 weeks) treatment with an antibiotic administered by any route; or (5) nasal carriage of mupirocin-resistant Staphylococcus aureus., METHODS: 370 subjects will be randomized 1:1 to receive either daily topical exit-site application of Medihoney Antibacterial Wound Gel (all patients) or nasal application of mupirocin if staphylococcal nasal carriage is demonstrated. All patients in the control and intervention groups will perform their usual exit-site

care according to local practice. The study will continue until 12 months after the last patient is recruited (anticipated recruitment time is 24 months)., MAIN OUTCOME MEASURES: The primary outcome measure will be time to first episode of exit-site infection, tunnel infection, or peritonitis, whichever comes first. Secondary outcome measures will include time to first exit-site infection, time to first tunnel infection, time to first peritonitis, time to infection-associated catheter removal, catheter-associated infection rates, causative organisms, incidence of mupirocin-resistant microbial isolates, and other adverse reactions., CONCLUSIONS: This multicenter Australian and New Zealand study has been designed to provide evidence to help nephrologists and their PD patients determine the optimal strategy for preventing PD catheter-associated infections. Demonstration of a significant improvement in PD catheter-associated infections with topical Medihoney will provide clinicians with an important new prophylactic strategy with a low propensity for promoting antimicrobial resistance.

Kale Sniderman, J. M., et al. (2018). "Pollen analysis of Australian honey." PLoS One 13(5).

Pollen analysis is widely used to verify the geographic origin of honeys, but has never been employed in Australia. In this study, we analysed the pollen content of 173 unblended honey samples sourced from most of the commercial honey producing regions in southern Australia. Southern Australian vegetation is dominated by *Eucalyptus* (Myrtaceae) forests and, as expected, most Australian honeys are palynologically dominated by *Eucalyptus*, while other important components include Myrtaceae taxa such as Corymbia/Angophora and the tribe Leptospermeae; plus Brassicaceae, Echium, Macadamia, and Acacia. An important feature of the honeys is the number of Myrtaceae pollen morphotypes per sample, which is generally high (mean = 4.6) compared to honeys produced outside of Australia, including *Eucalyptus* honeys produced in the Mediterranean region, and honeys produced in South America, which has its own rich indigenous Myrtaceae flora. In the latter regions, the number of Myrtaceae morphotypes is apparently generally 2. A high number of Myrtaceae morphotypes may be a feasible criterion for authenticating the origin of Australian honeys, since most Australian honey is produced by honey bees mainly working indigenous floral resources. Myrtaceae morphotype diversity is a convenient melissopalynological measure that could be applied even where detailed knowledge of the pollen morphology of the many component genera and species is absent. Palynological criteria developed in Europe for authenticating *Eucalyptus* honeys should not be relied upon for Australian honeys, since those criteria are not based on samples of Australian honey.

Keenan, J. I., et al. (2010). "Individual and Combined Effects of Foods on *Helicobacter pylori* Growth." Phytotherapy Research 24(8): 1229-1233.

Eradication of *H. pylori* can reduce the risk of non-cardia gastric cancer developing in infected humans. Thus, the consumption of foods that inhibit the growth of these bacteria may provide an alternative to current therapies that include antibiotics, proton pump inhibitors and/or bismuth salts. This study describes a simple broth dilution assay developed to screen a range of foods for their individual and combined effects on H. pylori growth. It was found that foods with measurable anti-H. pylori activity have an effect greater in combination than the sum of foods tested singly, and that this was most noticeable with a combination of broccoli sprouts and blackcurrant oil. The results suggest that food synergy should be considered in any nutraceutical approach to H. pylori infection.

Kelly, D., et al. (1992). "Honeydew standing crop and production over 24 hours in *Nothofagus solandri* forest in Canterbury." New Zealand Journal of Ecology 16(2): 69-75.

The rate of production of honeydew by Ultracoelostoma brittini on Nothofagus solandri var. solandri was investigated in August 1990 in Canterbury, New Zealand. The honeydew was considered to be important as a forage source for honey bees and birds. Mean production of honeydew per insect over 24 h was 0.169 micro litre, with a range of 0-11.5 micro litre. The standing crop peaked just after dawn, and production was apparently greater at night. There was variation in honeydew production between margarodids on different trees.

Langford, V., et al. (2012). "Application of selected ion flow tube-mass spectrometry to the characterization of monofloral New Zealand honeys." Journal of Agricultural & Food Chemistry 60(27, Sp. Iss. SI): 6806-6815.

Honeys have a range of physicochemical and organoleptic properties, depending on the nectar source. Selected Ion Flow Tube-Mass Spectrometry (SIFT-MS) is an emerging technology that quantifies volatile organic compounds (VOCs) to low concentrations (usually parts-per-trillion (ppt) levels) and is here applied to monitor the aromas in the headspace of different New Zealand monofloral honeys. Honey aromas arise from VOCs in the honeys that differ according to the flower type from which they were derived. In this exploratory study, the headspaces of nine monofloral New Zealand honeys (beech honeydew, clover, kamahi, manuka, rata, rewarewa, tawari, thyme, and vipers bugloss) were analyzed using SIFT-MS without sample preparation. The purpose of the investigation was to identify the major volatiles in each of the honeys and to test the feasibility of using SIFT-MS to distinguish between New Zealand monofloral honeys. In the nine monofloral honeys sampled, a clear distinction was observed between them based on their aroma signatures.

Langridge, D. F. (1973). "New guidelines for honey in Germany." Beekeepers' Bulletin 16(4): 3-7.

Some clauses from the guidelines published in 1972 by the German Federal Government are translated; the limits of HMF content and diastase activity are laid down. The rules also cover norms for designation of honeys according to floral and/or georgraphical origin. It is concluded that many Australian honeys already conform with the standard required for export to Germany, and other producers could, with care, reach this standard. P.Walker

Langridge, D. F. (1975). "Honey quality in relation to export market." Australasian beekeeper 77(3): 53-55.

Langridge, D. F. (1977). "International phytosanitary certificates for bees and apiary products." Australasian beekeeper: 131-132.

Ledgard, N. and W. Simes (1983). "Honey production at 900 m in Craigieburn Forest Park." New Zealand beekeeper(177): 25-27.

In 1980-81 and 1981-82, scale-hive records were kept for 6 hives sited close to a meteorological station. The mean annual yield was 80 kg/colony. Early in the season the main sources were Hieracium lachenalii, followed by Lotus [species not named], and only when the latter had finished flowering did the bees start collecting beech honeydew, which then became the main source for the rest of the season. In comparing hive weight gains with weather records, it was found that almost all of the gains occurred when the mean daily maximum temperature was 19 degrees C (or above). [See also next abstract.]P. Walker.

Leong, A. G., et al. (2012). "Indigenous New Zealand honeys exhibit multiple anti-inflammatory activities." Innate Immunity 18(3): 459-466.

Recent evidence suggests a potential role for honeys in mediating clinical inflammation and tissue damage. Here, we investigated the anti-inflammatory activity of a selection of previously untested indigenous New Zealand (NZ) honeys. We found that several, but not all, New Zealand rewarewa, manuka and kanuka honey samples exhibited potent, dose-dependent reduction of human neutrophil superoxide production in vitro. This inhibitory activity did not correlate with levels of known phenolic-based free radical scavengers. Furthermore, the active honeys did not scavenge superoxide generated in a cell-free xanthine/xanthine oxidase assay. In C57BL/6J mice, topical application of manuka and rewarewa honey samples with the highest in vitro activity suppressed arachidonic acid-induced ear oedema, and rewarewa honey suppressed both oedema and leukocyte (monocyte and neutrophil) infiltration. Together, these findings demonstrate that some indigenous NZ honeys exhibit clinically relevant anti-inflammatory activity. Further investigation is warranted to identify the active component(s) and mechanisms responsible for these activities and to determine potential applications for anti-inflammatory honeys in the topical treatment of clinical inflammation.

Lin, B., et al. (2020). "Utility of the *Leptospermum scoparium* Compound Lepteridine as a chemical marker for Manuka honey authenticity." ACS omega 5(15): 8858-8866.

Manuka honey is a premium food product with unique antimicrobial bioactivity. Concerns with mislabeled manuka honey require robust assays to determine authenticity. Lepteridine is a Leptospermum-specific fluorescent molecule with potential as an authenticity marker. We describe a mass spectrometry-based assay to measure lepteridine based on an isotopically labeled lepteridine standard. Using this assay, lepteridine concentrations in manuka honey samples strongly correlated with concentrations quantitated by either high-performance liquid chromatography-ultraviolet (HPLC-UV) or fluorescence. A derived minimum lepteridine threshold concentration was compared with the New Zealand regulatory definition for manuka honey to determine "manuka honey" authenticity on a set of commercial samples. Both methods effectively distinguished manuka honey from non-manuka honeys. The regulatory definition excludes lepteridine but otherwise includes the quantification of multiple floral markers together with pollen analysis. Our findings suggest that the quantification of lepteridine alone or in combination with leptosperin could be implemented as an effective screening method to identify manuka honey, likely to achieve an outcome similar to the regulatory definition. Copyright © 2020 American Chemical Society.

Lin, B., et al. (2017). "Lepteridine as a unique fluorescent marker for the authentication of manuka honey." Food Chemistry 225: 175-180.

The recent discovery of two unique manuka marker fluorescence wavelengths (MM1 and MM2) potentially offers a rapid and cost-effective approach for manuka honey authentication using spectroscopy. The fluorophore responsible for the MM1 marker has been identified as leptosperin. We investigated whether lepteridine may be responsible for the MM2 fluorescence. We quantified the lepteridine in manuka honey and manuka nectar, which ranged between 5-52 mg/kg and 80-205 mg/kg, respectively. Notably, the fluorescent spectrum of synthetic lepteridine matched the MM2 fluorescence signature. Fluorescence quenching was observed in the honey matrix but otherwise, lepteridine was stable over prolonged storage at 37 degrees C. Lepteridine was also found in Australian Leptospermum honeys and nectars. Lepteridine concentration was positively correlated with concentrations of the MM1 fluorescence marker leptosperin in honeys. These findings identify lepteridine as the principle compound responsible for MM2 fluorescence, and support the utility as a marker compound for manuka honey authentication. (C) 2017 Elsevier Ltd. All rights reserved.

Lin, S. M., et al. (2009). "The in vitro susceptibility of Campylobacter spp. to the antibacterial effect of manuka honey." European Journal of Clinical Microbiology & Infectious Diseases 28(4): 339-344.

We report the antimicrobial effect of manuka honey against Campylobacter spp. isolated by a diagnostic laboratory from specimens from a community in New Zealand. The isolates were differentiated according to species level using multiplex PCR. C. jejuni (20 strains) and C. coli (7 strains) were identified. The clinical isolates identified and type culture collection strains of these species were subjected to testing to determine the minimum inhibitory concentration (MIC) of manuka honey using a microdilution technique. The MIC of the manuka honey against all of the Campylobacter tested was found to be around 1% (v/v) honey. The low MIC values suggest that honey might still inhibit the growth of campylobacteria after dilution by fluid in the gut, but the actual concentration of honey that can be achieved in the intestine is unknown. Therefore, clinical investigation is required to establish the efficacy of honey against Campylobacter spp. in the gut environment.

Liu, M., et al. (2015). "Antibiotic-specific differences in the response of Staphylococcus aureus to treatment with antimicrobiala combined with manuka honey." Frontiers in Microbiology 5: 9-9.

Liu, M. Y., et al. (2018). "Rifampicin-Manuka Honey Combinations Are Superior to Other Antibiotic-Manuka Honey Combinations in Eradicating Staphylococcus aureus Biofilms." Frontiers in Microbiology 8: 12-12.

Chronic wound infections are a major burden to both society and the health care industry. Bacterial biofilms are the major cause of chronic wound infections and are notoriously recalcitrant to treatments with antibiotics,

making them difficult to eradicate. Thus, new approaches are required to combat biofilms in chronic wounds. One possible approach is to use drug combination therapies. Manuka honey has potent broad-spectrum antibacterial activity and has previously shown synergistic activity in combination with antibiotics against common wound pathogens, including Staphylococcus aureus. In addition, manuka honey exhibits anti-biofilm activity, thereby warranting the investigation of its potential as a combination therapy with antibiotics for the topical treatment of biofilm-related infections. Here we report the first use of MacSynergy II to investigate the response of established S. aureus (strain NCTC 8325) biofilms to treatment by combinations of Medihoney (medical grade manuka honey) and conventional antibiotics that are used for preventing or treating infections: rifampicin, oxacillin, fusidic acid, clindamycin, and gentamicin. Using checkerboard microdilution assays, viability assays and MacSynergy II analysis we show that the Medihoney-rifampicin combination was more effective than combinations using the other antibiotics against established staphylococcal biofilms. Medihoney and rifampicin were strongly synergistic in their ability to reduce both biofilm biomass and the viability of embedded S. aureus cells at a level that is likely to be significant in vivo. Other combinations of Medihoney and antibiotic produced an interesting array of effects: Medihoney-fusidic acid treatment showed minor synergistic activity, and Medihoney-clindamycin, -gentamicin, and -oxacillin combinations showed overall antagonistic effects when the honey was used at sub-inhibitory concentration, due to enhanced biofilm formation at these concentrations which could not be counteracted by the antibiotics. However, these combinations were not antagonistic when honey was used at the inhibitory concentration. Confocal scanning laser microscopy confirmed that different honey-antibiotic combination treatments could eradicate biofilms. Our results suggest that honey has potential as an adjunct treatment with rifampicin for chronic wounds infected with staphylococcal biofilms. We also show that MacSynergy II allows a comprehensive examination of the synergistic effects of honey-antibiotic combinations, and can help to identify doses for clinical use.

Locher, C., et al. (2017). "Authentication of Honeys of Different Floral Origins via High-Performance Thin-Layer Chromatographic Fingerprinting." Journal of Planar Chromatography - Modern TLC 30(1): 57-62.

This paper explores the high-performance thin-layer chromatographic (HPTLC) fingerprinting of non-sugar constituents for the authentication of honeys using highly antibacterial Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) honeys sourced from Western Australia, different Leptospermum-derived Manuka honeys, and a typical table honey from an undisclosed floral source as test samples. As is demonstrated in this study, using HPTLC fingerprinting, it is possible to define differences in botanical origin as the honey fingerprints exhibit a unique profile of bands (i.e., R-f values, color) and peak profiles (i.e., Rf and peak intensity values, peak intensity ratios) that differ distinctly from each other. The identification of patterns of common bands among honeys derived from the same floral source as authentication tool is possible. Further, slight differences among honeys from the same botanical origin might be due to age, processing, or regional factors. The HPTLC analysis of two differently aged Jarrah honeys of the same supplier indicates also that future closer investigation of intraspecies differences might assist in developing HPTLC- supported quality control tools.

Love, J. L., et al. (1986). "The determination of tutin and hyenanchin in honey by HPLC." New Zealand Journal of Technology 2(3): 179-182.

Honey samples from Marlborough, New Zealand, in 1985, were analysed by an HPLC method; both tutin and hyenanchin are stable during the process, which is therefore assessed as better than the GLC method previously used. Using this method, both toxins are detected at a wavelength of 195 nm; the limit of detection is somewhat above 0.2 mg/litre. Six of the 20 honeys examined contained traces of toxin and 13 contained no toxin, but one had 2 mg tutin/kg and 3 mg hyenanchin/kg. These are well below levels previously reported in honeys that caused poisoning (30-90 and 70-170 mg/kg, respectively). [See AA 622/82.]^CENTREQUAD~P. Walker.

Lu, J., et al. (2013). "The effect of New Zealand Kanuka, Manuka and Clover honeys on bacterial growth dynamics and cellular morphology varies according to the species." PLoS One 8(2): e55898-e55898.

Treatment of chronic wounds is becoming increasingly difficult due to antibiotic resistance. Complex natural products with antimicrobial activity, such as honey, are now under the spotlight as alternative treatments to

antibiotics. Several studies have shown honey to have broad-spectrum antibacterial activity at concentrations present in honey dressings, and resistance to honey has not been attainable in the laboratory. However not all honeys are the same and few studies have used honey that is well defined both in geographic and chemical terms. Here we have used a range of concentrations of clover honey and a suite of manuka and kanuka honeys from known geographical locations, and for which the floral source and concentration of methylglyoxal and hydrogen peroxide potential were defined, to determine their effect on growth and cellular morphology of four bacteria: Bacillus subtilis, Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa. While the general trend in effectiveness of growth inhibition was manuka>manuka-kanuka blend>kanuka>clover, the honeys had varying and diverse effects on the growth and cellular morphology of each bacterium, and each organism had a unique response profile to these honeys. P. aeruginosa showed a markedly different pattern of growth inhibition to the other three organisms when treated with sub-inhibitory concentrations of honey, being equally sensitive to all honeys, including clover, and the least sensitive to honey overall. While hydrogen peroxide potential contributed to the antibacterial activity of the manuka and kanuka honeys, it was never essential for complete growth inhibition. Cell morphology analysis also showed a varied and diverse set of responses to the honeys that included cell length changes, cell lysis, and alterations to DNA appearance. These changes are likely to reflect the different regulatory circuits of the organisms that are activated by the stress of honey treatment.

Lu, J., et al. (2019). "Honey can inhibit and eliminate biofilms produced by *Pseudomonas aeruginosa*." Scientific Reports 9: 18160-18160.

Chronic wound treatment is becoming increasingly difficult and costly, further exacerbated when wounds become infected. Bacterial biofilms cause most chronic wound infections and are notoriously resistant to antibiotic treatments. The need for new approaches to combat polymicrobial biofilms in chronic wounds combined with the growing antimicrobial resistance crisis means that honey is being revisited as a treatment option due to its broad-spectrum antimicrobial activity and low propensity for bacterial resistance. We assessed four well-characterised New Zealand honeys, quantified for their key antibacterial components, methylglyoxal, hydrogen peroxide and sugar, for their capacity to prevent and eradicate biofilms produced by the common wound pathogen Pseudomonas aeruginosa. We demonstrate that: (1) honey used at substantially lower concentrations compared to those found in honey-based wound dressings inhibited P. aeruginosa biofilm formation and significantly reduced established biofilms; (2) the anti-biofilm effect of honey was largely driven by its sugar component; (3) cells recovered from biofilms treated with sub-inhibitory honey concentrations had slightly increased tolerance to honey; and (4) honey used at clinically obtainable concentrations completely eradicated established *P. aeruginosa* biofilms. These results, together with their broad antimicrobial spectrum, demonstrate that manuka honey-based wound dressings are a promising treatment for infected chronic wounds, including those with *P. aeruginosa* biofilms.

Lu, J., et al. (2014). "Manuka-type honeys can eradicate biofilms produced by Staphylococcus aureus strains with different biofilm-forming abilities." PeerJ 2: e326-e326.

Chronic wounds are a major global health problem. Their management is difficult and costly, and the development of antibiotic resistance by both planktonic and biofilm-associated bacteria necessitates the use of alternative wound treatments. Honey is now being revisited as an alternative treatment due to its broad-spectrum antibacterial activity and the inability of bacteria to develop resistance to it. Many previous antibacterial studies have used honeys that are not well characterized, even in terms of quantifying the levels of the major antibacterial components present, making it difficult to build an evidence base for the efficacy of honey as an antibiofilm agent in chronic wound treatment. Here we show that a range of well-characterized New Zealand manuka-type honeys, in which two principle antibacterial components, methylglyoxal and hydrogen peroxide, were quantified, can eradicate biofilms of a range of Staphylococcus aureus strains that differ widely in their biofilm-forming abilities. Using crystal violet and viability assays, along with confocal laser scanning imaging, we demonstrate that in all S. aureus strains, including methicillin-resistant strains, the manuka-type honeys showed significantly higher anti-biofilm activity than clover honey and an isotonic sugar solution. We observed higher anti-biofilm activity as the proportion of manuka-derived honey, and thus methylglyoxal, in a honey blend increased. However, methylglyoxal on its own, or with sugar, was not able to effectively eradicate S. aureus biofilms. We also demonstrate that honey was able to

penetrate through the biofilm matrix and kill the embedded cells in some cases. As has been reported for antibiotics, sub-inhibitory concentrations of honey improved biofilm formation by some S. aureus strains, however, biofilm cell suspensions recovered after honey treatment did not develop resistance towards manuka-type honeys. New Zealand manuka-type honeys, at the concentrations they can be applied in wound dressings are highly active in both preventing S. aureus biofilm formation and in their eradication, and do not result in bacteria becoming resistant. Methylglyoxal requires other components in manuka-type honeys for this antibiofilm activity. Our findings support the use of well-defined manuka-type honeys as a topical anti-biofilm treatment for the effective management of wound healing.

Lusby, P. E., et al. (2002). "Honey: a potent agent for wound healing?" Journal of wound, ostomy, and continence nursing : official publication of The Wound, Ostomy and Continence Nurses Society 29(6): 295-300.

Although honey has been used as a traditional remedy for burns and wounds, the potential for its inclusion in mainstream medical care is not well recognized. Many studies have demonstrated that honey has antibacterial activity in vitro, and a small number of clinical case studies have shown that application of honey to severely infected cutaneous wounds is capable of clearing infection from the wound and improving tissue healing. The physicochemical properties (eg, osmotic effects and pH) of honey also aid in its antibacterial actions. Research has also indicated that honey may possess antiinflammatory activity and stimulate immune responses within a wound. The overall effect is to reduce infection and to enhance wound healing in burns, ulcers, and other cutaneous wounds. It is also known that honeys derived from particular floral sources in Australia and New Zealand *(Leptospermum* spp) have enhanced antibacterial activity, and these honeys have been approved for marketing as therapeutic honeys (Medihoney and Active Manuka honey). This review outlines what is known about the medical properties of honey and indicates the potential for honey to be incorporated into the management of a large number of wound types.

Ma, L., et al. (2020). "Identification of Manuka honey by multiplex qPCR method." Journal of Food Safety and Quality 11(19): 6905-6909.

Objective: To identify Manuka honey by applying the multiple qPCR method proposed by the Ministry of Primary Industries (MPI) of the New Zealand government. Methods: With referencing to the multiple qPCR method proposed by MPI, the Manuka standard curve was established. A total of 15 honey samples of unknown origin were detected, the pollen DNA in the samples was extracted, and the samples were analyzed by multiple qPCR Results: The Manuka standard curve was established to obtain the threshold range of the Manuka channel. It could be used for Manuka-specific analysis of future honey samples. The pollen DNA in M2-4 honey sample did not come from Leptospernnan scoparium. Conclusion: This article plays a very good role in promoting and guiding the identification method of Manuka honey proposed by MPI.

Manchester, A. (2005). "A passion for wound care." Nursing New Zealand (Wellington, N.Z. : 1995) 11(4): 15-15.

Mane, S., et al. (2018). "Successful Treatment of Actinic Keratosis with Kanuka Honey." Case reports in dermatological medicine 2018: 4628971-4628971.

Actinic keratoses form as rough, scaly plaques on sun-exposed areas; they can be an important step in premalignant progression to squamous cell cancer of the skin. Currently, pharmacological treatments consist of topical immunomodulatory agents with poor side effect profiles. Use of honey has been common in both ancient and modern medicine, where it is now a key therapy in the management of wound healing. In vitro studies show the New Zealand native Kanuka honey to have immunomodulatory and antimitotic effects, with recent evidence suggesting efficacy of topical application in a variety of dermatological contexts, including rosacea and psoriasis. Here, we present a case report of a 66-year-old gentleman with an actinic keratosis on his hand, which had been present for years. Regular application of Kanuka honey over three months resulted in remission immediately following the treatment period with no signs of recurrence at nine months.

Manning, R. (1993). "Honey production in Western Australia." Journal of agriculture. 34(3): 104-108.

Martindale, G. (1979). "Application of the Food Hygiene Regulations to honey houses [in New Zealand]." Application of the Food Hygiene Regulations to honey houses [in New Zealand]. 2-pp.

Martini, N. (2016). "Potion or Poison? Manuka Honey." Journal of primary health care 8(3): 277-278.

Martos, I., et al. (2000). "Flavonoids in monospecific *Eucalyptus* honeys from Australia." Journal of Agricultural & Food Chemistry 48(10): 4744-4748.

The HPLC analyses of Australian unifloral *Eucalyptus* honeys have shown that the flavonoids myricetin (3,5,7,3',4',5'-hexahydroxyflavone), tricetin (5,7,3',4',5'-pentahydroxyflavone), quercetin (3,5,7,3',4'-pentahydroxyflavone), luteolin (5,7,3',4'-tetrahydroxyflavone), and kaempferol (3,5,7,4'-tetrahydroxyflavone) are present in all samples. These compounds were previously suggested as floral markers of European *Eucalyptus* honeys. The present results confirm the use of flavonoid analysis as an objective method for the botanical origin determination of *Eucalyptus* honey. Honeys from E. camaldulensis (river red gum honey) contain tricetin as the main flavonoid marker, whereas in honeys from E. pilligaensis (mallee honey), luteolin is the main flavonoid marker, suggesting that species-specific differences can be detected with this analysis. The main difference between the flavonoid profiles of Australian and European *Eucalyptus* honeys is that in the Australian honeys, the propolis-derived flavonoids (pinobanksin (3,5,7-trihydroxyflavanone), pinocembrin (5,7-dihydroxyflavanone), and chrysin (5,7-dihydroxyflavone)) are seldom found and in much smaller amounts.

McComb, K. and R. Frew (2013). Using new analytical approaches to verify the origin of honey. New Analytical Approaches for Verifying the Origin of Food. Cambridge, Woodhead Publ Ltd. 245: 216-242.

Honey is a valuable food commodity that is utilised worldwide, as a direct food source or as an ingredient in a large number of manufactured foods. Honey is also of interest due to the antibacterial properties that it exhibits and many honeys are known for their antimicrobial action, some more than others. The honey trade has long been a target for fraudulent practices including the adulteration of honey with cheaper sugars or the passing off of honey from one source (regional or botanical) as that from a more valued source. This chapter reviews the literature on the use of chemical measures to differentiate honey to determine its botanical source and geographical origin. The chemical techniques applied include trace element analysis, stable isotopes, infrared and NMR spectroscopy.

McDonald, C. M., et al. (2018). "Using chemical and DNA marker analysis to authenticate a high-value food, manuka honey." NPJ science of food 2: 9-9.

Ensuring the authenticity of food is a rapidly emerging issue, especially in regard to high-value products that are marketed through increasingly complex global food chains. With the ever-increasing potential for mislabeling, fraud and adulteration, governments are increasingly having to invest in, and assure, the authenticity of foods in international trade. This is particularly the case for manuka honey, an iconic New Zealand food product. We show how the authenticity of a specific type of honey can be determined using a combination of chemicals derived from nectar and DNA derived from pollen. We employ an inter-disciplinary approach to evaluate a selection of authenticity markers, followed by classification modelling to produce criteria that consistently identify manuka honey from New Zealand. The outcome of our work provides robust identification criteria that can be applied in a regulatory setting to authenticate a high-value natural food. Our approach can transfer to other foods where assurance of authenticity must take into account a high level of natural variability.

McIver, V. C., et al. (2020). "Effects of topical treatment of cannabidiol extract in a unique manuka factor 5 manuka honey carrier on second intention wound healing on equine distal limb wounds: a preliminary study." Australian Veterinary Journal 98(6): 250-255.

ObjectiveEvaluate the effect of topical 1% cannabidiol on second intention wound healing in distal limb wounds of horses.DesignExperimental.AnimalsSix Standardbred horses.MethodsA total of five 2.5 cm × 2.5 cm full thickness skin wounds were created on the dorsomedial aspect of the metacarpi of 6 horses. Wounds were contaminated with faeces on the day of wound creation. Each wound was then assigned to a treatment group; compounded 1% cannabidiol in unique manuka factor (UMF) 5 manuka honey, UMF 5 manuka honey, UMF 20 manuka honey or saline. Each treatment was applied topically daily for a total of 42 days. Legs were bandaged and bandages were changed, daily, for 13 days postoperatively. Digital photographs of each wound were taken on day 1 then weekly for 6 weeks. Wound size, daily healing rate and total time to healing were recorded and compared statistically.ResultsIrrespective of the treatment, wounds did not retract as expected in the first 7 days after wound creation. There was no difference in wound area, daily healing rate, days to complete healing between treatment groups.ConclusionsThis preliminary study failed to demonstrate any difference in wound healing variables between treatment groups in this model of second intention wound healing. This was unexpected due to the established effects of UMF 20 manuka honey on wound healing using the same model. This may be due to systemic effects of cannabidiol and study design. Further research into the use of cannabidiol in equine wounds is warranted.

Mian Li, O., et al. (2019). "Manuka honey sinus irrigations in recalcitrant chronic rhinosinusitis: phase 1 randomized, single-blinded, placebo-controlled trial." International Forum of Allergy & Rhinology 9(12): 1470-1477.

BackgroundManuka honey (MH) has significant antibiofilm activity in vitro and in vivo against Staphylococcus aureus, methicillin-resistant S aureus (MRSA), and Pseudomonas aeruginosa. This is the first randomized, single-blinded, placebo-controlled phase 1 clinical trial investigating the safety and preliminary efficacy of MH with augmented methylglyoxal (MGO) rinses in recalcitrant chronic rhinosinusitis (CRS).MethodsPatients were included after previously undergoing endoscopic sinus surgery and presenting with signs and symptoms of sinus infection with positive bacterial cultures on sinus swabs. Patients were randomized to receive 14 days of twice-daily 16.5% MH + 1.3 mg/mL MGO sinonasal rinses and concurrent 10 days of placebo tablets (MH), or 14 days of twice-daily saline sinonasal rinses and concurrent 10 days of culture-directed antibiotic therapy (CON). Safety observations included the University of Pennsylvania Smell Identification Test (UPSIT) and adverse-event (AE) reporting. Efficacy was assessed comparing microbiology results, Lund-Kennedy scores (LKSs), and symptom scores using the visual analog scale (VAS) and 22-item Sino-Nasal Outcome Test (SNOT-22).ResultsTwenty-five patients completed the study. MH demonstrated a good safety profile with no major AEs and no changes in UPSIT. Six of 10 (60%) MH patients had a reduction in bacterial culture rate with 1 of 10 of those having negative cultures, compared with 12 of 15 (80%) in the control group with 7 of 15 having negative cultures upon completion of the study.ConclusionThis study concludes that twice-daily 16.5% MH augmented with 1.3 mg/mL MGO sinonasal rinses alone for 14 days is safe but not superior to culture-directed oral antibiotics and twice-daily saline rinses.

Miles, L. E., et al. (1964). "A taste of honey--critical analysis of the Folin Wu method of blood glucose estimation." The New Zealand medical journal 63: 232-236.

Molan, P. (1996). "Honey for the treatment of infections." Bee Informed 3(2): 6-9.

Recent research on differences in the antibacterial activity of different honeys is discussed. One antibacterial substance in honey is hydrogen peroxide, but it was found in tests on 26 honeys that 2, from viper's bugloss [Echium sp.] and manuka [Leptospermum scoparium], had antibacterial properties even when hydrogen peroxide had been removed. In the laboratory, a solution containing 5-10% of either honey halted growth of strains of Staphylococcus aureus that are resistant to most or all antibiotics. Also, in bioassays honey was effective against the bacteria which cause mastitis in dairy cows. Some traditional remedies for dyspepsia and stomach ulcers have used honey. In tests, 5% manuka honey solution halted the growth of strains of Helicobacter pylori isolated from samples of stomach ulcers.

Molan, P. and J. Betts (2000). "Using honey dressings: the practical considerations." Nursing times 96(49): 36-37.

Molan, P. C. (2001). "Potential of honey in the treatment of wounds and burns." American journal of clinical dermatology 2(1): 13-19.

There has been a renaissance in recent times in the use of honey, an ancient and traditional wound dressing, for the treatment of wounds, burns, and skin ulcers. In the past decade there have been many reports of case studies, experiments using animal models, and randomized controlled clinical trials that provide a large body of very convincing evidence for its effectiveness, and biomedical research that explains how honey produces such good results. As a dressing on wounds, honey provides a moist healing environment, rapidly clears infection, deodorizes, and reduces inflammation, edema, and exudation. Also, it increases the rate of healing by stimulation of angiogenesis, granulation, and epithelialization, making skin grafting unnecessary and giving excellent cosmetic results.

Molan, P. C. and K. M. Russell (1988). "Non-peroxide antibacterial activity in some New Zealand honeys." Journal of apicultural research. 27(1): 62-67.

Molan, P. C., et al. (1988). "A comparison of the antibacterial activities of some New Zealand honeys." Journal of apicultural research. 27(4): 252-256.

Moller, H. (1987). "Honeydew - a South Island beekeepers' bounty." New Zealand beekeeper(195): 31-33.

The beech scale insect lives within a wax capsule in the bark of [mountain] beech which grows in forests on S. Island, New Zealand. In their first and second growth stages, the insects produce honeydew; this splashes onto the tree trunks and the ground below, which eventually turns black because of the growth of sooty moulds. The honeydew is also an important energy source for several species of birds that normally feed on nectar, and for ants, small beetles, flies, bumble bees and, in particular, wasps and honeybees. The wasps, comparative newcomers to these forests, are more successful than solitary bees and honeybees in collecting honeydew.P. Walker.

Mossel, B., et al. (2003). "Determination of viscosity of some Australian honeys based on composition." International Journal of Food Properties 6(1): 87-97.

Rheological properties of four unprocessed unifloral Australian honeys (heath, tea tree, yapunya, and yellow box) and an artificial honey were analysed at 20°C. A model previously used to describe viscosity data of various sugar and sugar mixtures was used to describe the concentration dependence of the viscosity of honey samples with varying moisture contents. The model successfully described the sugar concentration dependence of the unadulterated and medium moisture (70–85% solids) range honey samples. [ABSTRACT FROM AUTHOR] Copyright of International Journal of Food Properties is the property of Taylor & Francis Ltd and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Muller, P., et al. (2013). "Synergism between Medihoney and rifampicin against methicillin-resistant Staphylococcus aureus (MRSA)." PLoS One 8(2): e57679-e57679.

Skin and chronic wound infections caused by highly antibiotic resistant bacteria such as methicillin-resistant Staphylococcus aureus (MRSA) are an increasing and urgent health problem worldwide, particularly with sharp

increases in obesity and diabetes. New Zealand manuka honey has potent broad-spectrum antimicrobial activity, has been shown to inhibit the growth of MRSA strains, and bacteria resistant to this honey have not been obtainable in the laboratory. Combinational treatment of chronic wounds with manuka honey and common antibiotics may offer a wide range of advantages including synergistic enhancement of the antibacterial activity, reduction of the effective dose of the antibiotic, and reduction of the risk of antibiotic resistance. The aim of this study was to investigate the effect of Medihoney in combination with the widely used antibiotic rifampicin on S. aureus. Using checkerboard microdilution assays, time-kill curve experiments and agar diffusion assays, we show a synergism between Medihoney and rifampicin against MRSA and clinical isolates of S. aureus. Furthermore, the Medihoney/rifampicin combination stopped the appearance of rifampicin-resistant S. aureus in vitro. Methylglyoxal (MGO), believed to be the major antibacterial compound in manuka honey, did not act synergistically with rifampicin and is therefore not the sole factor responsible for the synergistic effect of manuka honey with rifampicin. Our findings support the idea that a combination of honey and antibiotics may be an effective new antimicrobial therapy for chronic wound infections.

Newswire, P. R. (2018). Australia's Capilano honey introduces Beeotic®, the world's first clinically tested prebiotic honey, to the U.S. market. CAPILANO-HONEY-LTD, Y.

; BRISBANE, Australia, Sept. 25, 2018 /PRNewswire/ -- Capilano Honey Ltd, the market leader for honey in Australia and one of the world's largest honey packers, today announced the U.S. debut of Capilano Beeotic® Honey, the world's first clinically tested prebiotic honey. [ABSTRACT FROM PUBLISHER]

Nicholls, Y. M. and C. Newlands (2004). "World leaders in medical grade manuka honey." Honeybee Science 25(4): 159-164.

ApiMed Medical Honey Limited (ApiMed), Medical Division of Comvita New Zealand Limited (Comvita) is New Zealand's largest specialist medical grade active Manuka honey company. ApiMed started in August 2000 following global demand for high quality medical grade honey and honey-based health products. ApiMed has on going activities in honey research and intellectual property development together with the University of Waikato, Hamilton, New Zealand. The company currently holds a range of honey product patents and also participates and funds numerous research and clinical trials for further product development and extension. The research interest of the company extends from wound care to oral/dental hygiene, throat care, internal health, skincare, eye care and veterinary care. ApiMed has developed a unique "Accredited Honey Supply Program" in order to meet the requirements of a medical device manufacturer in the United Kingdom. The programme includes an Accredited Supplier Network with the development of standards and systems from resourcing to harvesting and extraction. Standards and systems have also been developed for honey processing. Strict product testing regimes were also set for ensuring the integrity of "Medical Grade Honey" supply. The systems developed for the programme was in consideration of preventing any possible microbiological, physical and chemical contamination that cannot be removed afterwards and also for the prevention of natural quality deterioration/loss during storage. Traceability of the honey from hive to finished product is also an essential part of the system developed. A series of workshops with landowners, beekeepers and honey extractors have been carried out in order to introduce the concept of "Medical Grade Honey" and to develop standards and systems. At the end of the Accredited Supplier Program an assessment is undertaken by the suppliers and only suppliers that passed the assessment are able to supply Medical Grade Honey to ApiMed. Those Accredited Suppliers are also audited, by ApiMed, throughout the honey season to ensure compliance with the standards and systems developed. From the results of honey supplied in 2003, it has been proven that production of medical grade honey is achievable through the cooperation of landowners, beekeepers and honey extractors. This is the direct result of stringent quality systems and standard management.

Nickless, E. M., et al. (2014). "Analytical FT-Raman spectroscopy to chemotype *Leptospermum scoparium* and generate predictive models for screening for dihydroxyacetone levels in floral nectar." Journal of Raman Spectroscopy 45(10): 890-894.

Leptospermum scoparium (Manuka) is the source of nectar for Unique Manuka Factor (UMF) honey. The chemical component of interest to this study is dihydroxyacetone (DHA). DHA is the precursor for the chemical methylglyoxyl which is the main chemical responsible for the UMF activity in Manuka honey. Screening commercially bred plants for increased DHA synthesis in L. scoparium is a critical factor in growing the Manuka Honey industry in New Zealand. FT-Raman spectroscopy, in combination with principal component analysis and partial least squares regression analysis, was investigated as an analytical tool for building a screening model for DHA in the nectar of L. scoparium. Leaf samples of seven cultivars of the species L. scoparium were collected in an attempt to correlate metabolic factors in the plant with DHA synthesis in the nectar. Leaf material was analysed using Fourier transform-raman spectroscopy (FT-Raman). The DHA levels in nectar samples of the same cultivars were measured using standard LC-MS methods. This study showed that the application of multivariate analysis of FT-Raman spectra from leaf material is a useful tool to screen for DHA potential in L. scoparium. The PLS regression shows that we can screen for DHA concentrations in the range of 3300-7600mg/kg plus or minus 20% standard error and can distinguish low medium and high DHA synthesis in the group of plants studied. The model for predicting DHA concentrations is influenced by a significant contribution from the spectral variance due to beta-carotene and other highly scattering compounds that are not directly correlated with UMF. Copyright (c) 2014 John Wiley & Sons, Ltd.

Norton, M. (2015). "Honey, essential oils top natural products awards." Pharmacy Today (11701927): 23-23.

Ophel, A. E. (1943). "Food value of honey." Journal of the Department of Agriculture of South Australia 46: 181-183.

Owens, A., et al. (2019). "Kinetics of conversion of dihydroxyacetone to methylglyoxal in New Zealand manuka honey: Part V - The rate determining step." Food Chemistry 276: 636-642.

Monomer formation from dimeric DHA has previously been suggested as the rate-determining step in formation of methylglyoxal, the bioactive component in manuka honey. This step was studied by 1H NMR in DMSO-d6. First order reaction rate was 3.31x10-3+/-9.1x10-4min-1. Upon titration with D2O, little change was observed until ~15 mass% whereupon an exponential increase in rate occurred until indistinguishable from the rate observed in water. Acid or base caused rate accelerations. Theoretical modelling confirmed the existence of acid and base-catalysed mechanisms for dimer decomposition and the structures of two intermediates observed. In honey it is likely the base-catalysed decomposition predominates with water as catalyst but there is little rate acceleration at the levels of water present normally in honey however a small increase in the mass% of water in the honey could cause significant rate acceleration of dimer decomposition and hence formation of methylglyoxal. Copyright © 2018 Elsevier Ltd. All rights reserved.

Packer, J. M., et al. (2012). "Specific non-peroxide antibacterial effect of manuka honey on the Staphylococcus aureus proteome." International journal of antimicrobial agents. 40(1): 43-50.

Manuka honey, derived from the New Zealand flowering plant Leptospermum scoparium, shows promise as a topical antibacterial agent and effective chronic wound dressing. The aim of this study was to determine the non-peroxide antibacterial effects of this honey on the proteome of the common wound pathogen Staphylococcus aureus. Proteomic analysis was performed on cells treated for a short time with manuka honey compared with the proteome of untreated cells as well as cells treated with a Leptospermum honey sample without antibacterial activity. Treatment with manuka honey resulted in a significant decrease in the bacterial cell growth rate as well as downregulation of ten and upregulation of two proteins. Nine of these proteins were also differentially expressed by cells treated with the inactive Leptospermum honey, but to a lesser degree, and the rate of bacterial growth was not affected. The differentially expressed proteins have roles in ribosomal function, protein synthesis, metabolic processes and transcription. Manuka honey uniquely caused downregulation of two proteins [dihydrolipoamide dehydrogenase (DLD) and elongation factor Tu (EF-Tu)] associated with two of these pathways as well as upregulation of one stress-related protein [cold shock protein C (CspC)]. The proteomic profile following treatment

with manuka honey differed from the profiles of other antibacterial agents, indicating a unique mode of action and its potenial value as a novel antimicrobial agent.

Palmer-Jones, T. (1947). "A recent outbreak of honey poisoning. 1. Historical and descriptive." New Zealand Journal of Science and Technology, Section A 29: 107-114.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Palmer-Jones, T. (1947). "A recent outbreak of honey poisoning. 3. The toxicology of the poisonous honey and the antagonism of tutin, mellitoxin, and picrotoxin by barbiturates." New Zealand Journal of Science and Technology, Section A 29: 121-125.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Palmer-Jones, T. (1965). "Poisonous honey overseas and in New Zealand." The New Zealand medical journal 64(399): 631-637.

Pankiw, P. (1974). "A comparison of queens from New Zealand and California for production of honey and package bees in Canada." Bee World 55(4): 141-145.

Queens (C) imported as usual from California were compared in 1968, 1969 and 1970 with queens transported by air from New Zealand (NZ). Queens were introduced into 1-kg packages shaken in late April from colonies overwintered in southern British Columbia; packages were taken to Alberta for testing. After 4-5 weeks brood production in the two groups was similar, and honey production was also similar. NZ queens were more "docile" than C queens, particularly so in 1968. In 1969 and 1970 EFB developed in 1 of 30 and 6 of 45 C colonies, and in 9 of 36 and 4 of 31 NZ colonies, respectively. Sacbrood affected 9 NZ colonies in 1969, but no C colonies.A number of strong colonies were overwintered and used for package production in the following spring. Although NZ colonies survived, and consumed a similar amount of stores to C colonies, they produced less brood and smaller packages in all 3 years. The 60 NZ colonies produced 17.2 kg of package bees and the 50 C colonies 21.6 kg.D.G.Lowe

Pappalardo, M., et al. (2016). "Rapid and Reliable HPLC Method for the Simultaneous Determination of Dihydroxyacetone, Methylglyoxal and 5-Hydroxymethylfurfural in Leptospermum Honeys." PLoS One 11(11): e0167006-e0167006.

A reliable determination of dihydroxyacetone, methylglyoxal and 5-hydroxymethylfurfural is essential to establishing the commercial value and antimicrobial potential of honeys derived from the Leptospermum species endemic to Australia and New Zealand. We report a robust method for quantitation of all three compounds in a single HPLC run. Honey samples (n = 6) that are derivatized with o-(2,3,4,5,6-Pentafluorobenzyl) hydroxylamine were quantitated against a stable anisole internal standard. Linear regression analysis was performed using calibration standards for each compound (n = 6) and results indicated a high degree of accuracy (R-2 = 0.999) for this method. The reliability of some commercial methylglyoxal solutions were found to be questionable. Effective quantitation of methylglyoxal content in honey is critical for researchers and industry, and the use of some commercial standards

may bias data. Two accurate methylglyoxal standards are proposed, including a commercial standard and a derivative that can be prepared within the laboratory.

Parkar, S. G., et al. (2017). "Metabolic and microbial responses to the complexation of manuka honey with alpha-cyclodextrin after simulated gastrointestinal digestion and fermentation." Journal of Functional Foods 31: 266-273.

Manuka honey (MH), ot-cyclodextrin (C) and a formulation containing these two components (MH + C) were subjected to simulated gastrointestinal digestion followed by fermentation with human faecal microbiota. The honey monosaccharides, glucose and fructose were 9- and 3-fold higher respectively in the digesta of MH + C compared with MH. Methylglyoxal (MGO), characteristic of MH was absent after gastric digestion. The precursor of MGO, 1,3-dihydroxyacetone was found to be at a higher concentration in MH + C, compared with MH, after digestion. The MH + C fermenta were more acidic (pH 4.6, $p < 0.05$), with a higher lactate concentration ($p < 0.005$). Compared with water control, MH + C fermenta significantly inhibited Salmonella enterica Typhimurium ($p = 0.041$) and enhanced Lactobacillus reuteri ($p = 0.016$). These findings suggest that complexation with cl-cyclodextrin protects some MH components during digestion. This increases the availability of substrates to faecal bacteria resulting in the generation of metabolites that favour gut health. (C) 2017 Elsevier Ltd. All rights reserved.

Parsons, E., et al. (2012). "Manuka honey mouthwash does not affect oral mucositis in head and neck cancer patients in New Zealand." Journal of Radiotherapy in Practice 11(4): 249-256.

Oral mucositis is an unavoidable side effect of radiation therapy to the head and neck, which can compromise patient health and quality of life. This study investigates the effect of manuka honey on the extent of oral mucositis in head and neck patients in New Zealand. A total of 28 patients were recruited; 10 patients received standard care and 18 patients were given additional manuka honey. Honey was used three times a day; assessment included: extent of oral mucositis using a multi-site mucositis scoring system, weight and quality of life. The first six patients, randomised to the honey arm, used undiluted honey and pulled out in the first week because of extreme nausea, vomiting and stinging sensations in the mouth. The next 12 honey patients used a honey mouthwash (diluted 1:3). Six of these patients completed the trial and four more completed the first 4 weeks of the trial. Eight control patients completed the trial. In contrast to previous honey trials in Malaysia, Egypt, Iran and India, diluted manuka honey did not decrease the extent and onset of radiation-induced oral mucositis but did appear to ameliorate radiation-induced weight loss and increase quality of life in the absence of cisplatin chemotherapy. © 2011 Cambridge University Press.

Paterson, C. R. (1947). "A recent outbreak of honey poisoning. 4. The source of the toxic honey-field observations." New Zealand Journal of Science and Technology, Section A 29: 125-129.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Paust, G. (1975). "The Australian and Western Australian honey industries." Farm Policy 15(2): 44-48.

Recent studies in Australia have attempted to determine the relative contributions of variation in the price of a product and variation in the quantity produced to variation in the gross receipts derived from the sale of that product. Such analysis has important implications for policy. As yet this type of analysis has not been applied to receipts derived from honey and beeswax production. In this article an outline of the Australian and Western Australian beekeeping industry is presented. A later article will analyze the variation in gross receipts from honey and beeswax in terms of price and quantity variation.

Perkins, C. (2017). "New Zealand battles 'fake' manuka honey with export checks." Grocer: 13-13.

The article informs that Ministry for Primary Industries of New Zealand has finalized its 'scientifically robust definition for manuka honey,' which is made with a combination of four chemical markers from nectar and one DNA marker from manuka pollen. It mentions manuka honey for export from New Zealand would require testing and meeting of scientific definition before it can be sold overseas. it also mentions the views of Unique Manuka Factor Honey Association spokesman John Rawcliffe, on it.

Perkins, C. (2017). "New Zealand cracks down on manuka honey fraud." Grocer: 4-4.

The article focuses on the New Zealand government taking efforts to prevent fraud in the New Zealand manuka honey export sector. It looks at the increase in mislabeling of the honey resulting in the Ministry of Primary Industries (MPI) proposing a scientific definition to identify the real honey and directing operators to give a honey sample for testing under the definition.

Priest, C. S. (1946). "Honey and beeswax." The Australasian journal of pharmacy 27(314): 97-97.

Robertson, L. M., et al. (2010). "Investigating the importance of altitude and weather conditions for the production of toxic honey in New Zealand." New Zealand Journal of Crop & Horticultural Science 38(2): 87-100.

Toxic honey is produced in New Zealand when honey bees (*Apis mellifera*) forage on honeydew containing the phytotoxin tutin that is produced by the passion vine hopper (Scolypopa australis) when feeding on the poisonous plant tutu (Coriaria arborea). Observational studies suggest that there are a set of conditions required for the production of toxic honey, but these factors have not been well studied. This research aims to investigate the importance of altitude and weather conditions for the production of toxic honey in New Zealand and makes some recommendations for a review of the New Zealand Food Safety Authority (NZFSA) Food (tutin in honey) Standard 2008 that was introduced after a toxic honey outbreak in 2008. Transects were established in parts of the North Island during the summer of 2009 and were visited weekly for 6 consecutive weeks. Variables recorded were elevation, S. australis density, honeydew abundance, honey bee and wasp (Vespula spp.) presence and temperature and rainfall data. Weather conditions present during the 2008 outbreak were compared with those from 1999 to 2009. S. australis were not present at altitudes of 375 m and above; with more research, some higher areas of New Zealand may be able to be reclassified as 'low risk'. Honeydew was available in a wide range of temperature and rainfall conditions. Rainfall appeared to wash honeydew from tutu bushes; however, it quickly reappeared in densely populated sites. Honey bee and wasp presence was positively affected by the presence of honeydew, nevertheless 30-50% of the time they were observed foraging in the absence of honeydew, indicating they may feed on small amounts of dew. As the absence of honeydew is an option given by the NZFSA to demonstrate honey safety, this requires investigation. Weather conditions leading up to the 2008 toxic honey outbreak were warm and dry but were not significantly different from other years. Therefore, inadequate management practices, rather than more favourable environmental conditions were probably responsible for the 2008 toxic honey outbreak. Future research should focus on determining the conditions required for toxic levels of honeydew to be incorporated into hives, and regions that have not produced toxic honey historically should be closely studied to determine whether any fit the low-risk criteria.

Roff, C. (1969). "Honey production in Paroo district Australia." Queensland Agricultural Journal 95(3): 163-166.

Rogers, K. M., et al. (2014). "The unique Manuka effect: why New Zealand Manuka honey fails the AOAC 998.12 c-4 sugar method." Journal of agricultural and food chemistry. 62(12): 2615-2622.

Conversion of dihydroxyacteone (DHA) to methylglyoxal (MGO) has been shown to be the key mechanism for the growth in apparent C-4 sugar content in nonperoxide activity (NPA) manuka honey. This reaction is enhanced by heating and storage time and is demonstrated for the first time in clover honey adulterated with DHA purchased

from a chemical supplier and in manuka honey containing naturally occurring DHA and MGO. After heating at 37 pC for 83 days, pure clover honey with no added DHA has the same apparent C-4 sugar content as at t = 0 days. The same clover honey adulterated with synthetic DHA added at t = 0 days and heated at 37 pC over the same time scale shows a change in apparent C-4 sugars from 2.8 to 5.0%. Four NPA manuka honeys heated over longer periods show an increase in apparent C-4 sugars of up to 280% after 241 days. This study strongly suggests that a protein fractionation effect occurs in the conversion of DHA to MGO in higher NPA manuka honey, rendering the remaining t13C protein value more negative and falsely indicating C-4 sugar addition when using the AOAC 998.12 method.

Rogers, K. M., et al. (2014). "Investigating C-4 Sugar Contamination of Manuka Honey and Other New Zealand Honey Varieties Using Carbon Isotopes." Journal of agricultural and food chemistry. 62(12): 2605-2614.

Carbon isotopes (t13C honey and t13C protein) and apparent C-4 sugar contents of 1023 New Zealand honeys from 15 different floral types were analyzed to investigate which New Zealand honey is prone to failing the AOAC 998.12 C-4 sugar test and evaluate the occurrence of false-positive results. Of the 333 honey samples that exceeded the 7% C-4 sugar threshold, 324 samples of these were New Zealand manuka honey (Leptospermum scoparium, 97.2% of all fails found in the study). Three monofloral honeys (ling, kamahi, and tawari) had nine samples (2.8% of all fails found in the study) with apparent C-4 sugars exceeding 7%. All other floral types analyzed did not display C-4 sugar fails. False-positive results were found to occur for higher activity New Zealand manuka honey with a methylglyoxal content >250 mg/kg or a nonperoxide activity >10+, and for some ling, kamahi and tawari honeys. Recommendations for future interpretation of the AOAC 998.12 C-4 sugar method are proposed.

Rope, C. G. (1978). "New Zealand honey: quality standards." New Zealand beekeeper 39(4): 25-27.

Rosendale, D. I., et al. (2008). "High-throughput microbial bioassays to screen potential New Zealand functional food ingredients intended to manage the growth of probiotic and pathogenic gut bacteria." International journal of food science & technology. 43(12): 2257-2267.

A spectrophotometric bioassay was used to screen selected food ingredients intended for development of functional foods designed to influence the growth of gut bacteria. Dose-response profiles displaying growth, the magnitude of deviation from growth of controls, were generated for probiotics Lactobacillus reuteri, Lactobacillus rhamnosus, Bifidobacterium lactis and pathogens Escherichia coli, Salmonella Typhimurium and Staphylococcus aureus. Ingredients were manuka honey UMF[trade mark sign]20+(dose-dependently increased probiotics and decreased pathogens); bee pollen (biphasic growth effects against all); Rosehips and BroccoSproutsp (increased all dose-dependently); blackcurrant oil (little effect) and propolis (inhibited all strains). Ingredients were also bioassayed in pairs to assess desirable or undesirable synergistic interactions. Observed synergies included manuka honey (predominantly desirable); rosehips or BroccoSproutsp (desirable and undesirable); blackcurrant oil (desirable) and propolis (tended towards synergies reinforcing its antimicrobial effects), collectively revealing a complex web of interactions which varied by ingredient and bacterial strain. Manuka honey was particularly effective at influencing gut bacteria. The surprising frequency of undesirable synergistic interactions illustrates the importance of pre-testing potential ingredient combinations intended for use in functional foods.

Roshan, N., et al. (2017). "Antibacterial activity and chemical characteristics of several Western Australian honeys compared to manuka honey and pasture honey." Archives of Microbiology 199(2): 347-355.

The physicochemical parameters and antibacterial activity of 10 Western Australian (WA) and two comparator honeys were determined. Honeys showed a pH range of 4.0-4.7, colour range of 41.3-470.7 mAU, methylglyoxal levels ranging from 82.2 to 325.9 mg kg(-1) and hydrogen peroxide levels after 2 h of 22.7-295.5 A mu M. Antibacterial activity was assessed by the disc diffusion assay, phenol equivalence assay, determination of minimum inhibitory and bactericidal concentrations and a time-kill assay. Activity was shown for all honeys by one or more method, however, activity varied according to which assay was used. Minimum inhibitory concentrations for WA honeys against 10 organisms ranged from 4.0 to > 32.0% (w/v). Removal of hydrogen peroxide activity by

catalase resulted in decreased activity for several honeys. Overall, the data showed that honeys in addition to those derived from Leptospermum spp. have antimicrobial activity and should not be overlooked as potential sources of clinically useful honey.

Russell, K. M., et al. (1990). "Identification of some antibacterial constituents of New Zealand manuka honey." Journal of agricultural and food chemistry. 38(1): 10-13.

Some components responsible for the exceptionally high antibacterial activity of manuka honey were isolated by testing fractions of the honey for activity against Staphylococcus aureus. An ethanol-ether extract of the honey was separated by preparative-layer chromatography and the fractions thus obtained were assessed for antibacterial activity. One fairly homogeneous fraction was identified as methyl 3,5-dimethoxy-4-hydroxybenzoate (methyl syringate, 1b). Combined gas chromatography-mass spectroscopy indicated the presence of this compound in some of the other antibacterial fractions together with methyl 3,4,5-trimethoxybenzoate (1c) and 3,4,5-trimethoxybenzoic acid (1a). Authentic specimens of 3,5-dimethoxy-4-hydroxybenzoic acid (syringic acid, 1d) and 3,4,5-trimethoxybenzoic acid (1a) and their methyl esters were tested against S. aureus. The acids and, to a lesser extent, methyl syringate were found to possess significant antibacterial activity.

Seijo, M. C., et al. (2003). "Palynological differences in the pollen content of *Eucalyptus* honey from Australia, Portugal and Spain." Grana 42(3): 183-190.

A melissopalynological study was carried out on 75 samples of *Eucalyptus* honey from different countries (22 from Australia, 13 from Portugal and 40 from Northwest Spain), in which a total of 145 different pollen types were identified. Of such, only *Eucalyptus*, Acacia, Brassica, Echium, Ligustrum, Plantago, Rumex, Taraxacum, Trifolium and Vicia pollen are present in the honeys from all three countries. Among the most abundant pollen types in Australian honeys, those belonging to the following families stand out: Myrtaceae (Angophora and Melaleuca), Fabaceae, Asteraceae, Proteaceae and Euphorbiaceae, along with Raphanus, Echium and Citrus. In the Portuguese honeys, the presence of Fabaceae, Rosaceae and Cistaceae stands out, with Castanea and Erica as secondary pollen types, while Fabaceae, Asteraceae, Boraginaceae, Cistaceae and Scrophulariaceae are the families with the highest quantity of pollen types in the samples from Spain. In the latter, the most important secondary pollen types are: Castanea, Cytisus, Erica, Lotus, Salix and Rubus.

Seijo, M. D., et al. (2002). "Eucryphia honeys of Tasmania." Grana 41(3): 194-198.

A total of 22 honey samples from the west of Tasmania were analysed. All of them were monofloral leatherwood honeys containing between 79.9% and 99.1% of Eucryphia sp. pollen. Furthermore, 27 different pollen types were identified, the most frequent of which were *Eucalyptus*, Leptospermum (Myrtaceae), Trifolium (Fabaceae), Rosaceae, Banksia (Proteaceae), Lotus (Fabaceae), Bursaria (Pittosporaceae) and Brassica (Brassicaceae), which appeared in a great number of honeys with different percentages. The pollen spectrum characteristics of Tasmania's monofloral leatherwood honeys differentiate them from Chilean honeys of the same floral origin.

Seijo, M. d. C., et al. (2002). "Eucryphia honeys of Tasmania." Grana 41(3): 194-198.

A total of 22 honey samples from the west of Tasmania were analysed. All of them were monofloral leatherwood honeys containing between 79.9% and 99.1% of Eucryphia sp. pollen. Furthermore, 27 different pollen types were identified, the most frequent of which were *Eucalyptus*, Leptospermum (Myrtaceae), Trifolium (Fabaceae), Rosaceae, Banksia (Proteaceae), Lotus (Fabaceae), Bursaria (Pittosporaceae) and Brassica (Brassicaceae), which appeared in a great number of honeys with different percentages. The pollen spectrum characteristics of Tasmania's monofloral leatherwood honeys differentiate them from Chilean honeys of the same floral origin.

Semprini, A., et al. (2016). "Randomised controlled trial of topical kanuka honey for the treatment of acne." BMJ Open 6(2): e009448-e009448.

Objective: To investigate the efficacy of Honevo, a topical 90% medical-grade kanuka honey, and 10% glycerine (honey product) as a treatment for facial acne. Design: Randomised controlled trial with single blind assessment of primary outcome variable. Setting: Outpatient primary care from 3 New Zealand localities. Participants: Of 136 participants aged between 16 and 40 years with a diagnosis of acne and baseline Investigator's Global Assessment (IGA) for acne score of >=2.68, participants were randomised to each treatment arm. Interventions: All participants applied Protex, a triclocarban-based antibacterial soap twice daily for 12 weeks. Participants: randomised to the honey product treatment arm applied this directly after washing off the antibacterial soap, twice daily for 12 weeks. Outcome measures: The primary outcome was >=2 point decrease in IGA score from baseline at 12 weeks. Secondary outcomes included mean lesion counts and changes in subject-rated acne improvement and severity at weeks 4 and 12, and withdrawals for worsening acne. Results: 4/53 (7.6%) participants in the honey product group and 1/53 (1.9%) of participants in the control group had a >=2 improvement in IGA score at week 12, compared with baseline, OR (95% CI) for improvement 4.2 (0.5 to 39.3), p=0.17. There were 15 and 14 participants who withdrew from the honey product group and control group, respectively. Conclusions: This randomised controlled trial did not find evidence that addition of medical-grade kanuka honey in combination with 10% glycerine to standard antibacterial soap treatment is more effective than the use of antibacterial soap alone in the treatment of acne.

Semprini, A., et al. (2015). "A single-blind randomised controlled trial of topical kanuka honey for the treatment of nappy rash." Focus on Alternative and Complementary Therapies 20(3/4): 187-188.

Semprini, A., et al. (2019). "Kanuka honey versus aciclovir for the topical treatment of herpes simplex labialis: a randomised controlled trial." BMJ Open 9(5): e026201-e026201.

Objective: To compare New Zealand medical grade kanuka honey with topical aciclovir for the treatment of herpes simplex labialis.; Design: Prospective parallel randomised controlled open-label superiority trial.; Setting: 76 community pharmacies across New Zealand between 10 September 2015 and 13 December 2017.; Participants: 952 adults randomised within the first 72 hours of a herpes simplex labialis episode.; Interventions: Random assignment 1:1 to either 5% aciclovir cream or medical grade kanuka honey (90%)/glycerine (10%) cream, both applied five times daily.; Outcome Measures: The primary outcome was time from randomisation to return to normal skin (stage 7). Secondary outcomes included time from randomisation to stage 4 (open wound), time from stage 4 to 7, maximal pain, time to pain resolution and treatment acceptability.; Results: Primary outcome variable: Kaplan-Meier-based estimates (95% CI) for the median time in days for return to normal skin were 8 (8 to 9) days for aciclovir and 9 (8 to 9) for honey; HR (95% CI) 1.06 (0.92 to 1.22), p=0.56. There were no statistically significant differences between treatments for all secondary outcome variables. No related serious adverse events were reported.; Conclusion: There was no evidence of a difference in efficacy between topical medical grade kanuka honey and 5% aciclovir in the pharmacy-based treatment of herpes simplex labialis.; Trial Registration Number: ACTRN12615000648527;Post-results. (© Author(s) (or their employer(s)) 2018. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.)

Semprini, A., et al. (2017). "Protocol for a randomised controlled trial of 90% kanuka honey versus 5% aciclovir for the treatment of herpes simplex labialis in the community setting." BMJ Open 7(8): e017766-e017766.

INTRODUCTION: Worldwide, about 90% of people are infected with the herpes simplex virus, 30% of whom will experience recurrent herpes simplex labialis, commonly referred to as 'cold sores', which can last up to 10 days. The most common treatment is aciclovir cream which reduces healing time by just half a day compared with no specific treatment. This is a protocol for a randomised controlled trial (RCT) to determine the efficacy of medical grade kanuka honey-based topical treatment (Honevo) in reducing the healing time and pain of cold sores, compared with topical aciclovir treatment (Viraban)., METHODS AND ANALYSIS: This open-label, parallel-group, active comparator superiority RCT will compare the efficacy of medical grade kanuka honey with 5% aciclovir cream in the treatment of cold sores in the setting of a pharmacy research network of 60 sites throughout New Zealand. Adults presenting with a cold sore (N=950) will be randomised by pharmacy-based investigators. The pharmacy-based

investigators will dispense the investigational product to randomised participants and both study groups apply the treatment five times daily until their skin returns to normal or for 14 days, whichever occurs first. In response to a daily SMS message, participants complete an assessment of their cold sore healing, with reference to a visual guide, and transmit it to the investigators by a smartphone eDiary in real time. The primary outcome variable is time (in days) from randomisation to return to normal skin. Secondary endpoints include total healing time stratified by stage of the lesion at onset of treatment, highest pain severity and time to pain resolution., ETHICS AND DISSEMINATION: New Zealand Ethics Registration 15/NTB/93. Results will be published in a peer-reviewed medical journal, presented at academic meetings and reported to participants., TRIAL REGISTRATION NUMBER: Australia New Zealand Clinical Trials Registry: ACTRN12615000648527, pre-results.SCOTT Registration: 15/SCOTT/14 PROTOCOL VERSION: 4.0 (12 June 2017).

Senanayake, M. (2009). "Extractable organic substances from New Zealand kamahi (*Weinmannia racemosa*) honey." Science in New Guinea 29: 2-13.

The levels of extractable organic substances in the diethyl ether extracts of ten New Zealand kamahi (Weinmannia racemosa) unifloral grade 2002 season honey samples were determined using combined GC-MS methods. The most distinctive components in the extracts were 2,6-dimethylocta-3,7-diene-2,6-diol (average level 31 mg/kg), meliracemoic acid (average level 14 mg/kg) and kamahines A-C (average level 73 mg/kg). These compounds are proposed as floral marker compounds for New Zealand kamahi honey. Lesser levels of a variety of oxygenated linalool analogues, and dehydroabietic acid were also detected in the extracts.

Simon, A., et al. (2009). "Medical honey for wound care--still the 'latest resort'?" Evidence-based Complementary & Alternative Medicine (eCAM) 6(2): 165-173.

While the ancient Egyptians and Greeks used honey for wound care, and a broad spectrum of wounds are treated all over the world with natural unprocessed honeys from different sources, Medihoney™ has been one of the first medically certified honeys licensed as a medical product for professional wound care in Europe and Australia. Our experience with medical honey in wound care refers only to this product. In this review, we put our clinical experience into a broader perspective to comment on the use of medical honey in wound care. More prospective randomized studies on a wider range of types of wounds are needed to confirm the safety and efficacy of medical honey in wound care. Nonetheless, the current evidence confirming the antibacterial properties and additional beneficial effects of medical honey on wound healing should encourage other wound care professionals to use CE-certified honey dressings with standardized antibacterial activity, such as Medihoney™products, as an alternative treatment approach in wounds of different natures. [ABSTRACT FROM AUTHOR]

Sindi, A., et al. (2019). "Anti-biofilm effects and characterisation of the hydrogen peroxide activity of a range of Western Australian honeys compared to Manuka and multifloral honeys." Scientific Reports (Nature Publisher Group) 9: 1-17.

The antibacterial activity of honeys derived from the endemic flora of the southwest corner of Western Australia, including the trees Jarrah (*Eucalyptus marginata*) and Marri (Corymbia calophylla), remains largely unexplored. Investigation of these honeys showed minimum inhibitory concentrations (MICs) of 6.7–28.0% (w/v) against Gram positive and negative bacteria. Honey solutions showed enhanced antibacterial activity after hydrogen peroxide was allowed to accumulate prior to testing, with a mean MIC after accumulation of 14.3% compared to 17.4% before accumulation. Antibacterial activity was reduced after treatment with catalase enzyme, with a mean MIC of 29.4% with catalase compared to 15.2% without catalase. Tests investigating the role of the Gram negative

outer membrane in honey susceptibility revealed increases in activity after destabilisation of the outer membrane. Honeys reduced both the formation of biofilm and the production of bacterial pigments, which are both regulated by quorum sensing. However, these reductions were closely correlated with global growth inhibition. Honey applied to existing biofilms resulted in decreased metabolic activity and minor decreases in viability. These results enhance our understanding of the mechanisms of antibacterial action of Jarrah and Marri honeys, and provide further support for the use of honey in the treatment of infected wounds.

Smallfield, B. M., et al. (2018). "Developmental and compositional changes in *Leptospermum scoparium* nectar and their relevance to mānuka honey bioactives and markers*." New Zealand Journal of Botany 56(2): 183-197.

Mānuka (Leptospermum scoparium) is valued for its unique bioactive honey, but relatively little is known about mānuka nectar and the factors modulating its production. In this study the compositional variability of nectar collected throughout mānuka floral development was measured in glasshouse-cultivated plants. The total yield of nectar was estimated by rinsing flowers with water and measuring total sugars (°Brix). The concentration of total sugars and of dihydroxyacetone (DHA), the precursor to methylglyoxal and the key mānuka honey bioactive, increased through floral development and maximised just prior to initiation of flower degradation. Similarly, the patterns of several mānuka honey authenticity markers including lepteridine, leptosperin and 3-phenyllactic acid also followed a similar trend through flower development, suggesting that their biosynthesis was associated with nectar production. Leaf exudates produced as a result of scale insect infestation of some mānuka plants were deficient in the key markers DHA, leptosperin and lepteridine, but did contain 4-hydroxyphenyllactic acid. This study suggests that the predominant key markers of genuine mānuka are biosynthesised in the floral tissues of the plant rather than elsewhere. For robust analysis and comparison of mānuka nectar yield and composition, sampling needs to take into account the floral developmental stage of the flowers sampled.

Snow, M. J. and M. Manley-Harris (2004). "On the nature of non-peroxide antibacterial activity in New Zealand manuka honey." Food chemistry. 84(1): 145-147.

Some conclusions, which exist in the literature about the nature of non-peroxide antibacterial activity in manuka honey, have been revisited. The stability of non-peroxide antibacterial activity in manuka honey at basic pH was investigated. At pH 11 antibacterial activity was immediately and irreversibly destroyed. This indicates that it is not possible to carry out chromatography of honey solutions at elevated pH with the intent to isolate the active fraction. The effect of 10-fold excess of catalase upon the antibacterial assay was examined. No statistical difference in the outcome was observed between the normal amount of catalase and the 10-fold excess. This indicates that non-peroxide antibacterial activity in manuka honey is not likely to be due to residual hydrogen peroxide.

Somal, N. A., et al. (1994). "Susceptibility of *Helicobacter pylori* to the antibacterial activity of manuka honey." Journal of the Royal Society of Medicine 87(1): 9-12.

The antibacterial effect of honey was tested on H. pylori using isolates from biopsies of gastric ulcers. All 5 isolates tested were sensitive to a 20% (vol/vol) solution of Leptospermum scoparium (manuka) honey in an agar well diffusion assay, but not to a 40% solution of Knightia excelsa (rewarewa) honey (peroxide activity equivalent to 21.5% (wt/vol) phenol, non-peroxide activity undetectable). The minimum inhibitory concentration of manuka honey was determined as 5% (vol/vol).

Sopade, P. A., et al. (2003). "Application of the Williams-Landel-Ferry model to the viscosity-temperature relationship of Australian honeys." Journal of food engineering. 56(1): 67-75.

The rheological behaviour of nine unprocessed Australian honeys was investigated for the applicability of the Williams-Landel-Ferry (WLF) model. The viscosity of the honeys was obtained over a range of shear rates (0.01-40 s-1) from 2degrees to 40degrees C, and all the honeys exhibited Newtonian behaviour with viscosity reducing as the temperature was increased. The honeys with high moisture were of lower viscosity. The glass transition temperatures of the honeys, as measured with a differential scanning calorimeter (DSC), ranged from -40degrees to -

46degrees C, and four models (WLF, Arrhenius, Vogel-Tammann-Fulcher (VTF), and power-law) were investigated to describe the temperature dependence of the viscosity. The WLF was the most suitable and the correlation coefficient averaged 0.999 +/- 0.0013 as against 0.996 +/- 0.0042 for the Arrhenius model while the mean relative deviation modulus was 0-12% for the WLF model and 10-40% for the Arrhenius one. With the "universal" values for the WLF constants, the temperature dependence of the viscosity was badly predicted. From non-linear regression analysis, the constants of the WLF models for the honeys were obtained (C1=13.7-21.1; C2=55.9-118.7) and are different from the universal values. These WLF constants will be valuable for adequate modeling of the rheology of the honeys, and they can be used to assess the temperature sensitivity of the honeys.

Sopade, P. A., et al. (2006). "Specific heat capacity of Australian honeys from 35 to 165C as a function of composition using differential scanning calorimetry." Journal of Food Processing and Preservation 30(2): 99-109.

Modulated temperature differential scanning calorimetry was used to investigate the specific heat capacity (Cp) of 10 Australian honeys within the processing and handling temperatures. The values obtained were found to be different from the literature values at certain temperatures, and are not predictable by the additive model. The Cp of each honey exhibited a cubic relationship (P<0.001) with the temperature (T, C). In addition, the moisture (M, %), fructose (F, %) and glucose (G, %) contents of the honeys influenced their Cp. The following equation (r2=0.92) was proposed for estimating Cp of honey, and is recommended for use in the honey industry and in research: Cp=996.7+1.4x10-3T+5.6x10-5T2-2.4x10-7T3-56 .5M-25.8F-31.0G+1.5(M * F)+1.8(M * G)+0.8(F * G)-4.6x10-(M * F * G).

Sopade, P. A., et al. (2004). "Dynamic and steady-state rheology of Australian honeys at subzero temperatures." Journal of food process engineering. 27(4): 284-309.

Sparks, C. (2011). "Sweet Science." Horse Sport 44(10): 36-37.

The article focuses on the results of a study on the effectiveness of Manuka honey to heal wounds in horses. Manuka honey comes from New Zealand and is being sold by health food retailers, by specialty food markets, and through the Internet. Horse rider Vanessa Blythe expressed her views on the effectiveness of such product after she applied it on her Thoroughbred.

Steinhorn, G., et al. (2011). "Isolation and characterisation of arabinogalactan-proteins from New Zealand kanuka honey." Food chemistry. 128(4): 949-956.

Fractionation of manuka, kanuka and clover honeys indicated the >10kDa fraction contained small amounts of type II arabinogalactans (AGs), which are often present as arabinogalactan proteins (AGPs). AGPs were isolated from the >10kDa fraction of kanuka honey using o-glucosyl Yariv reagent and their composition and structure analysed. Constituent sugar, glycosyl linkage and NMR spectroscopy analysis of the purified AGP fraction revealed a predominance of neutral sugars, mainly galactose and arabinose, linked in a highly-branched structure typical of type II AGs. The molecular weight of the major component of the purified AGPs was o110kDa, as determined by size-exclusion chromatography-multi-angle laser light scattering (SEC-MALLS). The Yariv supernatant fraction contained less total sugar, especially galactose, and more protein than purified AGPs. Linkage analysis indicated this fraction also contained an AG-type polymer in addition to various other polysaccharides and SEC-MALLS indicated the molecular weight of the major component was o32kDa.

Stephens, J. M., et al. (2010). "Phenolic compounds and methylglyoxal in some New Zealand manuka and kanuka honeys." Food chemistry. 120(1): 78-86.

The principal phenolic compounds and methylglyoxal were analysed in New Zealand Leptospermum scoparium (manuka) and Kunzea ericoides (kanuka) honeys. These honeys shared six phenolic acids as primary components and differentiation was possible as relative proportions varied. Manuka honey contained an elevated

concentration of a trimethoxybenzoic acid and methylglyoxal; and 2-methoxybenzoic acid and methylglyoxal concentrations were linearly correlated in fresh manuka honey. Kanuka honey contained an elevated concentration of methoxyphenyllactic acid. The concentration of the phenolic components increased with maturation in both honey types; and this profile development, along with a corresponding increase of methylglyoxal concentration, was linear in manuka honey. Nectar analysed from the plant species contained the same phenolic components as the honeys. These results demonstrated the phenolic profile could be used to differentiate the honey types, heat treatment of honey could be identified, and the presence of these components may contribute to the efficacy of these honeys in therapeutic uses.

Subhashree, V. and D. Subashini (2011). "Estimation of total flavonoids, phenols and antioxidant activity of local and New Zealand manuka honey." Journal of Pharmacy Research 4(2): 464-466.

Honey samples collected from the different locations of Vellore district were screened for total phenolic content, total flavonoid content and for the potential radical scavenging activity respectively. Honey samples were compared with that of standard manuka honey which was purchased from New Zealand. The results of the assay were then compared with gallic acid (phenolics), chrysin (flavonoids) and ascorbic acid (DPPH radical scavenging activity). Honey sample (S2) honey showed higher range of phenolic content, whereas manuka honey (S3) from Leptospermum species, showed higher range of flavonoid content and radical scavenging activity when compared to other honey samples. Phenolic content was higher in honey sample (S2) when compared to flavonoid content.

Sultanbawa, Y., et al. (2015). "Infrared spectroscopy as a rapid tool to detect methylglyoxal and antibacterial activity in Australian honeys." Food Chemistry 172: 207-212.

Methylglyoxal (2-oxopropanal) is a compound known to contribute to the non-peroxide antimicrobial activity of honeys. The feasibility of using infrared spectroscopy as a predictive tool for honey antibacterial activity and methylglyoxal content was assessed. A linear relationship was found between methylglyoxal content (279-1755 mg/kg) in Leptospermum polygalifolium honeys and bacterial inhibition for Escherichiacoli (R(2) = 0.80) and Staphylococcusaureus (R(2) = 0.64). A good prediction of methylglyoxal (R(2) 0.75) content in honey was achieved using spectroscopic data from the mid infrared (MIR) range in combination with partial least squares regression. These results indicate that robust predictive equations could be developed using MIR for commercial application where the prediction of bacterial inhibition is needed to 'value' honeys with methylglyoxal contents in excess of 200mg/kg. (Copyright © 2014 Elsevier Ltd. All rights reserved.)

Sushil, A., et al. (2019). "Antimicrobial activity of Agastache honey and characterization of its bioactive compounds in comparison with important commercial honeys." Frontiers in Microbiology 10(February): 263-263.

There is an urgent need for new effective antimicrobial agents since acquired resistance of bacteria to currently available agents is increasing. The antimicrobial activity of Mono-floral Agastache honey produced from Australian grown Agastache rugosa was compared with the activity of commercially available honeys derived from Leptospermum species and with Jarrah honey for activity against clinical and non-clinical strains of Staphylococcus aureus (methicillin-susceptible and methicillin-resistant strains), Pseudomonas aeruginosa, and Escherichia coli. The minimum inhibitory concentration (MIC) for Agastache honey was in the range of 6-25% (w/v) for all species examined. The MICs for Leptospermum honeys were generally similar to those of Agastache honey, but MICs were higher for Super manuka and Jarrah honeys and lower for Tea tree honey. Staphylococci were more susceptible to all honeys than Pseudomonas aeruginosa and Escherichia coli. Pretreatment of honey with catalase increased the bacterial growth at MIC of Tea tree honey (35%), Super Manuka (15%), Jarrah honeys (12%), and Agastache honey (10%), indicating variable contributions of hydrogen peroxide to antimicrobial activity. Manuka and Jelly bush honeys retained their antimicrobial activity in the presence of catalase, indicating the presence of other antimicrobial compounds in the honey. An LC-MS/MS method was developed and used to identify possible antimicrobial phenolic compounds in Agastache honey and flowers, and five commercial honeys. The chemical markers characteristic of Agastache honey and honeys of Leptospermum origin were phenyllactic acid and methyl syringate. Overall, the

bioactive compounds with antimicrobial and antioxidant activity in Agastache honey suggested a possible use for topical application and in wound care.

Sushil, A., et al. (2018). "Characterization of physico-chemical properties and antioxidant capacities of bioactive honey produced from Australian grown Agastache rugosa and its correlation with colour and poly-phenol content." Molecules 23(1): 108-108.

The antioxidant and antimicrobial components of honey vary based on sourced of nectar. Medicinal plants with the therapeutic value have potential to produce honey with greater bioactivity. The aim of the present study was to characterize the physico-chemical and antioxidant capacities of Agastache honey produced from Agastache rugosa and compare them with other popular commercial honeys sold in Australia. The total phenolics, total flavonoids, moisture content, colour, pH, protein content and antioxidant capacity were evaluated for Agastache, Manuka, Jelly bush, Tea tree, Super manuka and Jarrah honeys. The results reveal that the moisture content ranged from 17-21%, pH ranged from 3.8-4.3 and estimated protein content ranged from 900-2200 micro g/g. The DPPH., ABTS.+, ORAC and FRAP methods were used to measure the antioxidant capacity of the honey samples. The DPPH.% inhibition, ABTS.+, ORAC and FRAP values for Agastache honey were 9.85 (+or-1.98 micro mol TE/g), 26.88 (+or-0.32 micro mol TE/g), 19.78 (+or-1.1 micro mol TE/g) and 3.61 (+or-0.02 micro mol TE/g) whereas the highest antioxidant capacity values obtained were 18.69 (+or-0.9 micro mol TE/g), 30.72 (+or-0.27 micro mol TE/g), 26.95 (+or-0.9 micro mol TE/g) and 3.68 (+or-0.04 micro mol TE/g), respectively. There was a positive correlation between colour, total phenolic content and DPPH. scavenging activity for most of the honeys except Tea tree honey. However, there was no clear correlation with ABTS.+, ORAC and FRAP values. The measured antioxidant capacity of samples varied with the assays used. The DPPH. assay clearly indicated that the phenolic compounds contribute to the scavenging activity of the honeys. Nevertheless, all assays confirm that Agastache honey has significant antioxidant capacity. Therefore, Agastache honey can be important to human nutrition and health.

Sutherland, M. D. and T. Palmer-Jones (1947). "A recent outbreak of honey poisoning. 2. The toxic substances of the poisonous honey." New Zealand Journal of Science and Technology, Section A 29: 114-120.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Sutherland, M. D. and T. Palmer-Jones (1947). "A recent outbreak of honey poisoning. 5. The source of the toxic honey-laboratory investigations." New Zealand Journal of Science and Technology, Section A 29: 129-134.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Swapna, G., et al. (2012). "Arabinogalactan proteins contribute to the immunostimulatory properties of New Zealand honeys." Immunopharmacology and Immunotoxicology 34(3/4): 598-607.

Context: Factors in honey that improve wound healing are poorly understood, but are thought to include lipopolysaccharide (LPS), apalbumin-1 and -2, and a 5.8 kDa component that stimulate cytokine release from macrophages. Background: To characterize the ability of New Zealand honeys to elicit the release of tumor necrosis factor- alpha (TNF- alpha) from monocytic cell lines as a model for early events within a wound site. Materials and methods: The ability of kanuka (Kunzea ericoides), manuka (Leptospermum scoparium), and clover (Trifolium spp.) honeys to stimulate the release of TNF- alpha from monocytic cell lines THP-1 and U937 was assayed by ELISA. Results: All three honeys stimulated TNF- alpha release from THP-1 cells, with kanuka honey being the most active.

The activity of kanuka honey was associated with a high molecular weight (>30 kDa) component that was partially heat labile and inhibitable with polymyxin B. LPS concentrations in the honeys were too low to adequately explain the level of immunostimulation. The contribution of type II arabinogalactan proteins (AGPs) we recently identified in kanuka honey was tested, as AGPs are known immunostimulators. AGPs purified from kanuka honey stimulated the release of TNF- alpha from THP-1 and U937 cells. Discussion: Here we demonstrated that AGPs we recently identified in kanuka honey have immunostimulatory activity. We propose that the immunostimulatory properties of individual honeys relate to their particular content of LPS, apalbumins, the 5.8 kDa component and AGPs. Conclusion: The immunostimulatory activity of kanuka honey may be particularly dependent on AGPs derived from the nectar of kanuka flowers.

Tan, J., et al. (2019). "The effect of Manuka eye drops on tear film properties." IOVS 60(9): 6739-6739.

Purpose : To evaluate the effects of Manuka (Leptospermum sp. honey) eye drops versus a conventional non-lipid based eye drop on tear film properties in symptomatic dry eye subjects after 28 days of treatment. Methods: Forty-six subjects with symptoms of dry eye (Ocular Surface Disease Index [OSDI] score >12) were enrolled and randomly assigned to receive either the test Manuka (Melcare Biomedical, Australia) or control non-lipid based lubricant (Alcon, USA) eye drops in this double-masked study (NCT03622619). Lipid layer thickness (LLT; Lipiview II, TearScience), tear film evaporation rate (TER; Vapometer, Delfin Technologies), fluorescein tear film break-up time (TBUT) and subjective symptoms scores (OSDI) and visual analogue scales (VAS) for burning/stinging, grittiness/foreign body sensation, dryness, blurry vision and overall discomfort were measured before and after 28 days of instilling the eye drops three times daily. Independent t-tests or Mann Whitney U tests were used to compare the two groups. Results : Forty-two subjects completed the study: 21 subjects (9 males and 12 females) with average age 22.2 +/- 3.5 years in the test group, and 21 subjects (5 males and 16 females) with average age 20.6 +/- 3.2 years in the control group. After 28 days of treatment, TER showed a significantly greater reduction in the test group compared to the control group (-10.8 +/- 16.8 vs. 0.7 +/- 10.8 gm-2h, p = 0.01). TBUT tended to increase in the test group compared to the control group (2.0 +/- 3.0 vs. 0.0 +/- 3.1 sec, p = 0.06), and a significantly greater reduction (improvement) in OSDI scores was observed in the test group compared to the control group (-19.6 +/- 10.9 vs.-10.7 +/- 7.1, p = 0.01). No significant differences were found between the two groups for LLT and any of the VAS scores. Conclusions: The Manuka eye drops were more effective for reducing TER, increasing TBUT and improving symptoms of dry eye compared to the conventional non-lipid based eye drops after 28 days of daily use.

Tan, S. T., et al. (1989). "Isolation and X-ray crystal structure of (E)-4-(r-1',t-2',c-4'-trihydroxy-2',6',6'-trimethyl-cyclohexyl)but-3-en-2-one, a constituent of New Zealand thyme honey." Australian Journal of Chemistry 42: 1799-1804.

This degraded carotenoid-like substance was identified by X-ray crystallographic analysis. The only honeys in which it was found, in a study involving more than 200 samples, were those containing a thyme (Thymus) component. It is suggested that this substance could be used to verify the botanical origin of honeys labelled as New Zealand thyme honey.

Tan, S. T., et al. (1989). "Extractives from New Zealand unifloral honeys. 2. Degraded carotenoids and other substances from heather honey." Journal of agricultural and food chemistry. 37(5): 1217-1221.

Tan, S. T., et al. (1990). "Extractives from New Zealand honeys. 3. Unifloral thyme and willow honey constituents." Journal of agricultural and food chemistry. 38(9): 1833-1838.

Tan, S. T., et al. (1990). "A chemical procedure for the characterization of New Zealand thyme and willow honeys." New Zealand beekeeper(205): 11-12.

Gas chromatography profiles were determined for non-carbohydrate organic substances present in samples of thyme honey and willow honey. The profiles differed from those previously reported for the honeys of *Trifolium repens*, Knightia excelsa, Calluna vulgaris and Leptospermum scoparium. In thyme honey the dominant non-carbohydrate organic substance was shown by X-ray crystallography to be the degraded carotenoid trihydroxyketone. In willow honey, different degraded carotenoids were identified, especially 2 isomers of abscisic acid. In an examination of more than 200 New Zealand honeys, trihydroxyketone was present only in honeys with a contribution from thyme, and abscisic acid isomers only in those with a contribution from willow.

Tan, S.-T., et al. (1988). "Extractives from New Zealand honeys. 1. White clover, manuka, and kanuka unifloral honeys." Journal of Agricultural and Food Chemistry 36(3): 453-460.

Ether extracts were made from aqueous solutions of manuka (Leptospermum scoparium), kanuka (Leptospermum ericoides), and clover (*Trifolium repens*) honeys with use of a continuous liquid/liquid extractor. The components of the extracts were methylated before being separated and identified by gas chromatography and mass spectrometry, and also by preparative thin-layer chromatography followed by super(1)H and super(13)C NMR analyses. A total of 61 different compounds were detected, and 56 of these were identified. Compounds reported for the first time in honey include 2-decenedioic, decanedioic, nonanedioic, and octanedioic acids.

Tang, J. S., et al. (2020). "Mānuka honey-derived methylglyoxal enhances microbial sensing by mucosal-associated invariant T cells (Electronic supplementary information (ESI) available. See DOI: 10.1039/d0fo01153c)." Food & Function 11(7): 5782-5787.

Methylglyoxal (MGO) is the main antimicrobial determinant associated with using Mānuka Honey as a topical dressing. While direct mechanisms of Mānuka honey MGO's antimicrobial activity have been demonstrated, such as disruption of bacterial fimbria and flagella, no interaction of Mānuka honey-derived MGO with antimicrobial effector cells of the immune system, such as mucosal-associated invariant T cells (MAIT cells), has yet been reported. MAIT cells are an abundant subset of human T cells, critical for regulating a diverse range of immune functions, including antimicrobial defense mechanisms but also mucosal barrier integrity. MAIT cells become activated by recognition of an important microbial metabolite, 5-amino-6-d-ribitylaminouracil (5-A-RU), which is produced by a wide range of microbial pathogens and commensals. Recognition is afforded when 5-A-RU condenses with mammalian-cell derived MGO to form the potent MAIT cell activator, 5-(2-oxopropylideneamino)-6-d-ribitylaminouracil (5-OP-RU). Formation of 5-OP-RU and its subsequent presentation to MAIT cells by major histocompatibility (MHC)-related molecule 1 (MR1) facilitates host–pathogen and host–commensal interactions. While MGO is a metabolite naturally present in mammalian cells, it is unclear whether exogenous dietary MGO sources, such as those obtained from Mānuka honey intake, can contribute to 5-OP-RU formation and enhance MAIT cell activation. In this work, we report that endogenous MGO is the rate-limiting substrate for converting microbial 5-A-RU to 5-OP-RU and that Mānuka honey-derived MGO significantly enhances MAIT cell activation in vitro. Our findings posit a novel mechanism by which intake of a food item, such as Mānuka honey, can potentially support immune homeostasis by enhancing MAIT cell-specific microbial sensing.

Taplin, J. and P. Smallhorn (1970). "The supply of honey in Australia." Quarterly Review of Agricultural Economics 23(2): 97-109.

The industry has expanded consistently since the late 1930s.The honey yield per hive doubled between 1935 and 1968 (the period reviewed), annual results showing various fluctuations, notably two very good years in the late 1940s. Such an increase is possible by moving hives from one eucalyptus flow to another: such migratory beekeeping accounts for half the total production. Internal consumption doubled since 1952; exports reached a peak in 1961-62. In 1967-68 the average yield per hive was 55 kg, the total production 19 thousand tonnes of which 41/2 were exported.In a statistical analysis, honey supply was examined in 3 stages: number of productive hives, total honey produced, supply from stock. The elasticity of supply from stocks, held mainly by beekeepers, is sufficiently high to effect considerable price stabilization. P. Walker.

Thomson, R. H. K. (1936). "Chemical composition of New Zealand honey." New Zealand Journal of Science and Technology 18: 124-131.

The results of the analyses of 21 samples of New Zealand honey are recorded, together with information, where available, as to the floral source of the honey. The data recorded are percentages of moisture, ash, dextrose, laevulose, sucrose and N, and the values for titratable acidity, formol titration, J? H and specific gravity. New Zealand honey has, on the average, a composition very similar to that of honey from Great Britain or the United States. Certain differences in composition, apparently due to floral type, are indicated.-W. Godden. See also Absts. 4290, 4503, 4504, 4507.

Thomson, R. H. K. (1939). "The removal of undesirable flavour and colour from New Zealand honey." New Zealand Journal of Science and Technology, Section B 20: 220-227.

Tomas-Barberan, F. A., et al. (1993). "Flavonoids in honey of different geographical origin." Zeitschrift fur Lebensmittel-Untersuchung und -Forschung 196(1): 38-44.

The flavonoids present in honey samples from Europe, North America, Equatorial regions, South America, China and Australia were analysed by HPLC. These flavonoids are incorporated into honey from propolis, nectar or pollen. As a general rule, honey samples from the Northern Hemisphere (where poplars, the source of propolis, are native) showed flavonoid profiles characterized by the presence of propolis flavonoids. In contrast, honey samples from most Equatorial regions and Australia were generally devoid of propolis-derived flavonoids, showing only flavonoids from other plant sources. However, several honey samples from Central and South America and from New Zealand did contain flavonoids characteristic of propolis. This means that imported *Apis mellifera* colonies may locate poplar trees, occasionally finding an imported specimen in gardens or agroindustrial exploitations, and incorporate propolis flavonoids into honey. These preliminary results show that flavonoid analysis could be used as an adjunct to studies of the geographical origin of honey.

Tomás-Barberán, F. A., et al. (2012). Flavonoids in stingless-bee and honey-bee honeys. Pot-Honey: A Legacy of Stingless Bees, Springer New York: 461-474.

Both stingless-bee honey and *Apis mellifera* honey contain flavonoids that originate from nectar, pollen, and plant resins collected by bees. Such flavonoids indicate the botanical and geographical origins of honey and have associated health benefits. A survey of flavonoids in pot honey from Venezuela, Australia, Brazil, and Bolivia shows they are richer in flavonoid glycosides than *Apis mellifera* honey. Honey of Apis contains larger amounts of flavonoid aglycones that originate from propolis or from enzymatic hydrolysis of nectar flavonoid glycosides. The low diastase content of stingless-bee honey may explain the higher content of flavonoid glycosides in this honey.

Tsang, A. S., et al. (2017). "Comparison of the effects of topical application of UMF20 and UMF5 manuka honey with a generic multifloral honey on wound healing variables in an uncontaminated surgical equine distal limb wound model." Australian Veterinary Journal 95(9): 333-337.

Objective To compare the effect of application of manuka honey with unique manuka factor (UMF) 5 or 20 with a generic multifloral honey on equine wound healing variables. Methods Two full-thickness skin wounds (2.5×2.5cm) were created on the metatarsus of both hindlimbs of eight Standardbred horses. The wounds on each horse were assigned to 1 of 4 treatments: UMF20 (UMF20) and UMF5 (UMF5) manuka honey; generic multifloral honey (GH); and a saline control. Bandages were changed daily for 12days, after which treatment was stopped and the bandages were removed. Wound area was measured on day 1, then weekly until day 42. Overall wound healing rate (cm2/day) and time to complete healing were recorded. Results There was no difference in wound area for any of the treatments on any measurement day except for day 21, where the mean wound area for wounds treated with UMF20 was smaller than the mean wound area for the UMF5-treated wounds (P=0.031). There was no difference in

mean (± SE) overall healing rate (cm2/day) among the treatment groups. There were differences in mean (± SE) days to complete healing. Wounds treated with UMF20 healed faster than wounds treated with GH (P=0.02) and control wounds (P=0.01). Conclusions Treatment of wounds with UMF20 reduced overall wound healing time compared with wounds treated with GH and control wounds. However, using this model the difference in the overall time to complete healing was small.

van der Weyden, E. (2005). "Treatment of a venous leg ulcer with a honey alginate dressing." British Journal of Community Nursing 10: S21-27.

The management of chronic wounds such as venous ulcers is a common and long-term issue with the aging population. Non-standard treatment that is both medically and financially effective needs to be identified. Honey has been used for its healing properties for centuries and has been used to successfully heal wounds including pressure-ulcers in our care facility. However, there is not much evidence for its use in treating venous ulcers. To this end, I trialed the use of a honey-impregnated alginate dressing on a man who had a long-standing history of fenous ulcers on his leg with the aim of evaluating the effectiveness of honey as an alternative treatment to the current wound management therapies. The honey seemed to act as an effective antibacterial, anti-inflammatory and deodorizing dressing, with total healing of the ulcer achieved. This result, together with past successes with the use of honey alginate on ulcerated wounds, has led to this product becoming mainstream in the treatment of chronic wounds within our care facility.

Vastag, B. (2007). "Sticky treatment for staph infections." Science News 171(23): 366-366.

This article reports that honey made by bees pollinating a New Zealand bush has the ability stop bacteria growth. A few reports note that slathering manuka-bush honey on wound dressings seems to reverse Staphylococcus aureus infections which are notoriously drug resistant. Researchers say that the application of the honey seems to stop the staphylococcus cells from completing their cycle.

Visser, F. R., et al. (1988). "The effect of heat on the volatile flavour fraction from a unifloral honey." Journal of apicultural research. 27(3): 175-181.

Vitetta, L. and A. Sali (2006). "Treatments for damaged skin." Australian family physician 35(7): 501-502.

This is the fifth of a series of articles looking at the available evidence for complementary medicine relating to the theme topic in Australian Family Physician. Any ointment or device when applied to damaged skin whether it be burned or cut, has a legion of tasks to perform: maintaining the integrity of the skin affected, repelling infective agents, and promotion of the healing process.

Wallace, A., et al. (2010). "Demonstrating the safety of manuka honey UMFReg. 20+ in a human clinical trial with healthy individuals." British Journal of Nutrition 103(7): 1023-1028.

Honey is an established traditional medicine with a variety of putative nutritional and health effects, including antibacterial, antioxidant, anti-inflammatory and prebiotic. The aim of the present study was to investigate the safety of consuming manuka honey, UMFReg. 20+, on healthy individuals by establishing whether UMFReg. 20+ caused an allergic response (as measured by IgE levels), changed major commensal and beneficial microbial groups in the gut and/or affected levels of one of the most common advanced glycation endpoints, N epsilon -(carboxymethyl)-lysine (CML). The study had a randomised, double-blind cross-over design. A total of twenty healthy individuals aged 42-64 years were recruited. We tested two different honeys - a multiflora honey and UMFReg. 20+, both produced by Comvita New Zealand Ltd (Te Puke, New Zealand). Multiflora honey or UMFReg. 20+ (20 g) was consumed daily for 4 weeks, with a 2-week 'washout' period in between. Blood samples were collected every week for each intervention period and used to measure total IgE levels in serum and advanced glycation endproducts - a consequence of methyglyoxal accumulation. Faecal samples were collected at the beginning and end of each 4-week period. DNA was extracted from faecal samples and the levels of a number of microbial groups in the gut, both

beneficial and commensal, were analysed. Neither product changed the levels of IgE or CML or altered gut microbial profiles during the trial, confirming that UMFReg. 20+ is safe for healthy individuals to consume. Despite anecdotal evidence suggesting that manuka honey is good for digestive health, we observed no beneficial effects on lower gut bacterial levels with either honey in this healthy population.

Walton, G. (1979). "Beech honeydew honey - a vast potential." New Zealand beekeeper 40(4): 6-9.

Many of the 30 or so scale insects found on southern beech (Nothofagus spp.) in New Zealand secrete honeydew; the most important is Ultracoelostoma assimile (sooty beech scale). The resulting beech honeydew honey produced by bees is sometimes misleadingly called beech honeydew, birch honey or bush honey. From the results of a survey of Canterbury lowland forest, actual and potential honeydew honey yields are assessed. It is estimated that in 20 000 ha of forest there is a potential for 60 000 hives, producing at least 3000 t of honeydew honey annually. At present there are less than 7000 colonies there. Peak honeydew flows occurred in the spring and early summer, and again in late summer and autumn. Shortage of pollen sources in these forests could be overcome by feeding pollen supplements [see also AA 981/79]. P. Walker

Walton, G. M. (1977). "Weather factors influencing the production of white clover (*Trifolium repens* L.) honey in southern New Zealand." Proceedings of the XXVIth International Apicultural Congress, Adelaide.: 429-432.

Daily hive weights were recorded from November to March; this period included the full flowering period of T. repens, the major nectar source. Results for 1973-1977 are examined in relation to daily weather recordings. Average daily weight gain in January was 2.0 kg, but the range was -5.4 to +11.8 kg. The daily weight variation (Wv) in January was strongly and inversely correlated with wind force; Wv was usually also correlated with solar radiation, maximum temperature, temperature range and atmospheric pressure. Some additional correlations were found in some Januarys. Multiple correlations were derived between Wv and a combination of 8 meteorological variables. P. Walker

Ward, A. B., et al. (1974). "Marketing of honey." New Zealand beekeeper 36(4): 22-36.

Divided into 3 sections on marketing within New Zealand, and 3 sections on exports.

Weller, C. and G. Sussman (2006). "Wound dressings update." Journal of Pharmacy Practice and Research 36(4): 318-324.

The availability of different types of wound dressings has increased in the last decade. Wound care practitioners have at their disposal an extensive range of dressings. Emerging dressing types include interactive/bioactive dressings and tissue-engineered skin substitutes. There is no one dressing that is suitable for the management of all types of chronic wounds and few are suited for the treatment of a single wound during all stages of the healing cycle. Successful wound management depends on an understanding of the healing process combined with knowledge of the properties of the various dressings available. Without such knowledge and careful assessment of all the factors that effect healing, dressing selection is likely to be arbitrary and ineffective, wasteful both in terms of time and physical resources. This article is an overview of some of the first-line and second-line interactive/bioactive dressings available. A synopsis of wound assessment and wound bed preparation will aid in choosing the appropriate dressings. It will also touch on advanced technologies including tissue-engineered skin substitutes.

Weston, R. J. (2000). "The contribution of catalase and other natural products to the antibacterial activity of honey: a review." Food Chemistry 71(2): 235-239.

Several natural products are collected or manufactured by bees to construct their hive and produce honey. These include beeswax, flower volatiles, nectar, pollen, propolis and honey itself. Some of the components of these materials possess antibacterial properties and are discussed briefly to ascertain their contribution to the antibacterial

activity of honey. New Zealand's manuka honey is known to possess a high level of "non-peroxide" antibacterial activity and research to identify the origin of this activity is briefly reviewed. Finally a hypothesis is advanced to explain the phenomenon of "non-peroxide" antibacterial activity in honey. The author concludes that this activity should be interpreted as residual hydrogen peroxide activity, which is probably due to the absence of plant-derived catalase from honey, an idea first suggested by Dustman in 1971. Ueber die Katalaseaktivitaet in Bienenhonig aus der Tracht der Heidekrautgewaechse (Ericaceae). Zeitschrift fuer Lebensmittel-Untersuchung und Forschung, 145, 292-295].

Weston, R. J. and L. K. Brocklebank (1999). "The oligosaccharide composition of some New Zealand honeys." Food chemistry. 64(1): 33-37.

The oligosaccharide fraction of samples of manuka (Leptospermum), heather (Calluna), clover (Trifolium) and beech honeydew (Nothofagus) honeys from New Zealand was separated from the monosaccharides and then analysed by high performance anion-exchange chromatography with pulsed amperometric detection (hpaec-pad). Significant oligosaccharide components of manuka honey were isomaltose (or maltulose), kojibiose, turanose (or gentiobiose), nigerose and maltose which was the major component. The composition of clover honey was identical to that of manuka, while heather honey differed from these two only because isomaltose was the major component. Beech honeydew honey was characterised by the complexity of the oligosaccharide composition. The trisaccharides melezitose and panose were the most abundant components. No differences were observed between the oligosaccharide compositions of manuka honeys which did or did not exhibit non-peroxide residual antibacterial activity. Manuka honey was shown to be derived from nectar and not honeydew as has been suggested.

Weston, R. J., et al. (2000). "Identification and quantitative levels of antibacterial components of some New Zealand honeys." Food Chemistry 70(4): 427-435.

High performance liquid chromatograms of the phenolic fraction of 19 samples of New Zealand manuka honey, some with high levels of non-peroxide antibacterial activity and some with no such activity, were identical, which indicated that phenolic components of this honey are not responsible for the presence or absence of this activity in manuka honey. Similarly, the result showed that geography does not influence the phenolic composition of manuka honey. Antibacterial bee peptides and the antibacterial beta-triketone leptospermone were not detected in manuka honey. Methyl syringate constituted approximately 70% w/w of the phenolic fraction of manuka honey and can be regarded as a floral marker for this honey. High performance liquid chromatographic profiles of the phenolic components of manuka, heather, clover and beech honeydew honeys were significantly different and could be used to differentiate honeys if they can be shown to be as consistent as those of manuka honey.

Weston, R. J., et al. (1999). "Antibacterial phenolic components of New Zealand manuka honey." Food Chemistry 64(3): 295-301.

This paper describes several methods for isolation of the antibacterially active phenolic fraction of honey derived from the native New Zealand manuka tree, Leptospermum scoparium (Myrtaceae). This fraction consists of phenolic derivatives of benzoic acids, cinnamic acids and flavonoids, all of which have been identified previously in honeys which do not exhibit non-peroxide residual antibacterial activity. The flavonoids had not previously been identified in manuka honey. Furthermore, the flavonoids were different from those found in the leaves of manuka trees but were the same as those found in European honeys and propolis. while most of these phenolic products possess antibiotic activity, they do not individually or collectively account for the antibacterial activity of 'active' manuka honey. Essentially all of this activity is associated with the carbohydrate fraction of the honey.

White, A. (2010). "Manuka Honey." Hoofbeats: An Australian Riding, Training & Horse Care Magazine 32(4): 44-44.

The article presents information on the Manuka Honey, which comes from uncultivated Manuka bushes found in New Zealand. The honey is said to contain special qualities that differentiate it from other honeys. Among

the uses of the honey are in feed supplement, wound care and skin treatment. It notes on the discovery of hoof care professionals that Manuka Honey is excellent in treating thrush.

Whitfield, P., et al. (2016). "The effect of a cinnamon-, chromium- and magnesium-formulated honey on glycaemic control, weight loss and lipid parameters in type 2 diabetes: an open-label cross-over randomised controlled trial." European Journal of Nutrition 55(3): 1123-1131.

Purpose: This randomised controlled trial assessed the acute and long-term effects of daily supplementation of kanuka honey, formulated with cinnamon, chromium and magnesium on glucose metabolism, weight and lipid parameters in individuals with type 2 diabetes. Methods: Twelve individuals with type 2 diabetes received 53.5 g of a formulated honey and a control (non-formulated) kanuka honey in a random order for 40 days, using cross-over design. Fasting glucose, insulin, HbA1c, lipids and anthropometric measures were measured at baseline and end of treatment. A meal tolerance test was performed at baseline to assess acute metabolic response. Results: There was no statistically significant difference in acute glucose metabolism between treatment groups, as measured by the Matsuda index and AUC for glucose and insulin. After the 40-day intervention with honey, fasting glucose did not differ significantly between the two treatments (95 % CI −2.6 to 0.07). There was no statistically significant change in HbA1c or fasting insulin. There was a statistically significant reduction in total cholesterol by −0.29 mmol/L (95 % CI −0.57 to −0.23), LDL cholesterol by −0.29 mmol/L (95 % CI −0.57 to −0.23) and weight by −2.2 kg (95 % CI −4.2 to −0.1). There was a trend towards increased HDL and reduced systolic blood pressure in the intervention treatment. Conclusion: The addition of cinnamon, chromium and magnesium supplementation to kanuka honey was not associated with a significant improvement in glucose metabolism or glycaemic control in individuals with type 2 diabetes. Use of the formulated honey was associated with a reduction in weight and improvements in lipid parameters, and should be investigated further. [ABSTRACT FROM AUTHOR] Copyright of European Journal of Nutrition is the property of Springer Nature and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Whyte, D., et al. (2017). "The impact of feeding a supplement based on aloe and Manuka honey on milk yield from dairy cows." Journal of Applied Animal Nutrition 5: 6-6.

SummaryAn Aloe vera and manuka honey commercial supplement (Cow and Calf Formula, DairyCare Ltd, NZ) was fed to approximately 40% of a commercial New Zealand herd with over 1000 cows in lactation following spring calving (August) until the end of lactation (April the following year). The 5 ml of supplement was added automatically to the feed for the treatment group via transponder identification units during at milking. At peak lactation (until October) there was a 5.5% increase (11.76 versus 12.41 litres per milking for control and treated cows respectively; $P < 0.001$) in yield for the supplemented cows, and over the whole season there was a 4.7% milk yield increase (8.12 versus 8.50 litres per milking for control and treated cows respectively). Data from December and January (high summer) showed no significant increase in milk yield, which was due to a major drought in the area and loss of grazed forage intakes. From these results, it was considered that that the Aloe vera and manuka honey, acting either separately or in synergy, resulted in more nutrients being available for milk production.

Wijesinghe, M., et al. (2009). "Honey in the treatment of burns: a systematic review and meta-analysis of its efficacy." The New Zealand medical journal 122(1295): 47-60.

AIM: To determine the efficacy of honey in burn wound management., METHODS: A systematic review and meta-analysis of randomised controlled trials which compared the efficacy of honey with a comparator dressing treatment in the management of burns. The main outcome measure was the proportion of subjects with wounds healed at 15 days., RESULTS: Eight studies with 624 subjects were included in the meta-analysis. The quality of the studies was poor with each study having a Jadad score of 1. Six studies were undertaken by the same investigator. In most studies unprocessed honey covered by sterile gauze was compared with silver sulphadiazine-impregnated

gauze. The fixed effects odds ratio for healing at 15 days was 6.1 (95% CI 3.7 to 9.9) in favour of honey having a superior effect. The random effects pooled odds ratio was 6.7 (95% CI 2.8 to 15.8) in favour of honey treatment. The secondary outcome variables all showed significantly greater efficacy for honey treatment., CONCLUSION: Available evidence indicates markedly greater efficacy of honey compared with alternative dressing treatments for superficial or partial thickness burns, although the limitations of the studies included in the meta-analysis restrict the clinical application of these findings. Further studies are urgently required to determine the role of honey in the management of superficial or partial thickness burns.

Wilkins, A. L., et al. (1993). "Extractable organic-substances from New-Zealand unifloral Manuka (Leptospermum scoparium) honeys." Journal of Apicultural Research 32(1): 3-9.

The range and concentrations of extractable organic substances occurring in 14 samples of New Zealand manuka (Leptospermum scoparium) honey taken in the 1989-1990 season were compared with those found in some 1985-1987 samples. The samples were analysed using gas chromatography with flame ion detection and combined gas chromatography-mass spectrometry. The concentrations of 69 compounds are listed. The results verify an earlier proposition that irrespective of season and geographical origin, samples of unifloral manuka honey are characterized by a combined concentration of 2-hydroxy-3-phenylpropionic acid and 2-hydroxy-3-(4'-methoxyphenyl) propionic acid greater than 700 mg/kg honey, a combined concentration of syringic acid and 3,4,5-trimethoxybenzoic acid greater than 35 mg/kg honey, and a combined concentration of acetophenone and 2-methoxyacetophenone greater than 20 mg/kg honey.

Wilkins, A. L., et al. (1993). "Extractives from New Zealand honeys. 4. Linalool derivatives and other components from nodding thistle (Carduus nutans) honey." Journal of Agricultural and Food Chemistry 41(6): 873-878.

Sixteen linalool derivatives and a variety of aliphatic acids and diacids, aromatic acids, and phenols (total of 61 components) were identified in the methylated diethyl ether extracts of New Zealand nodding thistle (Carduus nutans) honeys using gas chromatography with flame ionization detection (GC-FID) and combined GC-MS methods. Separation of the diethyl ether extracts afforded three dominant linalool derivatives which were identified using one- and two-dimensional NMR procedures as (E)-2,6-dimethyl-3,7-octadiene-2,6-diol, (Z)-2,6-dimethyl-6-hydroxy-2,7-dienal, and (E)-2,6-dimethyl-6-hydroxy-2,7-octadienoic acid (characterized as methyl ester). The minor components, alpha ,5-dimethyl-5-ethenyl-2-tetrahydrofuranacetaldehydes (lilac aldehydes, four isomers) and beta ,5-dimethyl-5-ethenyl-2-tetrahydrofuranethanols (lilac alcohols, four isomers), were identified by comparison with synthetic samples. The total level of linalool derivatives in the nodding thistle honey samples was found to be between 15 and 87 micro g/g of honey (average level 43 micro g/g of honey).

Wilkins, A. L., et al. (1995). "Extractives from New Zealand honeys .5. Aliphatic dicarboxylic acids in New Zealand rewarewa (Knightea excelsa) honey." Journal of Agricultural and Food Chemistry 43(12): 3021-3025.

Thirty-two aliphatic dicarboxylic acids were identified as methyl esters in the methylated diethyl ether extracts of four unifloral grade New Zealand rewarewa (Knightea excelsa) honeys using combined gas chromatography-mass spectrometry (GC-MS). 2-Methoxybutanedioic acid (O-methylmalic acid) and 4-hydroxy-3-methyl-trans-2-pentenedioic acid are proposed as floral marker substances for New Zealand rewarewa honey. The total level of aliphatic dicarboxylic acids identified in the rewarewa honey samples ranged from 64 to 111 mg/kg with an average level of 88 mg/kg.

Wilkins, A. L., et al. (1995). "Extractable organic substances from New Zealand unifloral vipers bugloss (Echium vulgare) honey." Journal of apicultural research. 34(2): 73-78.

Williams, A. R. (2008). "Sweet Fix." National Geographic 213(6): 16-16.

This article reports on the use of honey as a medical treatment. Honey fights bacteria in wounds through the production of the antiseptic hydrogen peroxide. The article discusses how Asian and European hospitals are using Manuka tree honey from New Zealand and rating its strength on a Unique Manuka Scale.

Willix, D. J. (1991). "A comparative study of the antibacterial action spectrum of manuka honey and other honey." A comparative study of the antibacterial action spectrum of manuka honey and other honey.: 115-pp.

This study aimed to quantitatively determine the antibacterial action spectra of 2 types of antibacterial activity in honey: activity due to hydrogen peroxide, and the non-peroxide activity of manuka honey. Two New Zealand honeys, rewarewa (Knightia excelsa) and manuka (Leptospermum scoparium), were used for the comparison. Two assay methods were used in this investigation: measurement of the rate of growth and measurement of the amount of growth over an 8-h period. The results from the second method were used to construct dose-response curves of percentage inhibition vs. concentration (% wt/vol) of honey, and thus to determine the median response value of each bacterial species to each honey (i.e. the concentration of honey required to reduce the amount of growth by 50%). The species tested were Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhimurium, Serratia marcescens, Staphylococcus aureus and Streptococcus pyogenes. Both honeys were very active against the range of species tested, with median response values of 1.1, 6.6, 7.5, 1.8, 4.8, 1.3 and 3.1% (wt/vol) honey respectively for the manuka honey with non-peroxide activity, and 5.4, 3.6, 7.4, 1.8, 3.4, 3.8 and 1.9% (wt/vol) honey respectively for the rewarewa honey with peroxide activity. The rank order of sensitivity for the species tested was quite different for the 2 honey types, indicating the presence of two completely different types of activity.

Willix, D. J. (1991). "The marketing of honey as a medicine. A report for the Beekeepers' Association [of New Zealand]." The marketing of honey as a medicine. A report for the Beekeepers' Association [of New Zealand]. iii-pp.

This report [a case study for an industrial technology course] covers a wide range of aspects of the New Zealand honey industry. The first part describes the industry structure - producers, packers, National Beekeepers' Association, Ministry of Agriculture and Fisheries, and others - and the marketing of honey. Part 2 gives official regulations on the advertising of medicines, and part 3 is a survey of health food manufacturers. Part 4 reviews the literature on medicinal uses of honey, particularly the treatment of wounds, eye ailments, stomach and bladder ulcers, and gastroenteritis. Laboratory studies on animals are also covered. The niche marketing of honey as a health food is discussed and recommendations are made. There is a bibliography of 128 references.

Willix, D. J., et al. (1992). "A comparison of the sensitivity of wound-infecting species of bacteria to the antibacterial activity of manuka honey and other honey." Journal of applied bacteriology. 73(5): 388-394.

Both honey and sugar are used with good effect as dressings for wounds and ulcers. The good control of infection is attributed to the high osmolarity, but honey can have additional antibacterial activity because of its content of hydrogen peroxide and unidentified substances from certain floral sources. Manuka honey is known to have a high level of the latter. Seven major wound-infecting species of bacteria were studied to compare their sensitivity to the non-peroxide antibacterial activity of manuka honey and to a honey in which the antibacterial activity was primarily due to hydrogen peroxide. Honeys with activity in the middle of the normal range were used. A comparison of the median response of the various species of bacteria showed no significant difference between the two types of activity overall, but marked differences between the two types of activity in the rank order of sensitivity of the seven bacterial species. The non-peroxide antibacterial activity of manuka honey at a honey concentration of 1.8% (v/v) completely inhibited the growth of Staphylococcus aureus during incubation for 8 h. The growth of all seven species was completely inhibited by both types of honey at concentrations below 11% (v/v).

Wilshire, W. (1994). "Honey marketing 1994 & beyond." Australian bee journal 75(10): 12-25.

In the absence of official statistics for total honey sales in Australia an attempt is made to develop a profile of the market using available data. In 1992-93 an estimated 29 541 t honey was sold by the beekeeping industry: 20

503 t for the domestic market and 9038 t for export (7020 t in bulk and 2018 t in retail packs). On the domestic market 54% was sold through supermarkets (35% under packers' brands, 19% under generic brands), 24% directly by beekeepers, 10% to industrial customers, 7% through specialty shops and 5% to the catering trade. The honey market in Australia is mature, at least in the grocery and supermarket trade, with limited prospects for increased consumption through generic promotion or product innovation. Opportunities for increasing sales lie in identifying niche markets outside the grocery and supermarket segment and developing products for them. Australia's export market for bulk honey has declined in size and value from 1985 to 1993, but the opposite is true for packed honey. Opportunities for increasing export sales of packed honey are in identifying niche markets overseas and developing new products for them. A commitment to quality assurance will be important in doing this.

Wilshire, W. B. (1988). "Honey markets and marketing - the next decade." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 255-257.

Wilshire, W. B. (1990). "Honey marketing - past, present & future." Australasian beekeeper 91(12): 515-520.

In this discussion paper, the main problem examined is the effect on honey prices (in Australia) of the low value and large volume of bulk honey exports from the country. The factors involved are analysed, and many data are presented for the period from 1975 to 1989. It is concluded that honey producers are unlikely to be able to sell honey at a satisfactory price while exports remain high. Some changes in the industry may be necessary, and various options are put forward.

Wilshire, W. B. (1993). "Phenol residue in honey." Australasian beekeeper 94(10): 410-410.

Analysis of honey supplied to an Australian packing factory by 75 beekeepers showed that where phenol (carbolic acid) is used to repel bees during honey harvesting there is a > 90% chance of the honey containing phenol residues. Phenol was found in the range 0.2-12 mg/kg (average 4.3), with a positive correlation between the size of a beekeeper's operation and the level of phenol residue. Beekeepers are urged to cease using a phenol during honey harvesting.

Windsor, S., et al. (2012). "A convenient new analysis of dihydroxyacetone and Methylglyoxal applied to Australian Leptospermum honeys." Journal of Pharmacognosy and Phytotherapy 4(1): 6-11.

New Zealand manuka (*Leptospermum scoparium*) honey is known to exhibit non-peroxide antibacterial activity caused by the active ingredient methylglyoxal which arises by chemical conversion of dihydroxyacetone during honey maturation. This study determines whether methylglyoxal and dihydroxyacetone are present in Australian Leptospermum honeys. This research developed a rapid and sensitive high-performance liquid chromatographic method for the concurrent analysis of methylglyoxal and dihydroxyacetone in honeys. Both compounds were quantified as their O-(2, 3, 4, 5, 6-pentafluorobenzyl) hydroxylamine. HCl derivatives on single run reversed phase high-performance liquid chromatography with diode array detection. Four species of monofloral Leptospermum honeys sourced from Northern Rivers Region, New South Wales, Australia contained methylglyoxal and dihydroxyacetone. The highest methylglyoxal concentrations were found in Leptospermum polygalifolium honeys. © 2012 Academic Journals.

Wood, B., et al. (1997). "Manuka honey, a low cost leg ulcer dressing." New Zealand Medical Journal 110(1040): 107-107.

A pilot study was performed [at Waikato Hospital, Hamilton, New Zealand ?, date not given] on 4 female and 6 male patients (age range 18-76 years) with a total of 11 ulcers (7 varicose, 2 neuropathic, 1 traumatic and 1 arterial) in which median ulcer duration was 1 year and average ulcer size 9 cmsuperscript 2. The ulcers were treated for 8 weeks with a single daily application of a thin smear of manuka honey before covering with a gauze or Melolin dressing. There was little change in bacterial flora during the study period, except for some reduction in isolation of

coliforms; the traumatic ulcer, which healed completely, was the only ulcer cleared of bacteria. There was significant healing (>25% surface area) in 4 ulcers, no change in 6 and 1 ulcer increased in size. Stinging discomfort was the only side effect reported (in 3 patients), causing withdrawal of 1 patient from the study; 2 patients were withdrawn after 5 weeks due to infection requiring systemic antibiotic therapy. The estimated cost for patient self-administration for 8 weeks was $8.00, compared with $40.00 for Duoderm. It is concluded that manuka honey dressings are a reasonable, low-cost alternative to other dressings used on chronic recalcitrant leg ulcers.

Wootton, M., et al. (1978). "Antibacterial properties of some Australian honeys." Food Technology in Australia 30(5): 175-176.

Samples of 7 unifloral honeys were obtained from a packing plant and tested in 4%, 8%, 12%, 16% and 20% concentrations against Staphylococcus aureus. Stringybark (*Eucalyptus meullerana*) honey at 4% completely inhibited bacterial growth, 4 other *Eucalyptus* honeys were inhibitory at 16% and 1 at 20%, but Echium lycopsis honey and coolabah (*Eucalyptus microtheca*) honey had no inhibitory properties, even at the 20% concentration. No relationship was found between antibacterial activity and honey pH or soluble solids content. Temperatures of 60 deg C and above rapidly destroyed the antibacterial activity, which was also reduced by storage at temperatures above 42 deg . D. G. Lowe

Wootton, M., et al. (1985). "The effects of gamma-radiation from cobalt 60 on quality parameters of Australian honeys." Journal of apicultural research. 24(3): 188-189.

Yao, L., et al. (2003). "Crystallisation and moisture sorption properties of selected Australian unifloral honeys." Journal of the Science of Food and Agriculture 83(9): 884-888.

The sorption properties of yapunyah (*Eucalyptus ochropholia*) and yellow box (*Eucalyptus melliodora*) honeys (Australian unifloral honeys) were investigated in a controlled relative humidity (RH) environment at 30 degrees C for 71 days. The original water activity of the honeys affected the sorption properties. These two honeys absorbed moisture at and above 67.9% RH and desorbed moisture at and below 51.4% RH. The crystallisation behaviour of tea tree (*Melaleuca quinquenervia*) and yapunyah honeys was studied during storage at 13 and 23 degrees C. The degree of crystallisation was monitored by measuring the absorbance at 660 and 665 nm using a spectrophotometer. The heat-treated honeys did not show any sign of crystallisation after 5 months, whereas a seeding with precrystallised honey induced crystallisation of the same honeys. This crystallisation was more rapid at 13 than at 23 degrees C.

Yao, L. H., et al. (2003). "Flavonoids, phenolic acids and abscisic acid in Australian and New Zealand Leptospermum honeys." Food Chemistry 81(2): 159-168.

Flavonoids, phenolic acids and abscisic acid of Australian and New Zealand Leptospermum honeys were analyzed by HPLC. Fifteen flavonoids were isolated in Australian jelly bush honey (Leptospermum polygalifolium), with an average content of 2.22 mg/100 g honey. Myricetin (3,5,7,3',4',5'-hexahydroxyflavone), luteolin (5,7,3',4'-tetrahydroxyflavone) and tricetin (5,7,3',4',5'-pentahydroxyflavone) were the main flavonoids identified. The mean content of total phenolic acids in jelly bush honey was 5.14 mg/100 g honey, with gallic and coumaric acids as the potential phenolic acids. Abscisic acid was quantified as twice the amount (11.6 mg/100 g honey) of the phenolic acids in this honey. The flavonoid profile mainly consisted of quercetin (3,5,7,3',4'-pentahydroxyflavone), isorhamnetin (3,5,7,4'-tetrahydroxyflavone 3'-methyl ethyl), chrysin (5,7-dihydroxyflavone), luteolin and an unknown flavanone in New Zealand manuka (Leptospermum scoparium) honey with an average content of total flavonoids of 3.06 mg/100 g honey. The content of total phenolic acids was up to 14.0 mg/100 g honey, with gallic acid as the main component. A substantial quantity (32.8 mg/100 g honey) of abscisic acid was present in manuka honey. These results showed that flavonoids and phenolic acids could be used for authenticating honey floral origins, and abscisic acid may aid in this authentication. (C) 2002 Published by Elsevier Science Ltd.

Yao, L. H., et al. (2004). "Phenolic acids and abscisic acid in Australian *Eucalyptus* honeys and their potential for floral authentication." Food Chemistry 86(2): 169-177.

Seven phenolic acids related to the botanical origins of nine monofloral *Eucalyptus* honeys from Australia, along with two abscisic isomers, have been analyzed. The mean content of total phenolic acids ranges from 2.14 mg/100 g honey of black box (*Eucalyptus largiflorens*) honey to 10.3 mg/100 g honey of bloodwood (*Eucalyptus intermedia*) honey, confirming an early finding that species-specific differences of phytochemical compositions occur quantitatively among these *Eucalyptus* honeys. A common profile of phenolic acids, comprising gallic, chlorogenic, coumaric and caffeic acids, can be found in all the *Eucalyptus* honeys, which could be floral markers for Australian *Eucalyptus* honeys. Thus, the analysis of phenolic acids could also be used as an objective method for the authentication of botanical origin of *Eucalyptus* honeys. Moreover, all the honey samples analyzed in this study contain gallic acid as the main phenolic acid, except for stringybox (*Eucalyptus globoidia*) honey which has ellagic acid as the main phenolic acid. This result indicates that the species-specific differences can also be found in the honey profiles of phenolic acids. Further-more, the analysis of abscisic acid in honey shows that the content of abscisic acid varies from 0.55 mg/100 g honey of black box honey to 4.68 mg/ 100 g honey of bloodwood honey, corresponding to the contents of phenolic acids measured in these honeys. These results have further revealed that the HPLC analysis of honey phytochemical constituents could be used individually and/or jointly for the authentication of the botanical origins of Australian *Eucalyptus* honeys.

Zhou, X., et al. (2018). "Identifying Sources of Environmental Contamination in European Honey Bees (*Apis mellifera*) Using Trace Elements and Lead Isotopic Compositions." Environmental Science & Technology 52(3): 991-1001.

Trace element concentrations (As, Mn, Pb, and Zn) and Pb isotopic compositions were analyzed in honey bees, wax, and honey along with co-located soil and dust samples from Sydney metropolitan and Broken Hill, Australia. Compared with the other trace elements, Pearson correlations show that Pb concentrations in soil and dust had the strongest relationship to corresponding values in honey bees and their products. Dust Pb was not only highly correlated to corresponding soil values ($r = 0.806$, $p = 0.005$), it was the strongest predictor of Pb concentrations in honey bees, wax, and honey ($p = 0.001$, 0.007, 0.017, respectively). Lead isotopic compositions ((206)pb/(207)pb and Pb-208/Pb-207) showed that honey bees and their products from Broken Hill were nearly identical (95-98%) to the composition of the local ore body. Samples of honey bees and their products collected from background sites adjacent to, national parks in Sydney had Pb isotopic compositions (Pb-206/Pb-207 = 1.138-1.159, Pb-208/Pb-207 = 2.417-2.435) corresponding to local geogenic values (Pb-206/Pb-207 = 1.123-1.176, (Pb-208/Pb-207 = 2.413-2.500). By contrast, honey bees and their products ((206)pb/(207)pb = 1.081-1.126, (208)pb/(207)pb = 2.352-2.408) were similar to aerosols measured during the period of leaded petrol use ((206)pb/(207)pb = 2.341-2.410). These measurements show Pb concentrations and its isotopic compositions of honey bees, and their products can be used to trace both legacy and contemporary environmental contamination, particularly where sources are well documented. Moreover, this study demonstrates that legacy Pb emissions continue to be remobilized in dust, contaminating both food and ecological systems.

Zhou, X., et al. (2018). "Authenticity and geographic origin of global honeys determined using carbon isotope ratios and trace elements." Scientific Reports 8: 14639-14639.

Honey is the world's third most adulterated food. The addition of cane sugar or corn syrup and the mislabelling of geographic origin are common fraudulent practices in honey markets. This study examined 100 honey samples from Australia (mainland and Tasmania) along with 18 other countries covering Africa, Asia, Europe, North America and Oceania. Carbon isotopic analyses of honey and protein showed that 27% of commercial honey samples tested were of questionable authenticity. The remaining 69 authentic samples were subject to trace element analysis for geographic determination. One-way ANOVA analysis showed a statistical difference ($p < 0.05$) in trace element concentrations of honey from Australian regions and different continents. Principal component analysis (PCA) and canonical discriminant analysis (CDA) coupled with C5.0 classification modelling of honey carbon isotopes and trace element concentrations showed distinct clusters according to their geographic origin. The C5.0 model revealed trace elements Sr, P, Mn and K can be used to differentiate honey according to its geographic origin. The findings show the

common and prevalent issues of honey authenticity and the mislabelling of its geographic origin can be identified using a combination of stable carbon isotopes and trace element concentrations.

Pollen

Beales, K., et al. (2007). "Hepatotoxic pyrrolizidine alkaloids and their N-oxides in honey and pollen." Poisonous plants: global research and solutions: 94-100.

The pyrrolizidine alkaloids of 68 Australian honey samples as well as extracts of Australian and New Zealand pollen samples collected from anthers, and pollen baskets harvested from honeybees, were identified and quantified using HPLC-atmospheric pressure chemical ionization (APCI)-MS. HPLC-electrospray ionization (ESI)-MS was applied for simultaneous quantitation of the alkaloids and their N-oxides. The highest level of pyrrolizidine alkaloid content, in excess of 2500 micro g equivalents of echimidine per kg of honey (ppb), was observed with an Echium plantagineum-derived sample. Honeys attributed to E. plantagineum, Heliotropium europaeum and H. amplexicaule were determined by the presence of echimidine, heliotrine and indicine respectively as the major alkaloid observed, as identified by HPLC-APCI-MS. Use of the silica-based SCX SPE columns on the honey and pollen samples tentatively identified a new suite of alkaloids/N-oxides characteristic of E. vulgare. The highest level determined was approximately 5000 ppb. Four samples returned levels of between 1200 and 2850 ppb and four were between 550 and 950 ppb. The level of pyrrolizidine alkaloids/N-oxides in the pure pollen was considerably higher compared to the honey at about 11 000 +or- 3000 ppm (mg/kg) whereas levels in the pollen baskets from honeybees returned lower levels of alkaloids, with a range of 925 to 4000 ppm and a mean (from 4 samples) of 2125 ppm. The combination of silica-based SCX SPE and HPLC-ESI-MS analysis has confirmed the natural predominance of N-oxides over the parent, tertiary-base pyrrolizidine alkaloids in the honey and pollen samples.

Bell, R. R., et al. (1983). "Composition and protein quality of honeybee-collected pollen of *Eucalyptus marginata* and *Eucalyptus calophylla*." The Journal of nutrition 113(12): 2479-2484.

The composition and protein quality of the two most important Western Australian export-quality pollens were investigated. Crude pollen protein content was 20.6% and 27.9% for Jarrah (Eucalyptus marginata) and Marri (Eucalyptus calophylla), respectively. Lysine was the limiting amino acid relative to the FAO protein scoring pattern (Food and Agriculture Organization of the United Nations), and the amino acid scores were 0.73 and 0.66 for Jarrah and Marri pollen, respectively. Apparent biological value (BV) was 61.7 for Jarrah pollen, 66.9 for Marri pollen and 71.4 for the casein controls. Adjusted protein efficiency ratio (PER) values were 2.5, 1.2 and 1.1 for casein and Jarrah and Marri pollens, respectively. Apparent net protein utilization (NPU) was significantly reduced for both pollens (32.8 for Jarrah and 39.5 for Marri) compared to casein (63.6). The low apparent NPU values result from the relatively low digestibility of pollens. Apparent digestibility was 52 and 59% for Jarrah and Marri pollen compared to 89% for casein. Although both Jarrah and Marri pollen are relatively high in protein and have favorable amino acid patterns, their relatively low digestibility will be a limiting factor in their usefulness as a food for humans and monogastric animals. The proximate analysis and mineral content of the pollens are also presented.

Bibi, S., et al. (2008). "Pollen analysis and heavy metals detection in honey samples from seven selected countries." Pakistan Journal of Botany 40(2): 507-516.

Honey contains pollen grains derived from the foraging activity of honeybees that reflect the environmental location of the beehives. The variability of honey types produced in a region depends upon the diversity of nectar sources present in the region. Microscopic analysis of the pollen in honey was used to determine its geographical origin. This study describes a simplified method for determining the total amount of pollen grains and the relative frequencies of pollen from various plant sources in honey. In 7 commercially obtained honey samples from Austria, Pakistan, Canada, Germany, Australia, Saudi Arabia and America. Pollen of plant species from 12 families: Brassicaceae, Sapindaceae, Cannabaceae, Convolvulaceae, Myrtaceae, Pinaceae, Cupressaceae, Asteraceae, Moraceae, Fabaceae, Corylaceae and Loranthaceae were identified. In addition to pollen identification,

contamination due to heavy metals and their concentration in honey samples were also measured and the results are discussed in this paper.

Boontaganon, P., et al. (2011). "Comparative pollen analysis of manuka and other honeys produced in New Zealand." Proceedings of the Nutrition Society of New Zealand 35: 35-39.

New Zealand manuka honey is recognized for its highly effective antimicrobial activity due to its hydrogen peroxide and antioxidant contents. This study investigated the pollen content of manuka honey produced in New Zealand and compared it to clover honey from the same region. Seventy four honey samples were used in this study. After pollen analysis, only half the samples labelled as manuka met the criteria to be called authentic manuka while most clover honeys could be claimed as authentic clover.

Boontaganon, P., et al. (2011). "Characterisation of manuka honey produced in New Zealand based on pollen analysis, peroxide content and antioxidant activities." Australasian Medical Journal 4(12): 760-760.

Background New Zealand manuka honey is recognised for its highly effective antimicrobial activity due to its hydrogen peroxide and antioxidant content. To be classified as a manuka honey it should contain more than 70% manuka pollen, unfortunately many honey brands sold in New Zealand do not reach this minimum standard. Objective To investigate the hydrogen peroxide content, antioxidant activity and other characteristics of manuka honey produced in New Zealand. To compare composition of manuka honey to clover honey. Design Seventy four honey samples produced in New Zealand were analysed for pollen, moisture, total acidity, total phenols, peroxide, glucose, fructose, HMF contents, pH, colour, conductivity value and antioxidant activities. Outcomes Thirty nine honey samples were labeled as pure manuka, 9 samples were labeled as manuka blends, while the remaining samples were clover (25) and tawari. From the pollen counts, only 17 samples could be classified as manuka honey. The pollen in 35 of the remaining samples was predominantly manuka pollen but this was less than 70%. Twenty two samples were clover. For all of the parameters measured, there was no significant difference ($P<0.01$) between the true manuka honeys and the blends containing manuka. Peroxide values ranged from 1.2-11.7 mug/g/h and antioxidant activity (ORAC) ranged from 3.6-14.5 mumol trolox equivalent/g. The total phenolic content of manuka honey was significantly ($P<0.0001$) correlated to both the ORAC activity ($r=0.672$) and colour ($r=0.874$). Total phenolics and peroxide content in true manuka honey was significantly different to those in clover honey ($P<0.01$) whereas there was no significant difference in antioxidant activity and other parameters between these honeys. Conclusion The labelling of manuka honey is often poor. Honeys with greater than 70% manuka pollen did not significantly differ from manuka blends (<70%) in the chemical parameters that were measured here. Manuka honey had significantly higher total phenolics and peroxide content than clover honey.

Campos, M., et al. (1997). "An approach to the characterization of bee pollens via their flavonoid/phenolic profiles." Phytochemical Analysis 8(3): 181-185.

Bee-collected pollen varies widely in composition. A systematic method for characterizing bee pollen in terms of its constituent pollens is needed in view of the growing interest in bee pollen products. Studies involving 3 bee pollen samples collected from Portugal and New Zealand are reported. An approach based on flavonoid/phenolics profiles derived from HPLC was shown to be more precise and informative than traditional microscopy. This method provides a convenient means for identifying the contributing pollens, and for characterizing bee pollens in terms of their predominant constituent pollens. The flavonoid/phenolics profiles obtained also showed that bees are highly selective pollen gatherers. Bee pollens comprised pollen from only a few of the available species and pollen from only one floral source was found in each pollen pellet. Flavonoids are normally found as glycosides in pollens but were shown to occur naturally as aglycones in *Eucalyptus globulus* pollen. Two of these aglycones, tricetin and 3-O-methylquercetin, are reported as pollen constituents for the first time.

Chambers (1982). "Management, harvesting and processing of honey bee collected pollen in Western Australia." American bee journal 122(2): 97-102.

Feasability studies have shown that Western Australia indigenous floral sources provide for honey bee pollen foraging and honey bee colony inflow of pollen for nine months of the year. Over certain weather pattern situations the period of pollen flow may even be longer. Intensive pollen intake over major flow periods may commence late July and follow through on changing sequence of floral type to April of the following year. Drought and varying rainfall play an important part in progressive continuity of flow. Beekeeping of forest, woodland and ground flora on a pattern of naturally occurring stands often specific to supporting conditions of soil type, rainfall and seasonal maturity. Distances between suitable flows may be as great as 800 kilometers.

Day, S., et al. (1990). "The nutrient composition of honeybee-collected pollen in Otago, New Zealand." Journal of apicultural research. 29(3): 138-146.

Harris, W. F. and D. W. Filmeb (1947). "A recent outbreak of honey poisoning. 6. Botanical investigation of pollen and nectar flora." New Zealand Journal of Science and Technology, Section A 29: 134-143.

Previous cases of honey poisoning are quoted and the present outbreak in New Zealand is discussed. Toxicity tests with different species of animals showed that the guineapig was highly susceptible. The poisonous principle has been isolated, has the formula C16H1807 and is given the name mellitoxin. The use of nembutal in the treatment of honey poisoning is discussed. Honey-dew, the excretion of the passion vine hopper obtained from the leaves of the tutu plant, Coriaria arborea, is incriminated.-J. S. Thomson.

Harris, W. F. and D. W. Filmer (1948). "Pollen is honey and bee loads." New Zealand Journal of Science and Technology 30: 178-187.

Samples of honey and bee loads obtained from test hives situated within "bee range" of native bush, scrab and pasture, at Pongakawa, New Zealand, were examined for their pollen content. It was found that during the season November, 1945, to March, 1946, the pollen of only a few of the species in this area, which are known to be visited by honey bees, was recovered in the honey and bee loads. Most of the pollen in the honey came from scrub (manuka= Leptospermum scoparium), pasture and waste places (clover, lotus, catsear, hawk-bit, and thistle). Native bush was represented by a small percentage of rewarewa (Knightia excelsa). The principal pollen types in the bee loads were from pastures and roadsides (lupin, clover, thistle, lotus, catsear, hawkbit, and plantain).-Authors' summary.

Holt, K. A. and M. S. Bebbington (2014). "Separating morphologically similar pollen types using basic shape features from digital images: A preliminary study(1.)." Applications in Plant Sciences 2(8).

UNLABELLED:, PREMISE OF THE STUDY: One of the many advantages offered by automated palynology systems is the ability to vastly increase the number of observations made on a particular sample or samples. This is of particular benefit when attempting to fully quantify the degree of variation within or between closely related pollen types. *, METHODS: An automated palynology system (Classifynder) has been used to further investigate the variation in pollen morphology between two New Zealand species of Myrtaceae (Leptospermum scoparium and Kunzea ericoides) that are of significance in the New Zealand honey industry. Seven geometric features extracted from automatically gathered digital images were used to characterize the range of shape and size of the two taxa, and to examine the extent of previously reported overlap in these variables. *, RESULTS: Our results indicate a degree of overlap in all cases. The narrowest overlap was in measurements of maximum Feret diameter (MFD) in grains oriented in polar view. Multivariate statistical analysis using all seven factors provided the most robust discrimination between the two types. *, DISCUSSION: Further work is required before this approach could be routinely applied to separating the two pollen types used in this study, most notably the development of comprehensive reference distributions for the types in question.

Kale Sniderman, J. M., et al. (2018). "Pollen analysis of Australian honey." PLoS One 13(5).

Pollen analysis is widely used to verify the geographic origin of honeys, but has never been employed in Australia. In this study, we analysed the pollen content of 173 unblended honey samples sourced from most of the commercial honey producing regions in southern Australia. Southern Australian vegetation is dominated by *Eucalyptus* (Myrtaceae) forests and, as expected, most Australian honeys are palynologically dominated by *Eucalyptus*, while other important components include Myrtaceae taxa such as Corymbia/Angophora and the tribe Leptospermeae; plus Brassicaceae, Echium, Macadamia, and Acacia. An important feature of the honeys is the number of Myrtaceae pollen morphotypes per sample, which is generally high (mean = 4.6) compared to honeys produced outside of Australia, including *Eucalyptus* honeys produced in the Mediterranean region, and honeys produced in South America, which has its own rich indigenous Myrtaceae flora. In the latter regions, the number of Myrtaceae morphotypes is apparently generally 2. A high number of Myrtaceae morphotypes may be a feasible criterion for authenticating the origin of Australian honeys, since most Australian honey is produced by honey bees mainly working indigenous floral resources. Myrtaceae morphotype diversity is a convenient melissopalynological measure that could be applied even where detailed knowledge of the pollen morphology of the many component genera and species is absent. Palynological criteria developed in Europe for authenticating *Eucalyptus* honeys should not be relied upon for Australian honeys, since those criteria are not based on samples of Australian honey.

Kleinschmidt, G. J. and A. C. Kondos (1977). "The influence of crude protein levels on colony production." South African Bee Journal 49(4): 16-19.

Pollen samples collected by bees in Queensland and New South Wales, Australia, contained 7-37% crude protein; further analysis by species showed that eucalypt pollens contained 20-33% protein. Results are given for pollens of several *Eucalyptus* species and of 27 other species. Brood rearing and length of adult life are affected by the protein content and availability of pollen, and by the body protein levels of bees, which fluctuate in cycles. To reduce the adverse effect of low protein levels it is recommended that: (a) management should be based on the anticipated protein cycle in the colony so that if low protein levels are predicted during a flow, colonies with high body protein levels and a large brood nest should be used; (b) site selection should be based on a knowledge of pollen availability and protein contents of pollens. P. Walker

Kleinschmidt, G. J. and A. C. Kondos (1979). "Colony management for low quality pollens." Australasian beekeeper 81(1): 5-6.

Colonies of honeybees which wintered in an area of light nectar and pollen flows in Queensland, Australia, were able to maintain brood rearing and body protein. Colonies which foraged throughout summer on sunflower (which has low quality pollen) maintained their colony strength although body protein decreased. When moved to a winter honey flow with a scarcity of pollen, colony size showed a rapid reduction. If the winter flow was light and intermittent, the colonies were able to build up body protein gradually. J. M. Gedye

Lagerstrom, R., et al. (2015). "Pollen image classification using the classifynder system: Algorithm comparison and a case study on New Zealand honey." Signal and Image Analysis for Biomedical and Life Sciences: 207-226.

We describe an investigation into how Massey University's Pollen Classifynder can accelerate the understanding of pollen and its role in nature. The Classifynder is an imaging microscopy system that can locate, image and classify slide based pollen samples. Given the laboriousness of purely manual image acquisition and identification it is vital to exploit assistive technologies like the Classifynder to enable acquisition and analysis of pollen samples. It is also vital that we understand the strengths and limitations of automated systems so that they can be used (and improved) to compliment the strengths and weaknesses of human analysts to the greatest extent possible. This article reviews some of our experiences with the Classifynder system and our exploration of alternative classifier models to enhance both accuracy and interpretability. Our experiments in the pollen analysis problem domain have been based on samples from the Australian National University's pollen reference collection (2,890 grains, 15 species) and images bundled with the Classifynder system (400 grains, 4 species). These samples have

been represented using the Classifynder image feature set. We additionally work case study where we assess the ability of the system to determine the pollen make-up of samples of New Zealand honey. In addition to the Classifynder's native neural network classifier, we have evaluated linear discriminant, support vector machine, decision tree and random forest classifiers on these data with encouraging results. Our hope is that our findings will help enhance the performance of future releases of the Classifynder and other systems for accelerating the acquisition and analysis of pollen samples.

Prichard, M. and K. J. Turner (1985). "Acute hypersensitivity to ingested processed pollen." Australian and New Zealand journal of medicine 15(3): 346-347.

Ingestion of commercially processed honeybee-collected pollen produced potentially fatal consequences in a 19 year old asthmatic male. Symptoms of sore throat, facial itch and swelling, difficulty in breathing and stridor lasted for approximately two hours and was followed by clinical respiratory distress with widespread wheeze on auscultation of his chest. RAST and skin test data suggest that these complications appear to be mediated by IgE antibodies directed against the processed pollen, but not bee venom. Consumption of processed pollen by atopic individuals is, therefore, a potentially hazardous procedure with little therapeutic benefit.

Sala Llinares, A. (1991). "Palynological studies of honeys of the western Mediterranean. Comparison with honeys from other origins." Estudi palinologic de les mels de la Mediterrania occidental. Comparacio amb mels d'altres origens.: xi-pp.

Pollen analyses are presented for 121 samples of honey from the Spanish Mediterranean region, 20 from Mexico, 20 from Argentina, 9 from Australia, 30 from Nicaragua, 3 from the USSR, 3 from Cuba and 2 from Costa Rica. [See also Vida Apicola (1989) No. 37, 47-51.]

Seijo, M. C., et al. (2003). "Palynological differences in the pollen content of *Eucalyptus* honey from Australia, Portugal and Spain." Grana 42(3): 183-190.

A melissopalynological study was carried out on 75 samples of *Eucalyptus* honey from different countries (22 from Australia, 13 from Portugal and 40 from Northwest Spain), in which a total of 145 different pollen types were identified. Of such, only *Eucalyptus*, Acacia, Brassica, Echium, Ligustrum, Plantago, Rumex, Taraxacum, Trifolium and Vicia pollen are present in the honeys from all three countries. Among the most abundant pollen types in Australian honeys, those belonging to the following families stand out: Myrtaceae (Angophora and Melaleuca), Fabaceae, Asteraceae, Proteaceae and Euphorbiaceae, along with Raphanus, Echium and Citrus. In the Portuguese honeys, the presence of Fabaceae, Rosaceae and Cistaceae stands out, with Castanea and Erica as secondary pollen types, while Fabaceae, Asteraceae, Boraginaceae, Cistaceae and Scrophulariaceae are the families with the highest quantity of pollen types in the samples from Spain. In the latter, the most important secondary pollen types are: Castanea, Cytisus, Erica, Lotus, Salix and Rubus.

Sniderman, J. M. K., et al. (2018). "Pollen analysis of Australian honey." PLoS One 13(5): e0197545-e0197545.

Pollen analysis is widely used to verify the geographic origin of honeys, but has never been employed in Australia. In this study, we analysed the pollen content of 173 unblended honey samples sourced from most of the commercial honey producing regions in southern Australia. Southern Australian vegetation is dominated by *Eucalyptus* (Myrtaceae) forests and, as expected, most Australian honeys are palynologically dominated by *Eucalyptus*, while other important components include Myrtaceae taxa such as Corymbia/Angophora and the tribe Leptospermeae; plus Brassicaceae, Echium, Macadamia, and Acacia. An important feature of the honeys is the number of Myrtaceae pollen morphotypes per sample, which is generally high (mean = 4.6) compared to honeys produced outside of Australia, including *Eucalyptus* honeys produced in the Mediterranean region, and honeys produced in South America, which has its own rich indigenous Myrtaceae flora. In the latter regions, the number of Myrtaceae morphotypes is apparently generally <= 2. A high number of Myrtaceae morphotypes may be a feasible criterion for authenticating the origin of Australian honeys, since most Australian honey is produced by honey bees

mainly working indigenous floral resources. Myrtaceae morphotype diversity is a convenient melissopalynological measure that could be applied even where detailed knowledge of the pollen morphology of the many component genera and species is absent. Palynological criteria developed in Europe for authenticating *Eucalyptus* honeys should not be relied upon for Australian honeys, since those criteria are not based on samples of Australian honey.

Thomas, D. (1993). "Pollen, its trapping and storage." Bee Briefs 9(4): 7-9.

Van Der Moezel, P. G., et al. (1987). "Pollen selection by honeybees in shrublands of the northern sandplains of Western Australia." Journal of Apicultural Research 26(4): 224-232.

Commercial apiarists utilize the Northern Sandplain shrublands of Western Australia as winter honeybee (*Apis mellifera* L.) maintenance areas. Analyses of pollen loads collected from two hives stationed in these sandplains during June-September 1981-1982 showed that, among a total of 44 species exploited by the bees for pollen, the most commonly exploited were Leucopogon conostephioides, L. striatus and Acacia stenoptera. Species flowering locally in abundance were preferred, but some common species were never visited. L. conostephioides was a major source of pollen early in the two study seaons (1981 and 1982), followed later in the seaons by L. striatus (1981 only) and A. stenoptera (1982 only). A high degree of constancy during foraging forays by individual bees was evident from the finding that 52-79% of the pollen pellets of weekly samples consisted solely of pollen of a single plant species. Pollen of Northern Sandplain species varied considerably in crude protein, amino acid concentration and levels of nitrogen, calcium, potassium, phosphorus and magnesium. Preference of bees for pollen of certain species did not appear to be related to the presence in that pollen of high concentrations of any of the above consituents. The individual-constancy foraging theory best explains honeybee behaviour in the floristically rich shrublands of this region.

Webby, R. (2004). "Floral origin and seasonal variation of bee-collected pollens from individual colonies in New Zealand." Journal of apicultural research. 43(3): 83-92.

Propolis

Amini Moghadam Farouj, N. and A. Nematollahi (2017). "Structure elucidation and botanical characterization of diterpenes from a specific type of bee glue." Molecules 22(7): 1185-1185.

Investigation of the single plant source bee glue type originating from Southern Australia resulted in the isolation and structure elucidation of major serrulatane diterpenes, novel 7,8,18-trihydroxyserrulat-14-ene (1), along with its oxidized product, 5,18-epoxyserrulat-14-en-7,8-dione (3) and known (18RS)-5,18-epoxyserrulat-14-en-8,18-diol (2). Exploration into the botanical origin revealed *Myoporum insulare* R. Br, as the plant source of the bee glue materials. This discovery was made through comparative analysis of the myoporum bee glue samples collected from the beehives, analyses of plant resinous exudate, and resin carried on the hind legs of bees foraging for bee glue.

Bhargava, P., et al. (2018). "Anticancer activity of the supercritical extract of Brazilian green propolis and its active component, artepillin C: Bioinformatics and experimental analyses of its mechanisms of action." International Journal of Oncology 52(3): 925-932.

Propolis, a resinous substance collected by honeybees by mixing their saliva with plant sources, including tree bark and leaves and then mixed with secreted beeswax, possesses a variety of bioactivities. Whereas caffeic acid phenethyl ester (CAPE) has been recognized as a major bioactive ingredient in New Zealand propolis, Brazilian green propolis, on the other hand, possesses artepillin C (ARC). In this study, we report that, similar to CAPE, ARC docks into and abrogates mortalin-p53 complexes, causing the activation of p53 and the growth arrest of cancer cells. Cell viability assays using ARC and green propolis-supercritical extract (GPSE) revealed higher cytotoxicity in the latter, supported by nuclear translocation and the activation of p53. Furthermore, in vivo tumor suppression assays using nude mice, we found that GPSE and its conjugate with cyclodextrin (CD) possessed more potent anticancer activity than purified ARC. GPSE-CD may thus be recommended as a natural, effective and economic anticancer amalgam.

Burke, J. (2012). "Pack it in!" Food Magazine: 13-13.

The article discusses a process developed by family-owned Australian business Maya Sunny Honey wherein authentic honey is created inside the jar it is sold in. The company uses a system in which bees create honeycombs in empty jars placed upside down on top of a beehive. The jars are then sealed and sold in supermarkets. The layer of the natural antibiotic propolis on top of the honey is described. The work done by the husband and wife team of Andrew and Joanna Wyszynski is also discussed.

Eaton, C. v. and R. Law (2000). "Marketing apitherapy products and the challenge of government regulation." Bee World 81(3): 109-115.

The marketing of apitherapy products offers significant potential for the further development of beekeeping industries worldwide. Royal jelly produced in China is distributed to many countries, and propolis production is a major industry in both China and Brazil. A substantial trade also exists in bee pollen, with countries as diverse as Canada, Australia, Mexico, Argentina and Spain supplying the world market. Manuka honey from New Zealand has gained an international reputation for its unique antibacterial properties. All of these products, as well as a number of others, are raw materials used in apitherapy.

Gonzalez-Canavaciolo, V. L., et al. (2015). "Stability of 50mg-beeswax alcohols tablets (Abexol) packed in high-density polyethylene flasks." Revista Cubana de Farmacia 49(4).

Introduction: beeswax alcohols, consisting in a reproducible mixture of six primary fatty alcohols from 24 to 34 carbon atoms purified from *Apis mellifera* beeswax, has been shown to produce antioxidant and gastroprotective effects. This substance is used to manufacture Abexol 50 mg tablets, the finished form used in clinical studies and in routine practice. Objective(s): to determine the stability of 50 mg-Beeswax alcohols tablets (Abexol) packed in high-density polyethylene flasks. Method(s): samples from three batches of Abexol 50 mg tablets packed in white high density polyethylene flasks (Rainbow & Nature, Sydney, Australia) were put into cardboard boxes and kept under climatic conditions of the zone IV (30+/-2 C, 70+/-5 % of relative humidity) for five years. Result(s): all parameters tested were within specifications throughout the whole study: appearance (white round tablets with intact surfaces), average weight (initial average weight+/-7,5 %), total content of the six fatty alcohols (50+/-3.75 mg), disintegration time (<15 min), hardness (3 kg/cm2) and microbiological content (<=1 000 bacteria/g and <=100 fungi/g, absence of E. coli,S. aureus, Pseudomonas, Salmonella and C. albicans). This result is consistent with the data of a previous stability study of Abexol 50 mg tablets manufactured in Cuba and packed in blisters of polyvinyl chloride and aluminum. Conclusion(s): the results of the present study support that Abexol50mg tablets packed in white high density polyethylene flasks and stored at the conditions of the climatic zone IV have a shelf life of 5 years.

Martos, I., et al. (2000). "Flavonoids in monospecific *Eucalyptus* honeys from Australia." Journal of Agricultural & Food Chemistry 48(10): 4744-4748.

The HPLC analyses of Australian unifloral *Eucalyptus* honeys have shown that the flavonoids myricetin (3,5,7,3',4',5'-hexahydroxyflavone), tricetin (5,7,3',4',5'-pentahydroxyflavone), quercetin (3,5,7,3',4'-pentahydroxyflavone), luteolin (5,7,3',4'-tetrahydroxyflavone), and kaempferol (3,5,7,4'-tetrahydroxyflavone) are present in all samples. These compounds were previously suggested as floral markers of European *Eucalyptus* honeys. The present results confirm the use of flavonoid analysis as an objective method for the botanical origin determination of eucalyptus honey. Honeys from E. camaldulensis (river red gum honey) contain tricetin as the main flavonoid marker, whereas in honeys from E. pilligaensis (mallee honey), luteolin is the main flavonoid marker, suggesting that species-specific differences can be detected with this analysis. The main difference between the flavonoid profiles of Australian and European *Eucalyptus* honeys is that in the Australian honeys, the propolis-derived flavonoids (pinobanksin (3,5,7-trihydroxyflavanone), pinocembrin (5,7-dihydroxyflavanone), and chrysin (5,7-dihydroxyflavone)) are seldom found and in much smaller amounts.

Rosendale, D. I., et al. (2008). "High-throughput microbial bioassays to screen potential New Zealand functional food ingredients intended to manage the growth of probiotic and pathogenic gut bacteria." International journal of food science & technology. 43(12): 2257-2267.

A spectrophotometric bioassay was used to screen selected food ingredients intended for development of functional foods designed to influence the growth of gut bacteria. Dose-response profiles displaying growth, the magnitude of deviation from growth of controls, were generated for probiotics Lactobacillus reuteri, Lactobacillus

rhamnosus, Bifidobacterium lactis and pathogens Escherichia coli, Salmonella Typhimurium and Staphylococcus aureus. Ingredients were manuka honey UMF[trade mark sign]20+(dose-dependently increased probiotics and decreased pathogens); bee pollen (biphasic growth effects against all); Rosehips and BroccoSproutsp (increased all dose-dependently); blackcurrant oil (little effect) and propolis (inhibited all strains). Ingredients were also bioassayed in pairs to assess desirable or undesirable synergistic interactions. Observed synergies included manuka honey (predominantly desirable); rosehips or BroccoSproutsp (desirable and undesirable); blackcurrant oil (desirable) and propolis (tended towards synergies reinforcing its antimicrobial effects), collectively revealing a complex web of interactions which varied by ingredient and bacterial strain. Manuka honey was particularly effective at influencing gut bacteria. The surprising frequency of undesirable synergistic interactions illustrates the importance of pre-testing potential ingredient combinations intended for use in functional foods.

Tomas-Barberan, F. A., et al. (1993). "Flavonoids in honey of different geographical origin." Zeitschrift fur Lebensmittel-Untersuchung und -Forschung 196(1): 38-44.

The flavonoids present in honey samples from Europe, North America, Equatorial regions, South America, China and Australia were analysed by HPLC. These flavonoids are incorporated into honey from propolis, nectar or pollen. As a general rule, honey samples from the Northern Hemisphere (where poplars, the source of propolis, are native) showed flavonoid profiles characterized by the presence of propolis flavonoids. In contrast, honey samples from most Equatorial regions and Australia were generally devoid of propolis-derived flavonoids, showing only flavonoids from other plant sources. However, several honey samples from Central and South America and from New Zealand did contain flavonoids characteristic of propolis. This means that imported *Apis mellifera* colonies may locate poplar trees, occasionally finding an imported specimen in gardens or agroindustrial exploitations, and incorporate propolis flavonoids into honey. These preliminary results show that flavonoid analysis could be used as an adjunct to studies of the geographical origin of honey.

Weston, R. J. (2000). "The contribution of catalase and other natural products to the antibacterial activity of honey: a review." Food Chemistry 71(2): 235-239.

Several natural products are collected or manufactured by bees to construct their hive and produce honey. These include beeswax, flower volatiles, nectar, pollen, propolis and honey itself. Some of the components of these materials possess antibacterial properties and are discussed briefly to ascertain their contribution to the antibacterial activity of honey. New Zealand's manuka honey is known to possess a high level of "non-peroxide" antibacterial activity and research to identify the origin of this activity is briefly reviewed. Finally a hypothesis is advanced to explain the phenomenon of "non-peroxide" antibacterial activity in honey. The author concludes that this activity should be interpreted as residual hydrogen peroxide activity, which is probably due to the absence of plant-derived catalase from honey, an idea first suggested by Dustman in 1971. Ueber die Katalaseaktivitaet in Bienenhonig aus der Tracht der Heidekrautgewaechse (Ericaceae). Zeitschrift fuer Lebensmittel-Untersuchung und Forschung, 145, 292-295].

Weston, R. J., et al. (1999). "Antibacterial phenolic components of New Zealand manuka honey." Food Chemistry 64(3): 295-301.

This paper describes several methods for isolation of the antibacterially active phenolic fraction of honey derived from the native New Zealand manuka tree, Leptospermum scoparium (Myrtaceae). This fraction consists of phenolic derivatives of benzoic acids, cinnamic acids and flavonoids, all of which have been identified previously in honeys which do not exhibit non-peroxide residual antibacterial activity. The flavonoids had not previously been identified in manuka honey. Furthermore, the flavonoids were different from those found in the leaves of manuka trees but were the same as those found in European honeys and propolis. while most of these phenolic products possess antibiotic activity, they do not individually or collectively account for the antibacterial activity of 'active' manuka honey. Essentially all of this activity is associated with the carbohydrate fraction of the honey.

Royal Jelly

Aslan, A., et al. (2012). "Royal jelly can diminish secondary neuronal damage after experimental spinal cord injury in rabbits." Food and chemical toxicology. 50(7): 2554-2559.

The aim of this experimental study was to investigate the neuroprotective effect of Royal jelly (RJ) on traumatic spinal cord injury (SCI). Twenty-one New Zealand male rabbits, weighing between 2.5 and 3.0kg were divided into three groups: Sham (no drug or operation, n=7), Control (laminectomy+single dose of 1ml/kg saline orally, after trauma; n=7) and RJ (laminectomy+100mg/kg RJ, orally, after trauma, n=7). Laminectomy was performed at T10 and balloon catheter was applied extradurally for traumatic SCI. Four and 24h after surgery, rabbits were evaluated according to the Tarlov scoring system. Blood, cerebrospinal fluid and tissue sample from spinal cord were taken for measurements of antioxidant status or detection of apoptosis. Four hours after SCI, all animals in control or RJ treated groups became paraparesic. Significant improvement was observed in RJ treated group, 24h after SCI, with respect to control. Traumatic SCI led to increase in the lipid peroxidation and decrease enzymic or non-enzymic endogenous antioxidative defense systems, and increase in apoptotic cell numbers. RJ treatment mostly prevented lipid peroxidation and also augmented endogenous enzymic or non-enzymic antioxidative defense systems. Again, RJ treatment significantly decreased the apoptotic cell number induced by SCI.

Bullock, R. J., et al. (1994). "Fatal royal jelly-induced asthma." Medical Journal of Australia 160(1): 44-44.

An 11-year-old asthmatic girl was administered a 10 ml (500 mg) ampoule of "double strength" royal jelly. Within 20 min she suffered an acute anaphylactic reaction with diarrhoea and bronchospasm sufficiently severe for her immediate hospitalization. She died after failure to respond to resuscitation. On questioning, it was found that she had been exposed to royal jelly on 2 earlier occasions, and following the 2nd exposure she had developed mild asthma. Details of 4 other cases of anaphylactoid reaction to royal jelly, all in females, are held in the Australian database of the Therapeutic Goods Administration. It is emphasized that royal jelly, with its very high protein content, constitutes a major and life-threatening risk to patients with a known history of asthma or related allergies.

Harman, A. (2011). "Funny jelly nets fine." Bee Culture 139(9): 72-72.

The article reports on the 11,400-New Zealand-dollar fine imposed to Honey New Zealand Ltd. due to two charges of breaching the Fair Trading Act in relation to the marketing and distribution of the royal jelly Capsules through stores in Auckland and Christchurch, New Zealand.

Harwood, M., et al. (1996). "Asthma following royal jelly." The New Zealand medical journal 109(1028): 325-325.

Peacock, S., et al. (1995). "Respiratory distress and royal jelly." British Medical Journal (Clinical Research edition) 311(7018): 1472-1472.

A case of life-threatening respiratory distress following the ingestion of royal jelly capsules is reported from England. The patient in this case was a 31-year-old woman with a 15-year history of mild asthma, who developed severe respiratory distress on 2 occasions 40 min after ingestion of the royal jelly. [Similar reports appear in Medical Journal of Australia, 159: 639 (1993); ibid., 160: 44 (1994)].

Thien, F. C., et al. (1996). "Asthma and anaphylaxis induced by royal jelly." Clinical and experimental allergy : journal of the British Society for Allergy and Clinical Immunology 26(2): 216-222.

BACKGROUND: Asthma, together with, in some cases, anaphylaxis, was observed in seven subjects following ingestion of royal jelly, a secretion of honey bees which is used as a health tonic., OBJECTIVE: To determine if reactions were IgE-mediated and to identify allergenic components of royal jelly., METHODS: Skin-prick tests, immunoassays for specific IgE antibodies and protein blotting studies using patients' sera and anti-IgE second antibodies were employed., RESULTS: Immunoassays detected IgE antibodies to royal jelly proteins in sera of subjects who reacted to the substance. A total of 18 different IgE-binding components were detected on blots following electrophoretic separation of royal jelly under dissociating conditions. Examination of 63 sera from subjects allergic to bee venom showed that there is no direct relationship between IgE antibody reactivity to bee venom allergens and to royal jelly proteins although 38% of the sera reacted with a royal jelly solid phase. IgE antibody reactivity to royal jelly proteins was also detected in 52% of 75 subjects with allergies to inhalant and/or food allergens. Antibody binding of blotted royal jelly proteins was most marked in the molecular weight region 25-55 kDa

and one component of MW approximately 55 kDa was detected by all of the reactive sera from royal jelly-allergic and control allergic subjects., CONCLUSIONS: Symptoms of asthma and anaphylaxis seen in subjects following ingestion of royal jelly were true IgE-mediated hypersensitivity reactions. The clinical significance of the antibodies found in the sera of control subjects is not known but they may arise in response to common inhalant allergens that show allergenic cross-reactivity with royal jelly.

Van Toor, R. F. (1990). "Commercial production, storage, packaging and marketing of royal jelly in New Zealand." Commercial production, storage, packaging and marketing of royal jelly in New Zealand.: 30-pp.

Trials in three regions of New Zealand have shown that an average of 10 g of royal jelly (RJ) per honey bee colony can be harvested every 3 days during spring and autumn, though at the expense of surplus honey production. Using 30 production and 15 support colonies, one operator working for 2 days out of every 3 can produce 2.6 kg of RJ per month. Feeding protein supplements can increase yields by up to 57%, but only at pollen-deficient sites. This publication reviews the equipment and colony management needed for RJ production, and details harvesting methods, composition of and therapeutic claims for RJ, packaging, sales and marketing. There is an economic analysis of RJ production, a full reference list, and colour illustrations of production techniques.

Zheng, W., et al. (2018). "Development and validation of a simple solid-phase extraction method coupled with liquid chromatography-triple quadrupole tandem mass spectrometry for simultaneous determination of lincomycin, tylosin a and tylosin B in royal jelly." Biomedical Chromatography 32(4): e4145-e4145.

We have developed an analytical method for the determination of lincomycin, tylosin A and tylosin B residues in royal jelly using liquid chromatography-triple quadrupole tandem mass spectrometry analysis. For extraction and purification, we employed 1% trifluoroacetic acid and 0.1 M Na2EDTA solutions along with an Oasis HLB cartridge. The target antibiotics were well separated in a Kinetex EVO C18 reversed-phase analytical column using a combination of 0.1% formate acid in ultrapure water (A) and acetonitrile (B) as the mobile phase. Good linearity was achieved over the tested concentration range (5-50 micro g/kg) in matrix-matched standard calibration. The coefficients of determination (R2) were 0.9933, 0.9933 and 0.996, for tylosin A, tylosin B and lincomycin, respectively. Fortified royal jelly spiked with three different concentrations of the tested antibiotics (5, 10 and 20 micro g/kg) yielded recoveries in the range 80.94-109.26% with relative standard deviations <=4%. The proposed method was applied to monitor 11 brand of royal jelly collected from domestic markets and an imported brand from New Zealand; all the samples tested negative for lincomycin, tylosin A and tylosin B residues. In conclusion, 1% trifluoroacetic acid and 0.1 M Na2EDTA aqueous solvents combined with solid-phase extraction could effectively complete the sample preparation process for royal jelly before analysis. The developed approach can be applied for a routine analysis of lincomycin, tylosin A and tylosin B residues in royal jelly.

Wax

Gonzalez-Canavaciolo, V. L., et al. (2015). "Stability of 50mg-beeswax alcohols tablets (Abexol) packed in high-density polyethylene flasks." Revista Cubana de Farmacia 49(4).

Introduction: beeswax alcohols, consisting in a reproducible mixture of six primary fatty alcohols from 24 to 34 carbon atoms purified from *Apis mellifera* beeswax, has been shown to produce antioxidant and gastroprotective effects. This substance is used to manufacture Abexol 50 mg tablets, the finished form used in clinical studies and in routine practice. Objective(s): to determine the stability of 50 mg-Beeswax alcohols tablets (Abexol) packed in high-density polyethylene flasks. Method(s): samples from three batches of Abexol 50 mg tablets packed in white high density polyethylene flasks (Rainbow & Nature, Sydney, Australia) were put into cardboard boxes and kept under climatic conditions of the zone IV (30+/-2 C, 70+/-5 % of relative humidity) for five years. Result(s): all parameters tested were within specifications throughout the whole study: appearance (white round tablets with intact surfaces), average weight (initial average weight+/-7,5 %), total content of the six fatty alcohols (50+/-3.75 mg), disintegration time (<15 min), hardness (3 kg/cm2) and microbiological content (<=1 000 bacteria/g and <=100 fungi/g, absence of E. coli,S. aureus, Pseudomonas, Salmonella and C. albicans). This result is consistent with the data of a previous stability study of Abexol 50 mg tablets manufactured in Cuba and packed in blisters of polyvinyl chloride and aluminum. Conclusion(s): the results of the present study support that Abexol50mg tablets packed in white high

density polyethylene flasks and stored at the conditions of the climatic zone IV have a shelf life of 5 years.

Moller, H. (1987). "Honeydew - a South Island beekeepers' bounty." New Zealand beekeeper(195): 31-33.

The beech scale insect lives within a wax capsule in the bark of [mountain] beech which grows in forests on S. Island, New Zealand. In their first and second growth stages, the insects produce honeydew; this splashes onto the tree trunks and the ground below, which eventually turns black because of the growth of sooty moulds. The honeydew is also an important energy source for several species of birds that normally feed on nectar, and for ants, small beetles, flies, bumble bees and, in particular, wasps and honeybees. The wasps, comparative newcomers to these forests, are more successful than solitary bees and honeybees in collecting honeydew.P. Walker.

Nelson, D. E., et al. (1995). "Radiocarbon dates for beeswax figures in the prehistoric rock art of Northern Australia." Archaeometry 37(1): 151-156.

Five beeswax samples were collected from paintings in rock shelters in an area next to Kakadu National Park, and 2 other samples of beeswax were found in 2 nearby shelters. Accelerator mass spectrometry radiocarbon ages were obtained for all 7 samples and, as a control, for beeswax collected from an active *Apis mellifera* colony. The oldest painting is dated to c. 2000 B.C., and one to the recent past; the others are intermediate.

Priest, C. S. (1946). "Honey and beeswax." The Australasian journal of pharmacy 27(314): 97-97.

HUSBANDRY AND GENETICS

(1913). "Feeding Bees in Winter." Agricultural Gazette of New South Wales 24(8): 710-710.

In reply to a question from a correspondent as to whether it is advisable to feed bees during the winter, it is stated that bees should not be continuously fed during the winter, but put into winter quarters with enough stores to last until the spring. A mixture of 3 parts of honey to 1 of water should be made and fed to the bees while warm. If available some sort of inside feeder should be used, preferably the Miller or Alexander. If food has to be placed in the open it should be liquid enough to allow the bees to swim in it, and it must have plenty of dry floating matrial on its surface.

(1986). "Top bees for sale." Australasian beekeeper 88(3): 43-48.

Queen bees, bred from genetically improved Italian strains, will soon be on sale from the W. Australian Department of Agriculture. For the breeding programme, productive queens in Western Australia were selected, and were taken to Rottnest island (which has no feral bees) for mating with selected drones. Queens of the next generation were instrumentally inseminated with mixed semen from selected drones, and the resulting generations of queens will be sold to commercial apiaries.P. Walker.

(1987). "Export of queen bees from Australia to Canada." Australasian beekeeper 88(8): 155-156.

(2008). "Genetics: The genetics of anarchy." Nature 454(7200): 4-4.

The article focuses on the study of honeybee anarchy which has uncovered several regions of the genome that influence cheating behaviour. It is stated that honeybee queens emit a pheromone to switch off the ovaries of female worker bees. However, to those who fail to respond are branded anarchist since they disrupt the social order of the hive. On the other hand, Peter Oxley of the University of Sydney in New South Wales, and his colleagues had tracked down the regions of the genome that have a role in ovary activation. Their study found four such regions that together account for 25% of the variation in the trait observed in the population of honeybees they studied.

Alday, C. (2019). "How Is a Control Room Like a Hive?" Pipeline & Gas Journal 246(4): 2-2.

The article discusses control rooms and relates them with beehives. Topics discussed include queen bee that makes the workers working for production of honey, control room personnel that has to look after everyone and what they are doing, and research in control rooms in states including Australia, China, and Canada.

Allan, L. F. and M. J. Carrick (1984). "Development of a honey-bee improvement [breeding] programme." Australasian beekeeper 85(7): 128-132.

Allan, L. F. and M. J. Carrick (1988). "The Western Australian Bee Breeding Programme." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 51-53.

Allsopp, P. G. and R. H. Cherry (1991). "Attraction of *Apis mellifera* L. (Hymenoptera: Apidae) to volatile compounds." Journal of the Australian Entomological Society. 30(3): 219-220.

Anonymous (1933). "Queen Bees." Agric. J. Fiji 6: 39-41.

THE suggestion of queen bee raising in Fiji for the New Zealand market prefaces an abstract of a paper by E. A. Earp in the New Zealand Journal of Agriculture.

Avargues-Weber, A., et al. (2014). "Conceptualization of relative size by honeybees." Frontiers in Behavioral Neuroscience.

The ability to process visual information using relational rules allows for decisions independent of the specific physical attributes of individual stimuli. Until recently, the manipulation of relational concepts was

considered as a prerogative of large mammalian brains. Here we show that individual free flying honeybees can learn to use size relationship rules to choose either the larger or smaller stimulus as the correct solution in a given context, and subsequently apply the learnt rule to novel colors and shapes providing that there is sufficient input to the long wavelength (green) photoreceptor channel. Our results add a novel, size-based conceptual rule to the set of relational concepts that honeybees have been shown to master and underline the value of bees as an animal model for studying the emergence of conceptualization abilities.

Ayton, H. C. (1977). "The black bees of Tarraleah." Proceedings of the XXVIth International Apicultural Congress, Adelaide.: 266-268.

In this village in the Central Highlands of Tasmania, 40 hives of bees are kept by a beekeeper who started by collecting wild colonies. The black bees, which are gentler than other black bees in the State, seem to be pure descendants of *Apis mellifera* mellifera imported from Europe about 150 years ago. It is hoped to conserve this strain by declaring the area a bee sanctuary. P. Walker

Ayton, S., et al. (2016). "Phenophysiological variation of a bee that regulates hive humidity, but not hive temperature." Journal of Experimental Biology 219(10): 1552-1562.

Seasonal acclimatisation of thermal tolerance, evaporative water loss and metabolic rate, along with regulation of the hive environment, are key ways whereby hive-based social insects mediate climatic challenges throughout the year, but the relative importance of these traits remains poorly understood. Here, we examined seasonal variation in metabolic rate and evaporative water loss of worker bees, and seasonal variation of hive temperature and relative humidity (RH), for the stingless bee Austroplebeia essingtoni (Apidae: Meliponini) in arid tropical Australia. Both water loss and metabolic rate were lower in the cooler, dry winter than in the hot, wet summer at most ambient temperatures between 20 degrees C and 45 degrees C. Contrary to expectation, thermal tolerance thresholds were higher in the winter than in the summer. Hives were cooler in the cooler, dry winter than in the hot, wet summer, linked to an apparent lack of hive thermoregulation. The RH of hives was regulated at approximately 65% in both seasons, which is higher than unoccupied control hives in the dry season, but less than unoccupied control hives in the wet season. Although adaptations to promote water balance appear more important for survival of A. essingtoni than traits related to temperature regulation, their capacity for water conservation is coincident with increased thermal tolerance. For these small, eusocial stingless bees in the arid tropics, where air temperatures are relatively high and stable compared with temperate areas, regulation of hive humidity appears to be of more importance than temperature for maintaining hive health.

Baer, B., et al. (2016). "Sperm use economy of honeybee (*Apis mellifera*) queens." Ecology and Evolution 6(9): 2877-2885.

The queens of eusocial ants, bees, and wasps only mate during a very brief period early in life to acquire and store a lifetime supply of sperm. As sperm cannot be replenished, queens have to be highly economic when using stored sperm to fertilize eggs, especially in species with large and long-lived colonies. However, queen fertility has not been studied in detail, so that we have little understanding of how economic sperm use is in different species, and whether queens are able to influence their sperm use. This is surprising given that sperm use is a key factor of eusocial life, as it determines the fecundity and longevity of queens and therefore colony fitness. We quantified the number of sperm that honeybee (*Apis mellifera*) queens use to fertilize eggs. We examined sperm use in naturally mated queens of different ages and in queens artificially inseminated with different volumes of semen. We found that queens are remarkably efficient and only use a median of 2 sperm per egg fertilization, with decreasing sperm use in older queens. The number of sperm in storage was always a significant predictor for the number of sperm used per fertilization, indicating that queens use a constant ratio of spermathecal fluid relative to total spermathecal volume of $2.364 \times 10{-}6$ to fertilize eggs. This allowed us to calculate a lifetime fecundity for honeybee queens of around 1,500,000 fertilized eggs. Our data provide the first empirical evidence that honeybee queens do not manipulate sperm use, and fertilization failures in worker-destined eggs are therefore honest signals that workers can use to time queen replacement, which is crucial for colony performance and fitness.

Baumann, F. W. R. M. R. G. F. C. S. A. W. K. W. (1975). "The compound eye and vision of insects." The compound eye and vision of insects.: xviii-pp.

This well produced book consists of papers submitted at a symposium held during the International Entomology Congress at Canberra, 1972. Additional invited contributions are also included. Topics covered are: Receptor anatomy (Chapters 1 and 2); Receptor physiology (3-8); Optics (9-14); Electrophysiology of the optic lobe (15-20); Behavioural analysis (21-23); Ocellus (24).Chapters of special interest (either wholly or partly on honeybees) are:pp. 53-74 Baumann, F. : Electrophysiological properties of the honey bee retina.pp. 75-113 Wehner, R. : Pattern recognition.pp. 121-153 Menzel, R. : Colour receptors in insects.pp. 154-176 Gribakin, F.C. : Functional morphology of the compound eye of the bee.pp. 179-235 Snyder, A.W. : Optical properties of invertebrate physiology.pp. 359-377 Kaiser, W. : The relationship between visual movement detection and colour vision in insects.Publications referred to in the text are cited in a 42-page section which precedes the 41/2-page index.D.G. Lowe ADDITIONAL ABSTRACT: This book contains 14 papers read at a symposium on the eye and vision of insects held at the International Congress of Entomology in Canberra, Australia, in 1972 [cf. RAE/A61, 948 ; B 61, 498]. A further 10 papers are also included. The topics covered are receptor anatomy and physiology, optics, electrophysiology of the optic lobe, behavioural analysis, and ocellus.

Becker, N., et al. (2016). "Age-dependent transcriptional and epigenomic responses to light exposure in the honey bee brain." FEBS Open Bio 6(7): 622-639.

Light is a powerful environmental stimulus of special importance in social honey bees that undergo a behavioral transition from in-hive to outdoor foraging duties. Our previous work has shown that light exposure induces structural neuronal plasticity in the mushroom bodies (MBs), a brain center implicated in processing inputs from sensory modalities. Here, we extended these analyses to the molecular level to unravel light-induced transcriptomic and epigenomic changes in the honey bee brain. We have compared gene expression in brain compartments of 1- and 7-day-old light-exposed honey bees with age-matched dark-kept individuals. We have found a number of differentially expressed genes (DEGs), both novel and conserved, including several genes with reported roles in neuronal plasticity. Most of the DEGs show age-related changes in the amplitude of light-induced expression and are likely to be both developmentally and environmentally regulated. Some of the DEGs are either known to be methylated or are implicated in epigenetic processes suggesting that responses to light exposure are at least partly regulated at the epigenome level. Consistent with this idea light alters the DNA methylation pattern of bgm, one of the DEGs affected by light exposure, and the expression of microRNA miR-932. This confirms the usefulness of our approach to identify candidate genes for neuronal plasticity and provides evidence for the role of epigenetic processes in driving the molecular responses to visual stimulation.

Beekman, M., et al. (2003). "Sticking to their choice--honey bee subfamilies abandon declining food sources at a slow but uniform rate." Ecological entomology. 28(2): 233-238.

1. The allocation of honey bee foragers among food patches is a result of decisions made by individual bees that are based on internal and external cues. 2. Decision-making processes are often based on internal thresholds. For example, if the quality of the food source is assessed by a forager as exceeding its internal threshold, the bee will continue foraging on that food source. 3. It is often assumed that all individuals have the same threshold and therefore use the same thresholds in decision-making, but because the honey bee queen mates with 12-30 males, the workers within a colony are genetically heterogeneous. Thus, the thresholds used by individual bees may be genetically variable within a colony. 4. Models of colony-level foraging behaviour of honey bees suggest that the rate of abandoning food sources is a critical parameter affecting foraging success. Moreover, these models show that variance among subfamilies in their abandonment rates may increase the colony's foraging efficiency. 5. Experimental data showing the relationship between the probability of abandoning a food source and its profitability are lacking, as is information on any variation in abandonment rates among subfamilies. 6. Abandonment rates were determined experimentally for four honey bee families for seven different sucrose concentrations. The results showed that abandonment rates appear to be invariant among (sub)families. The importance of forager fidelity to declining food sources is discussed with respect to foraging efficiency in a changing environment.

Berry, I. (1983). "Winter feeding: feeding dry raw sugar to honeybees, New Zealand." New Zealand beekeeper.: 25-25.

Berry, R. P. and M. R. Ibbotson (2010). "A Three-Dimensional Atlas of the Honeybee Neck." PLoS One 5(5).

Three-dimensional digital atlases are rapidly becoming indispensible in modern biology. We used serial sectioning combined with manual registration and segmentation of images to develop a comprehensive and detailed three-dimensional atlas of the honeybee head-neck system. This interactive atlas includes skeletal structures of the head and prothorax, the neck musculature, and the nervous system. The scope and resolution of the model exceeds atlases previously developed on similar sized animals, and the interactive nature of the model provides a far more accessible means of interpreting and comprehending insect anatomy and neuroanatomy.

Bettesworth, D. (1989). "A bee stock improvement programme for New Zealand?" New Zealand beekeeper(202): 14-16.

At a meeting of queen producers and other interested beekeepers at the New Zealand Beekeepers' Association conference, in July 1988, it was agreed that New Zealand strains of honeybees should be identified and evaluated, and that a breeding programme should be set up. The present paper briefly discusses several points that must be considered, and puts forward 5 options for the breeding programme with advantages, disadvantages and costs.

Biswas, S., et al. (2010). "Sensory Regulation of Neuroligins and Neurexin I in the Honeybee Brain." PLoS One 5(2).

Background Neurexins and neuroligins, which have recently been associated with neurological disorders such as autism in humans, are highly conserved adhesive proteins found on synaptic membranes of neurons. These binding partners produce a trans-synaptic bridge that facilitates maturation and specification of synapses. It is believed that there exists an optimal spatio-temporal code of neurexin and neuroligin interactions that guide synapse formation in the postnatal developing brain. Therefore, we investigated whether neuroligins and neurexin are differentially regulated by sensory input using a behavioural model system with an advanced capacity for sensory processing, learning and memory, the honeybee. Methodology/Principal Findings Whole brain expression levels of neuroligin 1–5 (NLG1–5) and neurexin I (NrxI) were estimated by qRT-PCR analysis in three different behavioural paradigms: sensory deprivation, associative scent learning, and lateralised sensory input. Sensory deprived bees had a lower level of NLG1 expression, but a generally increased level of NLG2–5 and NrxI expression compared to hive bees. Bees that had undergone associative scent training had significantly increased levels of NrxI, NLG1 and NLG3 expression compared to untrained control bees. Bees that had lateralised sensory input after antennal amputation showed a specific increase in NLG1 expression compared to control bees, which only happened over time. Conclusions/Significance Our results suggest that (1) there is a lack of synaptic pruning during sensory deprivation; (2) NLG1 expression increases with sensory stimulation; (3) concomitant changes in gene expression suggests NrxI interacts with all neuroligins; (4) there is evidence for synaptic compensation after lateralised injury.

Biswas, S., et al. (2008). "Bridging the Synaptic Gap: Neuroligins and Neurexin I in *Apis mellifera*." PLoS One 3(10).

Vertebrate studies show neuroligins and neurexins are binding partners in a trans-synaptic cell adhesion complex, implicated in human autism and mental retardation disorders. Here we report a genetic analysis of homologous proteins in the honey bee. As in humans, the honeybee has five large (31–246 kb, up to 12 exons each) neuroligin genes, three of which are tightly clustered. RNA analysis of the neuroligin-3 gene reveals five alternatively spliced transcripts, generated through alternative use of exons encoding the cholinesterase-like domain. Whereas vertebrates have three neurexins the bee has just one gene named neurexin I (400 kb, 28 exons). However alternative isoforms of bee neurexin I are generated by differential use of 12 splice sites, mostly located in regions encoding LNS subdomains. Some of the splice variants of bee neurexin I resemble the vertebrate α- and β-neurexins, albeit in vertebrates these forms are generated by alternative promoters. Novel splicing variations in the 3′ region generate transcripts encoding alternative trans-membrane and PDZ domains. Another 3′ splicing variation predicts soluble neurexin I isoforms. Neurexin I and neuroligin expression was found in brain tissue, with expression present throughout development, and in most cases significantly up-regulated in adults. Transcripts of neurexin I and one neuroligin tested were abundant in mushroom bodies, a higher order processing centre in the bee brain. We show neuroligins and neurexins comprise a highly conserved molecular system with likely similar functional roles in insects as vertebrates, and with scope in the honeybee to generate substantial functional diversity through alternative splicing. Our study provides important prerequisite data for using the bee as a model for vertebrate synaptic development.

Blum, C., et al. (2008). "Swarm Intelligence: Introduction and Applications." Swarm Intelligence: Introduction and Applications.

This 291-page book consists of 8 individually-authored chapters divided into two parts. The book is intended to provide overview of swarm intelligence to novices, and to offer researchers in the field an update on interesting recent developments. Introductory chapters deal with the biological foundations, optimization, swarm robotics, and applications in new-generation telecommunication networks, while the second part contains chapters on more specific topics of swarm intelligence research such as the evolution of robot behavior, the use of particle swarms for dynamic optimization, and organic computing. This book will be of interest to computational biologists.

Bordier, C., et al. (2018). "Stress decreases pollen foraging performance in honeybees." The Journal of experimental biology 221(Pt 4).

Foraging in honeybees is energetically demanding. Here, we examined whether stressors, which generally increase metabolic demands, can impair foraging performance. A controlled non-pathogenic stressor (immune challenge) resulted in a change in the foraging preferences of bees. It reduced pollen foraging and increased the duration of trips in pollen foragers. Stress also reduced the amount of octopamine in the brain of pollen foragers (a biogenic amine involved in the regulation of foraging and flight behaviour in insects). According to the literature, flight metabolic rate is higher during pollen foraging than during nectar foraging, and nectar gives a higher energetic return relative to the foraging effort when compared with pollen. We thus propose that stress might be particularly detrimental to the performance of pollen foragers, and stressed bees prefer the energy-rich resource of nectar. In conclusion, stress, even at low levels, could have consequences for bee foraging behaviour and thereby the nutritional balance of the colony. Copyright © 2018. Published by The Company of Biologists Ltd.

Briggs, L. (1983). "National bee breeding and research project at Hawkesbury Agricultural College." Australian bee journal 64(1): 11-22.

This article is an extract from an application to 2 Australian grant institutions for financial assistance for this project; the aim of the full HAC project is to establish the capability to service the honeybee breeding research needed in Australia, and to provide high quality breeding stock to Australian beekeepers, and potentially to other countries.In the past most breeding queens have been imported, but the risk of importing disease is now recognized and a quarantine facility has been built near HAC. It is proposed that the College should import queens via this facility and make available instrumentally inseminated stock. At present 16 lines of pure races and strains are held at the College and it is important that evaluation of these lines and of new selections should continue. Also of considerable interest for research are the unique pure Ligurian honeybee population of Kangaroo Island, and the population of pure 'black English bees' near Tarraleagh.The historical background of the College and its present funding are summarized.P. Walker.

Chambers, S. (1990). "Feeding pollen to honeybees for colony development." Bee world. 71(1): 35-37.

Chapman, N. C., et al. (2019). "Genetic origins of honey bees (*Apis mellifera*) on Kangaroo Island and Norfolk Island (Australia) and the Kingdom of Tonga." Apidologie. 50(1): 28-39.

We examine the origin of honey bee (*Apis mellifera*) populations in Kangaroo Island (Australia), Norfolk Island (Australia) and the Kingdom of Tonga using a highly polymorphic mitochondrial DNA region and a panel of 37 single nucleotide polymorphisms that assigns ancestry to three evolutionary lineages: Eastern Europe, Western Europe and Africa. We also examine inbreeding coefficients and genetic variation using microsatellites and mitochondrial sequencing. The honey bees of Kangaroo Island have a high proportion of Eastern European ancestry (90.2%), consistent with claims that they are of the subspecies A. m. ligustica. The honey bees of Norfolk Island also had a majority of ancestry from Eastern Europe (73.1%) with some contribution from Western Europe (21.2%). The honey bees of Tonga are mainly of Western European (70.3%) origin with some Eastern European ancestry (27.4%). Despite the suspected severe bottlenecks experienced by these island population, inbreeding coefficients were low.

Chapman, N. C., et al. (2016). "Hybrid origins of Australian honeybees (*Apis mellifera*)." Apidologie 47(1): 26-34.

With increased globalisation and homogenisation, the maintenance of genetic integrity in local populations of agriculturally important species is of increasing concern. The western honeybee (*Apis mellifera*) provides an interesting perspective as it is both managed and wild, with a large native range and much larger introduced range.

We employed a newly created 95 single nucleotide polymorphism (SNP) test to characterise the genetic ancestry of the Australian commercial and feral honeybee populations. We found that most individuals were hybrids of mainly Western and Eastern European ancestry. Introductions of bees from North Africa are known from the historical record, and we show here the presence of alleles of African ancestry in some Australian bees, at levels comparable to those seen in the commercial populations of European-derived bees in North America.

Chapman, N. C., et al. (2008). "Population Genetics of Commercial and Feral Honey Bees in Western Australia." Journal of economic entomology. 101(2): 272-277.

Due to the introduction of exotic honey bee (*Apis mellifera* L.) diseases in the eastern states, the borders of the state of Western Australia were closed to the import of bees for breeding and other purposes >25 yr ago. To provide genetically improved stock for the industry, a closed population breeding program was established that now provides stock for the majority of Western Australian beekeepers. Given concerns that inbreeding may have resulted from the closed population breeding structure, we assessed the genetic diversity within and between the breeding lines by using microsatellite and mitochondrial markers. We found that the breeding population still maintains considerable genetic diversity, despite 25 yr of selective breeding. We also investigated the genetic distance of the closed population breeding program to that of beekeepers outside of the program, and the feral Western Australian honey bee population. The feral population is genetically distinct from the closed population, but not from the genetic stock maintained by beekeepers outside of the program. The honey bees of Western Australia show three mitotypes, originating from two subspecies: *Apis mellifera* ligustica (mitotypes C1 and M7b) and *Apis mellifera* iberica (mitotype M6). Only mitotypes C1 and M6 are present in the commercial populations. The feral population contains all three mitotypes.

Cheng, K. (2005). "Context cues eliminate retroactive interference effects in honeybees *Apis mellifera*." The Journal of experimental biology 208(Pt 6): 1019-1024.

Free flying honeybees were trained successively on two different tasks of landmark-based spatial memory. On both task 1 and task 2, the goal was at a consistent distance and direction from a cylindrical landmark. The colours of the landmarks differed for the two tasks. The target direction from the landmark in task 2 was opposite to that in task 1. The context in which task 2 took place was either the same as the task-1 context or different: being a short distance away, having different surrounding landmarks, and a different colour on the training table. After each task, the bees were tested on task 1 in the task-1 context (test 1 and test 2). If task 2 had the same context as task 1, the bees performed at chance on test 2. If task 2 had a different context, performance on test 2 was unaffected, remaining as good as on test 1. Contextual cues thus guide memory retrieval, and prevent any confusions about which response (that appropriate for task 1 or for task 2) to perform.

Clare, G., et al. (2000). "Pheromone trap colour determines catch of non-target insects." New Zealand Plant Protection Volume 53, 2000. Proceedings of a conference, Commodore Hotel, Christchurch, New Zealand, 8-10 August 2000: 216-220.

Pheromone traps were set up in apple orchards in Canterbury, Nelson and Hawke's Bay and in an apricot orchard in Central Otago, New Zealand between December 1999 and January 2000 to determine the impact of trap colour on the catch of target and nontarget insects. Red or green-coloured pheromone sticky traps caught fewer native and introduced bees compared to the standard white traps, and yellow or blue traps. Honey bees (*Apis mellifera*) were caught mainly in white followed by blue traps, while bumble bees (*Bombus* spp.) were most attracted to blue traps, with most of the remainder caught in white traps. Native bee (Lasioglossum and Hylaeus spp.) catches were greatest in white traps, followed by yellow traps, with a few in green traps. There was no significant differences in the catch of the target species, Cydia pomonella or Epiphyas postvittana, and trap colour. Replacement of the white traps with green or red traps is recommended to reduce nontarget impacts on bees.

Clarke, G. M. and B. P. Oldroyd (1996). "The genetic basis of developmental stability in *Apis mellifera*. II. Relationships between character size, asymmetry and single-locus heterozygosity." Genetica 97(2): 211-224.

Drones and workers from two honey bee colonies, headed by open-mated queens of mixed racial origin, in Bundoora, Australia, were examined for 6 characters on their forewings and hindwings. Their malate dehydrogenase (MDH) genotypes were also determined. Foraging workers, probably from many unrelated colonies, were collected from several plant species in Bundoora, and measurements of the same morphological characters and MDH

genotype determinations were also made for these bees. There were significant differences among MDH genotypes for mean character size within colonies, but these effects were inconsistent between colonies. There were no significant relationships between MDH genotype or heterozygosity and morphological asymmetry, indicating that genetic variation at this locus has no impact on developmental stability in *A. mellifera*.

Clarke, R. J. (1989). "Queen physiological quality. A discussion paper for N.Z. queen producers." Queen physiological quality. A discussion paper for N.Z. queen producers.: 10-pp.

A literature survey with 27 references covers queen weight, ovariole number, volume of the spermatheca and number of spermatozoa it contains. The reported ranges of values are discussed in relation to queen quality, and standards are suggested. The importance of nutrition in queen rearing is discussed. Finally, guidelines for queen rearers are presented. The discussion is focused mainly on *Apis mellifera* ligustica, the typical New Zealand commercial honeybee.

Cobey, S. (2001). "Beekeeping on the only mite-free continent--Australia." American bee journal. 141(7): 495-499.

Cobey, S. (2004). "New Zealand bee breeder David Yanke." American bee journal. 144(4): 296-299.

Cobey, S. W. (1979). "A New Zealander's unique system of queen rearing." American bee journal 119(6): 421-421.

Colin, T., et al. (2018). "The development of honey bee colonies assessed using a new semi-automated brood counting method: CombCount." PLoS One 13(10): e0205816-e0205816.

Precise, objective data on brood and honey levels in honey bee colonies can be obtained through the analysis of hive frame photographs. However, accurate analysis of all the frame photographs from medium-to large-scale experiments is time-consuming. This limits the number of hives than can be practically included in honeybee studies. Faster estimation methods exist but they significantly decrease precision and their use requires a larger sample size to maintain statistical power. To resolve this issue, we created 'CombCount' a python program that automatically detects uncapped cells to speed up measurements of capped brood and capped honey on photos of frames. CombCount does not require programming skills, it was designed to facilitate colony-level research in honeybees and to provide a fast, free, and accurate alternative to older methods based on visual estimations. Six observers measured the same photos of thirty different frames both with CombCount and by manually outlining the entire capped areas with ImageJ. The results obtained were highly similar between both the observers and the two methods, but measurements with CombCount were 3.2 times faster than with ImageJ (4 and 13 min per side of the frame, respectively) and all observers were faster when using CombCount rather than ImageJ. CombCount was used to measure the proportions of capped brood and capped honey on each frame of 16 hives over a year as they developed from packages to full-size colonies over about 60 days. Our data describe the formation of brood and honey stores during the establishment of a new colony.

Cook, V. A. (1967). "Facts about beekeeping in New-Zealand honey bees." Bee World 48(3): 88-100.

Cornuet, J. M., et al. (1995). "Unequal thermostability of allelic forms of malate dehydrogenase in honey bees." Journal of Apicultural Research 34(1): 45-47.

Malate dehydrogenase (MDH) activity was studied in homogenates of individual worker honey bees (*Apis mellifera*) which had been collected while foraging on flowers in Bundoora, Australia. The 3 alleles for MDH present in these bees - fast (F), medium (M) and slow (S) - produced 3 homodimers and 3 heterodimers. The 70 bees studied allowed 158 comparisons of these (37 SS, 47 MM, 30 FF, 21 SM, 13 MF, 10 SF). The FF and SS homodimers retained full to intermediate activity after 3 min at 65 degrees C, whereas all MM homodimers were undetectable after the same treatment. All heterodimers were still detectable but the loss of activity of the FM and SM heterodimers appeared larger than that of the FS heterodimer, suggesting an intermediate thermostability of heterodimers compared to the corresponding homodimers. The possible effects of temperature-dependent selection on MHD allelic variation is discussed.

Covey, C. W. (1987). "Establishment of Keswick Island Caucasian queen breeding genetic pool." Australasian beekeeper 89(1): 20-21.

The suitability of islands off the Queensland coast, Australia, as honeybee mating stations was discussed by R. L. Goebel [AA 201/88]. There are now 15 colonies on Keswick Island, belonging to 6 different strains of pure-bred Caucasian bees. The island, which will probably support 40 colonies, seems very suitable as a pure race isolated mating area. The writer urges that this island group should be declared a sanctuary for pure-bred Caucasians.

Cramp, D. C. (2017). "The use of an unmanned aerial vehicle (UAV) to investigate aspects of honey bee drone congregation areas (DCAs)." Journal of Apicultural Research 56(2).

Unmanned aerial vehicles (UAVs) are a relatively new method of acquiring scientific data in a variety of applications and although their use has expanded greatly in recent years there has been no evaluation of the use of UAVs in the investigation of honey bee drone congregation areas (DCAs). This scientific note describes the advantages of using a UAV for locating DCAs and investigating DCA boundaries in difficult terrain and adverse wind conditions. A Phantom Vision 2 Unmanned Arial Vehicle video camera drone fitted with an artificial queen bee was used to examine DCAs in a mountainous, bush clad area in the Wellington area of New Zealand. The UAV was able to investigate areas not easily accessible on foot and impassable for vehicles, and was able to investigate areas upwind of the operator. Results suggest that the directionality of a UAV is useful in investigating DCAs and helping to determine their boundaries in areas of difficult terrain in the Wellington area of New Zealand.

Cridge, A. G., et al. (2017). "The honeybee as a model insect for developmental genetics." Genesis 55(5).

Honeybees are an important component of modern agricultural systems, and a fascinating and scientifically engrossing insect. Honeybees are not commonly used as model systems for understanding development in insects despite their importance in agriculture. Honeybee embryogenesis, while being superficially similar to Drosophila, is molecularly very different, especially in axis formation and sex determination. In later development, much of honeybee biology is modified by caste development, an as yet poorly understood, but excellent, system to study developmental plasticity. In adult stages, developmental plasticity of the ovaries, related to reproductive constraint exhibits another aspect of plasticity. Here they review the tools, current knowledge and opportunities in honeybee developmental biology, and provide an updated embryonic staging scheme to support future studies.

Diesendorf, M. (1975). "General anesthetic excitation and inhibition of insect carbon dioxide receptors an interpretation." DENTON, DEREK A. AND JOHN P. COGHLAN (ED.). OLFACTION AND TASTE V. PROCEEDINGS OF THE FIFTH INTERNATIONAL SYMPOSIUM. MELBOURNE, AUSTRALIA, OCT. 1974. XXIV+460P. ILLUS. ACADEMIC PRESS, INC.: NEW YORK, N.Y., U.S.A.; LONDON, ENGLAND. ISBN 0-12-209750-5: 195-198.

Dobson, J. (1995). "NZ bee genetic improvement group - a unique response to the challenge." New Zealand beekeeper 2(2): 7-9.

A honey bee (*Apis mellifera*) stock improvement programme in New Zealand is operated by a private company owned by 25 beekeepers. The shareholders evaluate over 1 season 7-10 selected queens for brood viability and colony performance. The best queen from each group is returned to the programme manager in autumn to be used for rearing > 10 000 drones, and > 250 queens which are inseminated with semen pooled from drones reared from all the best queens. Queens thus produced are evaluated during the next season. With shareholders conducting evaluations the annual programme budget is only c. NZ$ 15 000.

Donovan, B. J. (1990). "Selection and importation of new pollinators to New Zealand." New Zealand Entomologist 13: 26-32.

The geographic isolation of New Zealand greatly limits the numbers and diversity of species of native bees compared to other areas of comparable size. The honey bee was introduced for honey production, but it provides adequate pollination for most of the introduced flowering crops that require insect pollination for fruit and seed production. The shortage of indigenous pollinators led to the importation of long-tongued bumble bees for pollination of red clover. This was the first introduction anywhere of bees especially for pollination. Following this success, 2 species of bees were introduced to pollinate lucerne. The importation of further specialist pollinators for selected crops could improve yields and quality. Criteria for selection of additional pollinators are suggested, which include minimizing disturbances to the existing flora and fauna, and the safeguarding of current crop yields. Had these criteria been in force last century, honey bees may have been excluded, but bumble bees probably would have been introduced. As an example of a candidate specialist pollinator, Osmia cornifrons is suggested for fruit flowers.

This bee species appears to comply with all criteria. New Zealand is uniquely placed to benefit more than most other areas from the introduction of selected, specialist pollinating bees.

Donovan, B. J. (2007). "Apoidea (Insecta : hymenoptera)." FAUNA OF NEW ZEALAND(57): 5-294.

The superfamily Apoidea in New Zealand is represented by 41 species in 4 families. The 28 species of the family Colletidae are represented by 12 previously described endemic species (Leioproctus (Leioproctus) boltoni, L. (L.) imitatus, L. (L.) metallicus, L. (L) purpureus, L. (L.) vestitus, L. (Nesocolletes)fulvescens, L. (N.) hudsoni, L. (N.) maritimus, L. (N.) monticola, Hylaeus (Prosopisteron) agilis, H. (P.) capitosus, and H. (P) relegatus), 12 newly described endemic species (Leioproctus (Leioproctus) huakiwi, L. (L.) kanapuu, L. (L) keehua, L. (L.) otautahi, L. (L.) pango, L. (L) waipounamu, L. (Nesocolletes) nunui, L. (N.) paahaumaa, L. (N.) pekanui, Hylaeus (Prosopisteron) kermadecensis, H. (P.) matamoko, and H. (P.) murihiku), and 4 adventive species from Australia (Hylaeus (Prosopisteron) asperithorax, H. (P.) perhumilis, Hyleoides concinna, and Euryglossina (Euryglossina) proctotrypoides). The 5 species of the family Halictidae are represented by the imported Nomia (Acunomia) melanderi melanderi, the previously described endemic species Lasioglossum (Austrevylaeus) sordidum, the 2 newly described endemic species L. (A) Mataroa and L. (A.) maunga, and the indigenous species L. (Chilalictus) cognatum, which is also found in Australia. The 3 species of the family Megachilidae consist of the adventive Anthidium (Anthidium) manicatum, and the imported Osmia (Helicosmia) coerulescens, and Megachile (Eutricharaea) rotundata. The 5 species of the family Apidae are represented by the imported species *Bombus terrestris*, B. (Megabombus) hortorum, B. (M.) ruderatus, B. (Subterraneobombus) subterraneus, and *Apis mellifera*. 10 new synonymies are established (valid name listed after equal sign): Paracolletes maorium Cockerell, 1913 and Paracolletes viridibasis Cockerell, 1936 = Leioproctus (Leioproctus) imitatus Smith, 1853; Dasycolletes hirtipes Smith, 1878, Paracolletes Waterhousei Cockerell, 1905, and Paracolletes opacior Cockerell, 1936 = Leioproctus (Nesocolletes) fulvescens (Smith, 1876); Prosopis maorica Kirkaldy, 1909 and Hylaeus (Prosopisteron) laevigatulus Mitchener, 1965 = Hylaeus (Prosopisteron) agilis (Smith, 1854); and Prosopis cameroni Cockerell, 1905, Prosopis maoriana Cockerell, 1909, and Hylaeus hudsoni Cockerell, 1925 = Hylaeus (Prosopisteron) relegatus (Smith, 1876).Data are presented and discussed on the origin, biogeography, history of research, the evolutionary relationships among endemic bees, life cycles, economic value, impact on human health, conservation status, and, for imported bees, their environmental impacts. Keys are given according to sex to families, subfamilies, genera, subgenera, and species, and by nests to genera.For the endemic, indigenous, and adventive species except Anthidium manicatum, all known references are presented with annotations, while for Anthidium manicatum and the imported species, the most important references are selected. All 27 previously named species and 14 new species are described, and distribution data with maps and details of biology are presented. For all species except *Bombus* and Apis, all flower visiting records for New Zealand are listed separately for native plants and introduced plants, while for *Bombus* flower visiting records for native plants are presented. The appendices provide information on species recorded in New Zealand but not established, species recorded incorrectly for New Zealand, and a subjective evaluation of the occurrence and abundance of the species throughout New Zealand.During this study 24,529 bees were inspected microscopically, many scores of thousands of Leioproctus spp., Hylaeus spp., and Lasioglossum spp. were observed on the wing, and for N. melanderi, O. coerulescens, All. rotundata, *Bombus* spp., and *Apis mellifera* collectively, millions have been handled and observed.

Doull, K. M. (1973). "Biological and technical factors affecting profitability in beekeeping." Australasian beekeeper 75: 40-167.

The author draws upon his own experience, as well as the standard works listed, in presenting biological factors which affect honey production. He shows ways in which an understanding of honeybee biology is necessary for successful colony management. Topics covered include: population size; length of life of individual bees; oviposition and brood development; effects of *Nosema* disease, temperature and hive size; bee forage and the importance of pollen.D.G.Lowe

Dyer, A. G. (1999). "Atmospheric ozone concentration and the colour vision of insect pollinators." Australian Journal of Zoology 47(5): 529-538.

Mean monthly atmospheric ozone concentrations for Melbourne, Australia, for the periods 1956-72 and 1992-97, and simulated depletion values for the period 1956-72, were calculated. Colour triangles were used to plot

colour mixes for bee vision. Using a theoretical model of *Apis mellifera* colour vision, and considering direct and diffuse illumination conditions, it was shown that a large reduction in atmospheric ozone concentration would have a minimal effect on bee colour vision over the whole of their colour space.

Dyer, A. G. (1999). "Broad spectral sensitivities in the honeybee's photoreceptors limit colour constancy." Journal of Comparative Physiology 185(5): 445-453.

Colour constancy allows for visual systems to be view stimuli independent of changes in spectral illumination. Chromatic adaptation is likely to be an important mechanism in colour constancy and can be explained by use of the von Kries coefficient law. Chromatic adaptation is compared for the honeybee and three hypothetical visual systems. It is shown that the spectral breadth and asymmetry of photoreceptors in the honeybee may limit colour constancy. In particular, it is demonstrated that the absorption of short-wavelength radiation by the cis-band of chromophore is responsible for a poorer correction for bee colours rich in ultraviolet reflectance. The results are discussed in relation to theoretical considerations of von Kries colour constancy and the physiology of eye design in some other species for which colour constancy has been demonstrated.

Dyer, A. G., et al. (2012). "Parallel evolution of angiosperm colour signals: common evolutionary pressures linked to hymenopteran vision." Proceedings of the Royal Society B-Biological Sciences 279(1742): 3606-3615.

Flowering plants in Australia have been geographically isolated for more than 34 million years. In the Northern Hemisphere, previous work has revealed a close fit between the optimal discrimination capabilities of hymenopteran pollinators and the flower colours that have most frequently evolved. We collected spectral data from 111 Australian native flowers and tested signal appearance considering the colour discrimination capabilities of potentially important pollinators. The highest frequency of flower reflectance curves is consistent with data reported for the Northern Hemisphere. The subsequent mapping of Australian flower reflectances into a bee colour space reveals a very similar distribution of flower colour evolution to the Northern Hemisphere. Thus, flowering plants in Australia are likely to have independently evolved spectral signals that maximize colour discrimination by hymenoptera. Moreover, we found that the degree of variability in flower coloration for particular angiosperm species matched the range of reflectance colours that can only be discriminated by bees that have experienced differential conditioning. This observation suggests a requirement for plasticity in the nervous systems of pollinators to allow generalization of flowers of the same species while overcoming the possible presence of non-rewarding flower mimics.

Eaton, C. v. (1986). "Determinants of queen quality in New Zealand commercial queens." New Zealand beekeeper(192): 28-30.

Thirteen commercial queen producers each supplied 5 randomly chosen queens for this study. Results, given as the mean value followed by the range, were: queen weight, 214.3 mg (181-256 mg); number of ovarioles, 296 (200-364); spermatheca volume, 0.943 mmsuperscript 3 (0.508-1.370 mmsuperscript 3); number of spermatozoa, 4.72 million (1.5-9.5 million); thorax width, 3.99 mm (3.7-4.5 mm), thorax length, 4.62 mm (3.4-5.1 mm). Among worker attendants sent with queens, 68% of the samples were infected with *Nosema*, and the mean spore level in these samples was 3.73 million spores/bee, but only 18% of the queens contained *Nosema* spores. It was concluded that the queens in this study were generally of high quality. Interviews with producers of above-average queens revealed various management practices which can improve queen quality. P. Walker.

Eaton, C. v. (1987). "Commercial queen production in New Zealand." American bee journal 127(11): 773-785.

In New Zealand there are 22 commercial and semi-commercial queen producers; about 75 000 queens are produced annually for the domestic market. In 1986, over 41 000 queens, as well as packages of bees, were exported

to 13 countries in N. America, Europe, Asia and the Pacific. Many honey producers also rear their own queens. Most New Zealand queen producers use free-flying starter/finishers, which are variations of the Doolittle system. For grafting, plastic cups and a sable-hair brush are used, and no more than 20-30 cells are finished per colony. The organization of the industry, and the advisory services provided, are described.P. Walker.

El-Sayed, A. M., et al. (2018). "Honey Norisoprenoids Attract Bumble Bee, *Bombus terrestris*, in New Zealand Mountain Beech Forests." Journal of agricultural and food chemistry. 66(50): 13065-13072.

Three varieties of honey of different dominant floral origin were found to attract social Hymenoptera, including the large earth bumble bee, *Bombus terrestris*, in a New Zealand mountain beech forest. This study was undertaken to identify volatile organic compounds that induce the attraction of bumble bees to honeybee (*Apis mellifera*) honey. We analyzed the chemical composition of the volatile organic compounds produced in three distinct varieties of honey (i.e., manuka, honeydew, and clover honey). The composition of the chemical profile of the three honey varieties differed in the quality and in the ratio of compounds in the headspace. o-Methoxyacetophenone was the main compound in the headspace of all three honey varieties. Among the 40 compounds identified in the headspace in the three varieties, only seven shared compounds (i.e., benzaldehyde, benzyl alcohol, phenylacetaldehyde, 2-phenylethanol, isophorone, 4-oxoisophorone, and o-methoxyacetophenone) were present in the headspace of the three honey varieties. The relative attractiveness of various blends of the seven common compounds found in the three honey varieties was tested for the attraction to bumble bees in a mountain beech forest. A binary blend of isophorone and 4-oxoisophorone at a ratio of 90:10 was the most attractive blend for both bumble bee workers and queens. A small number of honey bee workers were also attracted to the former binary blend. Our study represents the first identification of a honey-derived attractant for bumble bees and honey bees. The potential application of our finding for monitoring of bumble bees or to enhance crop pollination and help to tackle the current concern of a global pollination crisis is discussed.

Farrow, R. (2016). "Feeding strategies." Insects of South-Eastern Australia: An Ecological and Behavioural Guide: 51-70.

Forster, I. W. (1975). "An evaluation of various characteristics in 3 lines of New-Zealand honey bees." New Zealand journal of experimental agriculture 3(3): 293-296.

Forster, I. W. (1975). "An evaluation of various characteristics in three lines of -New Zealand honey bees." New Zealand journal of experimental agriculture: 293-296.

Furgala, B., et al. (1993). "Evaluation of honey bee stocks from New Zealand." American bee journal. 133(2): 131-132.

Gartside, D. F. (1980). "Similar allozyme polymorphism in honeybees (*Apis mellifera*) from different continents." Experientia. 36(6): 649-650.

Glatz, R. V. (2015). "Curious case of the Kangaroo Island honeybee *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae) sanctuary." Austral Entomology 54(2): 117-126.

Humans have had a long association with the honeybee *Apis mellifera*Linnaeus, 1758, which has been exploited for production of honey and for the crop pollination services it provides. This association facilitated movement of this species to such a degree that it is now virtually ubiquitous in all areas with flowering plants and available water. On Kangaroo Island (KI), a 'sanctuary' was created for the Ligurian bee subspecies A.mellifera ligustica, which is exotic to Australia and the entire New World. TheLigurianBeeAct was enacted in 1885 on the basis of perceived genetic purity and isolation of KI honeybee populations, and was updated in 1931 and 1997. It supports biosecurity protocols preventing importation of bees, bee-keeping equipment and bee-related products such as honey and wax. This represents a rare example of legislative protection for an invertebrate in Australia. This legislation and the apparent isolation of KI bees from mainland bees in the time since its enactment have led to the popular assertion that KI honeybee populations represent the last 'pure' genetic population of A.mellifera ligustica. However, historical accounts of bee introductions to KI show that A.mellifera mellifera-like bees were present on KI prior to the introduction of A.mellifera ligustica, and that multiple A.mellifera ligustica introductions to KI occurred

using bees of mixed heritage. Indeed, DNA sequence analyses of KI honeybees clearly indicate that while there is limited genetic diversity (supporting the assertions of limited introductions and recent geographic/genetic isolation), they are in fact hybrids and share more similarity with the A.mellifera mellifera subspecies. Therefore, the relevant state legislation should be updated to remove any mention of Ligurian or other honeybee strains. However, the biosecurity protocols relating to KI should continue due to the low incidence of some honeybee diseases and the threat posed by Varroa mite.

Gloag, R., et al. (2019). "The frequency of thelytokous parthenogenesis in European-derived *Apis mellifera* virgin queens." Apidologie 50(3): 295-303.

Thelytokous parthenogenesis is the asexual production of female progeny. In the honey bee, *Apis mellifera*, thelytoky is unknown from mated queens, but can occur in virgin queens that have been induced to lay. We used microsatellite markers to quantify theltyoky in virgin *A. mellifera* queens of European origin that were sham inseminated with saline and/or narcotised with carbon dioxide. Of 20 queens, 17 (85%) produced at least one daughter thelytokously during an 8-week period. One exceptional queen produced 19% thelytokous progeny, though few total offspring (20 daughters in 107 pupae). The average proportion of thelytokous progeny among the remaining queens was 0.9% (range 0-3.5%), with the balance being males. These results are consistent with observations from the pre-molecular biology era that virgin honey bee queens of non-African subspecies regularly produce thelytokous offspring at low frequency and indicate that there is significant natural variation in the capacity for thelytoky among these queens.

Gloag, R. S., et al. (2019). "Workers' sons rescue genetic diversity at the sex locus in an invasive honey bee population." Molecular Ecology 28(7): 1585-1592.

The hallmark of eusociality is the division of labour between reproductive (queen) and nonreproductive (worker) females. Yet in many eusocial insects, workers retain the ability to produce haploid male offspring from unfertilized eggs. The reproductive potential of workers has well-documented consequences for the structure and function of insect colonies, but its implications at the population level are less often considered. We show that worker reproduction in honey bees can have an important role in maintaining genetic diversity at the sex locus in invasive populations. The honey bee sex locus is homozygous-lethal, and, all else being equal, a higher allele number in the population lead to higher mean brood survival. In an invasive population of the honey bee *Apis cerana* in Australia, workers contribute significantly to male production: 38% of male-producing colonies are queenless, and these contribute one-third of all males at mating congregations. Using a model, we show that such male production by queenless workers will increase the number of sex alleles retained in nascent invasive populations following founder events, relative to a scenario in which only queens reproduce. We conclude that by rescuing sex locus diversity that would otherwise be lost, workers' sons help honey bee populations to minimize the negative effects of inbreeding after founder events and so contribute to their success as invaders.

Goodwin, R. M. and R. D. Lewis (1987). "Honeybees use a biological clock to incorporate sun positions in their waggle dances after foraging under heavy overcast skies." New Zealand Entomologist 10: 138-140.

By administering a cold temperature pulse to honeybees which had been foraging under heavy overcast skies it was shown that they use a biological clock to calculate the sun's position.

Gulliford, R. B. (1989). "Beekeeping for business & pleasure." Beekeeping for business & pleasure.

This home study course has been developed by NSW Agriculture & Fisheries to help both new and experienced beekeepers. The student profile is described as " A beekeeper with a range of 1 to 200 hives who is predominantly interested in honey production. The beekeeper may be a part-time farmer or have no involvement with farming. In either case there is a financial interest in the enterprise." The course comprises a course pack (268 pp.), which consists of 6 booklets in a loose-leaf folder, and a resource pack (244 pp.), which consists of a second folder with 8 booklets in the 'Bee Management Series', 5 'Agfacts' leaflets and 3 audio tapes. The basic course consists of 10 chapters: introduction to beekeeping; hives, equipment and maintenance; honey and pollen flora; selecting sites and moving bees; comb manipulation and hive management; the production enterprises [hive products, pollination]; swarming; queen rearing; diseases; financial management and decision making. Each chapter includes objectives, a technical section, a review and a series of practical exercises. The resource pack supplements the course by providing additional information and alternative ideas. The course is designed for Australian (and

particularly NSW) beekeepers, but much of the well-presented information and helpful advice it contains could also be useful to beekeepers keeping *Apis mellifera* in movable-comb hives elsewhere in the world. The course is available from Home Studies Courses, C.B. Alexander Agricultural College, Paterson, NSW 2421, Australia.

Hafi, A., et al. (2012). "A benefit-cost framework for responding to an incursion of *Varroa destructor*." ABARES Research Report(12.05): v-pp.

Australia remains the only continent free of *Varroa destructor*, a devastating mite pest of European honey bees. This research report outlines a benefit-cost analysis framework that can be used in the future to assess the economic feasibility of response plans in the event of an incursion of Varroa in Australia. The framework is based on a bio-economic model that links a spatially explicit Varroa spread module with partial equilibrium market modules for pollination services and commodities produced from pollination dependent crops. The pollination services market module allows for substitution of managed pollination for any lost feral honey bee pollination, as has been observed overseas following the establishment of Varroa. The report presents illustrative estimates of economic losses and demonstrates that slowing the spread can significantly reduce these losses. It also highlights the critical role that an expanded managed pollination industry could potentially play in helping to reduce economic losses from a Varroa incursion.

Harman, A. (1989). "Half-moon." Gleanings in Bee Culture. 117(5): 288-290.

The causes of half-moon disorder were studied in affected colonies in New Zealand. The queens in such colonies appear to be failing: they lay clumps of eggs in cells, and drone brood develops. Many larvae are neglected and die, drying into half-moon-shaped brown scales, and eventually the population of nurse bees becomes depleted. Experiments showed that the premature aging of the queen was not due to genetic factors, or to a pathogen. However, it was demonstrated that if workers do not feed young virgin queens with sufficient protein, premature aging occurs. It is possible that when queens are being reared on a large scale, insufficient protein is being supplied in the mating nuclei.

Harman, A. (2013). "Canadian bees to OZ." Bee Culture 141(12): 82-82.

The article reports that the first shipment of queen bees from Canada will arrive in Australia, and will spend the rest of their lives in a purpose-built quarantine facility in New South Wales, promising a significant benefit to the bee industry of Australia.

Hatty, S. and B. P. Oldroyd (1999). "Evidence for temperature-dependent selection for malate dehydrogenase allele frequencies in honeybee populations." Journal of heredity. 90(5): 565-568.

The MDH-1 genotype and a mitochondrial DNA haplotype was determined for feral honeybees (*Apis mellifera* L.) collected from 10 sites in southern New South Wales, Australia. The frequency of the Mdh(65) allele was positively correlated, and the Md(80) allele negatively correlated with increasing average daily temperature for July and January ($P < .01$), whereas no cline was found for the mitochondrial marker. Parallel clines in MDH allele frequencies have now been found on four continents, and the Mdh(80) allele has been shown to be less heat stable in vitro than the other alleles. We conclude that this is very strong evidence that the MDH-1 clines observed in honeybees are due to temperature-dependent selection.

He, X. J., et al. (2014). "Behavior and molecular physiology of nurses of worker and queen larvae in honey bees (*Apis mellifera*)." Journal of Asia-Pacific entomology 17(4): 911-916.

In a honey bee colony, worker bees rear a new queen by providing her with a larger cell in which to develop and a large amount of richer food (royal jelly). Royal jelly and worker jelly (fed to developing worker larvae) differ in terms of sugar, vitamin, protein and nucleotide composition. Here we examined whether workers attending queen and worker larvae are separate specialized sub-castes of the nurse bees. We collected nurse bees attending queen larvae (AQL) and worker larvae (AWL) and compared gene expression profiles of hypopharyngeal gland tissues, using Solexa/Illumina digital gene expression tag profiling (DGE). Significant differences in gene expression were found that included a disproportionate number of genes involved in glandular secretion and royal jelly synthesis. However behavioral observations showed that these were not two entirely distinct populations. Nurse workers were observed attending both worker larvae and queen larvae, and there was no evidence of a specialized group of workers that preferentially or exclusively attended developing queens. Nevertheless, AQL attended larvae more frequently

compared to AWL, suggesting that nurses sampled attending queen larvae may have been the most active nurses. This study serves as another example of the relationship between differences in gene expression and behavioral specialisation in honey bees.

He, X. J., et al. (2017). "Making a queen: an epigenetic analysis of the robustness of the honeybee (*Apis mellifera*) queen developmental pathway." Molecular Ecology 26(6): 1598-1607.

Specialized castes are considered a key reason for the evolutionary and ecological success of the social insect lifestyle. The most essential caste distinction is between the fertile queen and the sterile workers. Honeybee (*Apis mellifera*) workers and queens are not genetically distinct, rather these different phenotypes are the result of epigenetically regulated divergent developmental pathways. This is an important phenomenon in understanding the evolution of social insect societies. Here, we studied the genomic regulation of the worker and queen developmental pathways, and the robustness of the pathways by transplanting eggs or young larvae to queen cells. Queens could be successfully reared from worker larvae transplanted up to 3 days age, but queens reared from older worker larvae had decreased queen body size and weight compared with queens from transplanted eggs. Gene expression analysis showed that queens raised from worker larvae differed from queens raised from eggs in the expression of genes involved in the immune system, caste differentiation, body development and longevity. DNA methylation levels were also higher in 3-day-old queen larvae raised from worker larvae compared with that raised from transplanted eggs identifying a possible mechanism stabilizing the two developmental paths. We propose that environmental (nutrition and space) changes induced by the commercial rearing practice result in a suboptimal queen phenotype via epigenetic processes, which may potentially contribute to the evolution of queen-worker dimorphism. This also has potentially contributed to the global increase in honeybee colony failure rates.

He, X.-J., et al. (2019). "A comparison of honeybee (*Apis mellifera*) queen, worker and drone larvae by RNA-Seq." Insect science 26(3): 499-509.

Honeybees (*Apis mellifera*) have haplodiploid sex determination: males develop from unfertilized eggs and females develop from fertilized ones. The differences in larval food also determine the development of females. Here we compared the total somatic gene expression profiles of 2-day and 4-day-old drone, queen and worker larvae by RNA-Seq. The results from a co-expression network analysis on all expressed genes showed that 2-day-old drone and worker larvae were closer in gene expression profiles than 2-day-old queen larvae. This indicated that for young larvae (2-day-old) environmental factors such as larval diet have a greater effect on gene expression profiles than ploidy or sex determination. Drones had the most distinct gene expression profiles at the 4-day larval stage, suggesting that haploidy, or sex dramatically affects the gene expression of honeybee larvae. Drone larvae showed fewer differences in gene expression profiles at the 2-day and 4-day time points than the worker and queen larval comparisons (598 against 1190 and 1181), suggesting a different pattern of gene expression regulation during the larval development of haploid males compared to diploid females. This study indicates that early in development the queen caste has the most distinct gene expression profile, perhaps reflecting the very rapid growth and morphological specialization of this caste compared to workers and drones. Later in development the haploid male drones have the most distinct gene expression profile, perhaps reflecting the influence of ploidy or sex determination on gene expression.

Horridge, A. (2000). "Pattern vision of the honeybee (*Apis mellifera*). What is an oriented edge?" Journal of Comparative Physiology 186(6): 521-534.

Pairs of black patterns on a white background, one rewarded the other not, were presented vertically each in one arm of a Y-maze. During training the locations of the black areas were changed every 5 min to prevent the bees using them as cues, but cues from edges were kept consistent. Bees detect orientation even in a gradient that subtends 36° from black to white (normal to the edge). Orientation cues in short lengths of edge are detected and summed on each side of the fixation point, irrespective of the lay-out of the pattern. Edges at right angles reduce the total orientation cue. The polarity of edges in a sawtooth grating is weakly discriminated, but not the orientation of a fault line where two gratings meet. Edge quality can be discriminated, but is not recognised in unfamiliar orientations. When spot location is excluded as a cue, the orientation of a row of spots or squares which individually provide no net orientation cue is not discriminated. In conclusion, when locations of black areas are shuffled, the bees remember the sum of local orientation cues but not the global pattern, and there is no re-assembly of a pattern based on differently oriented edges. A neuronal model consistent with these results is presented.

Horridge, A. (2014). "How bees distinguish black from white." Eye and Brain 6: 9-17.

Bee eyes have photoreceptors for ultraviolet, green, and blue wavelengths that are excited by reflected white but not by black. With ultraviolet reflections excluded by the apparatus, bees can learn to distinguish between black, gray, and white, but theories of color vision are clearly of no help in explaining how they succeed. Human vision sidesteps the issue by constructing black and white in the brain. Bees have quite different and accessible mechanisms. As revealed by extensive tests of trained bees, bees learned two strong signals displayed on either target. The first input was the position and a measure of the green receptor modulation at the vertical edges of a black area, which included a measure of the angular width between the edges of black. They also learned the average position and total amount of blue reflected from white areas. These two inputs were sufficient to help decide which of two targets held the reward of sugar solution, but the bees cared nothing for the black or white as colors, or the direction of contrast at black/white edges. These findings provide a small step toward understanding, modeling, and implementing in silicon the anti-intuitive visual system of the honeybee, in feeding behavior.Copyright © 2014 Horridge.

Horridge, A. (2015). "How bees distinguish colors." Eye and Brain 7: 17-34.

Behind each facet of the compound eye, bees have photoreceptors for ultraviolet, green, and blue wavelengths that are excited by sunlight reflected from the surrounding panorama. In experiments that excluded ultraviolet, bees learned to distinguish between black, gray, white, and various colors. To distinguish two targets of differing color, bees detected, learned, and later recognized the strongest preferred inputs, irrespective of which target displayed them. First preference was the position and measure of blue reflected from white or colored areas. They also learned the positions and a measure of the green receptor modulation at vertical edges that displayed the strongest green contrast. Modulation is the receptor response to contrast and was summed over the length of a contrasting vertical edge. This also gave them a measure of angular width between outer vertical edges. Third preference was position and a measure of blue modulation. When they returned for more reward, bees recognized the familiar coincidence of these inputs at that place. They cared nothing for colors, layout of patterns, or direction of contrast, even at black/white edges. The mechanism is a new kind of color vision in which a large-field tonic blue input must coincide in time with small-field phasic modulations caused by scanning vertical edges displaying green or blue contrast. This is the kind of system to expect in medium-lowly vision, as found in insects; the next steps are fresh looks at old observations and quantitative models.Copyright © 2015 Horridge.

Horridge, A. (2015). "How bees distinguish patterns by green and blue modulation." Eye and Brain 7: 83-107.

In the 1920s, Mathilde Hertz found that trained bees discriminated between shapes or patterns of similar size by something related to total length of contrasting contours. This input is now interpreted as modulation in green and blue receptor channels as flying bees scan in the horizontal plane. Modulation is defined as total contrast irrespective of sign multiplied by length of edge displaying that contrast, projected to vertical, therefore, combining structure and contrast in a single input. Contrast is outside the eye; modulation is a phasic response in receptor pathways inside. In recent experiments, bees trained to distinguish color detected, located, and measured three independent inputs and the angles between them. They are the tonic response of the blue receptor pathway and modulation of small-field green or (less preferred) blue receptor pathways. Green and blue channels interacted intimately at a peripheral level. This study explores in more detail how various patterns are discriminated by these cues. The direction of contrast at a boundary was not detected. Instead, bees located and measured total modulation generated by horizontal scanning of contrasts, irrespective of pattern. They also located the positions of isolated vertical edges relative to other landmarks and distinguished the angular widths between vertical edges by green or blue modulation alone. The preferred inputs were the strongest green modulation signal and angular width between outside edges, irrespective of color. In the absence of green modulation, the remaining cue was a measure and location of blue modulation at edges. In the presence of green modulation, blue modulation was inhibited. Black/white patterns were distinguished by the same inputs in blue and green receptor channels. Left-right polarity and mirror images could be discriminated by retinotopic green modulation alone. Colors in areas bounded by strong green contrast were distinguished as more or less blue than the background. The blue content could also be summed over the whole target. There were no achromatic patterns for bees and no evidence that they detected black, white, or gray levels apart from the differences in blue content or modulation at edges. Most of these cues would be sensitive to background color but some were influenced by changes in illumination. The bees usually

learned only to avoid the unrewarded target. Exactly the same preferences of the same inputs were used in the detection of single targets as in discrimination between two targets.Copyright © 2015 Horridge.

Horridge, G. A. (1997). "Pattern discrimination by the honeybee: disruption as a cue." Journal of Comparative Physiology 181(3): 267-277.

The discrimination of pattern disruption in freely flying honeybees (*Apis mellifera*) was examined. Bees were trained to discriminate at a fixed distance between a regularly repeated black/white pattern and the same pattern at a different magnification in targets of the same angular size. The locations of areas of black were regularly shuffled to make them useless as cues. The results of the experiments indicate that the bees discriminate the disruption of the pattern as a whole, irrespective of the actual pattern. Bees trained to prefer a larger period transfer to an even larger period, when given a forced choice with a pair of patterns of differing disruption from those they were trained on, as if their spontaneous preference has not been overcome. Bees trained to prefer a smaller period, however, prefer the former negative pattern rather than transfer to an even smaller period. These results show that the bees do not rely solely on learning the absolute period of a pattern nor the relative disruption of two patterns, and they are confused when these two cues conflict in tests with unfamiliar targets. Bees can discriminate between fields of view that differ in average disruption as a generalized cue, irrespective of pattern.

Horridge, G. A. (1999). "Pattern discrimination by the honeybee (*Apis mellifera*) is colour blind for radial/tangential cues." Journal of Comparative Physiology 184(4): 413-422.

Bees were trained to discriminate between two patterns, one of which was associated with a reward, in a Y-choice apparatus with the targets presented vertically at a distance at an angular subtense of 50°. Previous work with this apparatus has found discrimination between two patterns of coloured gratings or radial sectors that are fixed in different orientations during the training. When there was contrast to the blue receptors alone, gratings of period 6° were resolved, and 4° when there was contrast to the green receptors. In the present work, bees discriminate between a pattern containing tangentially arranged edges and one containing radially arranged edges, both with no average edge orientation. The targets were rotated every 5 min to make the locations of areas useless as cues. The edges remained consistently radial or tangential and were therefore the only cues. Tests with patterns of selected colours and various levels of grey show that for each colour there is a level of grey at which discrimination fails. Discrimination is therefore colour-blind. The same patterns were made with combinations of coloured papers that give no contrast to the green receptors or alternatively to the blue receptors. The bees discriminate only if the edges between colours present a contrast to the green receptors. The system that discriminates generalized radial and tangential cues is therefore colour blind because the inputs are restricted to the green receptors, not because receptor outputs are added together. The same result was obtained with a very coarse pattern of period 20°.

Horridge, G. A. (1999). "Pattern vision of the honeybee (*Apis mellifera*): the effect of pattern on the discrimination of location." Journal of Comparative Physiology 185(1): 105-113.

This paper investigates how the pattern influences the discrimination of different locations of two or more areas of black, white or colour. The coloured patterns were made from two calibrated coloured papers that give contrast only to green receptors, or alternatively only to blue receptors. The patterns are fixed during training. It is found that the discrimination of translocation of two areas of colour involves green receptors and also blue receptors, and the resolution depends strongly on the pattern. Patterns that offer horizontal strips and up-down differences in locations are well resolved, even with no green contrast. Resolution of left-right reversal is greatly improved when the patterns promote fixation in the horizontal plane, as if green contrast is essential to stabilize the eye in yaw. The addition of radial bars with green contrast, a central black spot or a black surround, is particularly effective. The additions promote fixation, and would aid the detection of natural symmetrical objects.

Houston, T. F. (1975). "Nests, behaviour and larvae of the bee Stenotritus pubescens (Smith) and behaviour of some related species (Hymenoptera: Apoidea: Stenotritinae)." Journal of the Australian Entomological Society 14: 145-154.

Nests, provisions, and second and last larval instars of Stenotritus pubescens are described for the first time. The nests were found aggregated in a soil slope in an arid region of S. Australia. Unlike those of other ground-nesting colletid bees, the 2 nests excavated had cemented upper shaft walls, blind lateral tunnels, complete absence of any cellophane-like linings, and moulded ovoid pollen masses resting in globules, possibly honey. Observations were made of flight activity, foraging behaviour, behaviour of males, and mating, and the behaviour of other

Stenotritus species in Australia.It is considered that stenotritine bees are misplaced in the family Colletidae.J. M. Gedye

Kayaalp, P. and M. P. Schwarz (2007). "Egg size and number is influenced by both environmental and social factors in a facultatively social bee." Australian Journal of Zoology 55(6): 357-362.

Social factors influencing the trade-off between egg size and number have been almost entirely neglected in studies of social insects. We examined egg size and number in an Australian allodapine bee where nutritional resource availability and social competition during egg laying vary over colony development. We hypothesised that during August queens should lay many eggs to provide work incentives for subordinates, but because resources are strongly limited these eggs will be small. In spring, resources are less limited but some subordinates also lay eggs, resulting in competition between offspring for communally provided food. Here, we hypothesised that females should attempt to direct resources preferentially to their own offspring by laying large eggs. We analysed egg numbers and weights as functions of colony size. We found that a trade-off existed in August nests but that egg size increased with egg number in October. In November, when larval eclosion was commencing, colonies with larvae had smaller mean egg weights than those with only eggs, suggesting that resources are directed away from oviposition towards larval provisioning. Our analyses suggest that egg size is a function of egg number, rather than colony size per se.

Keith, D. G. (1988). "Collection, storage and feedback of pollen." Australasian beekeeper 90(4): 162-164.

At Inglewood, Queensland, Australia, autumn pollen flows are nutritionally deficient, so pollen is trapped in the spring during the pollen flow from wild turnip, Rapistrum rugosum. Preparation of colonies is described; about 6 kg is harvested from each colony. The pollen is kept in a deep freeze and then fed back to the bees in autumn while colonies are still strong. Each colony is given about 300 g per week for 6 weeks; the pollen is placed on a sheet of plastic spread over the top of the frames in the top super, with a gap for the bees to come up. They take the pellets readily, though for weak colonies it may be better to powder the pollen.

Kemp, R. (1985). "New Zealand bees... disease-free alternative?" Skeptic 4(6): 9-9.

Discusses possibility of importing queens and package bees to Canada from New Zealand.

Kersell, A. C. and R. C. Burking (1983). "Western Australia's beekeepers' reserves." Journal of Agriculture - Western Australia 24(3): 100-101.

An extensive area of land in Western Australia has been allotted to the conservation of flora for beekeeping.

Kleinschmidt, G. J. (1982). "Feeding and populations." Australasian beekeeper 84(5): 87-91.

This paper, presented at the 1982 Queensland and NSW (Australia) annual conferences, reviews past and present research by the author and colleagues on the effects of nutrition and other factors on colony population. [See e.g. AA 800/75, 1099/76, 1360/79, 222/81.]P. Walker

Kleinschmidt, G. J. (1985). "Building large hive populations." Australasian beekeeper 87(4): 76-89.

This paper presents and discusses procedures (and the biological facts on which they are based) for intensive management by a beekeeper with 600 hives in typical Queensland (Australia) conditions. The main nectar flow is in November-January. The aim is to get 4-5 supers on each hive filled with honey, giving a yield of 100-125 kg/colony. The steps necessary for building up a large population are listed month-by-month. Apart from any requeening, which is done in March, and feeding and disease control during the winter, the beekeeper starts brood manipulations when pollen is available and brood areas are expanding (September). When the nectar flow is strong and the first 2 supers are being filled, 2 more empty supers are added below them, i.e. directly above the brood chamber. A schematic diagram shows the field, hive and management factors that affect production and how they interact with each other.P. Walker.

Kleinschmidt, G. J. (1988). "Feeding and populations." Australian bee journal 69(1): 8-12.

Some research and current projects at the Queensland Agricultural College are reviewed briefly. The subjects covered are: determination of honeybee colony population level that is optimal for honey production;

management for optimal population, including feeding with sugar syrup and/or pollen (or pollen supplements) when necessary. Current research includes field trials with various pollen supplements.P. Walker.

Koulianos, S. and R. H. Crozier (1991). "Two ancient mitochondrial alleles in Australian honeybees." Apidologie 22(6): 621-626.

Sequence information (363 bases) was obtained, following polymerase chain reaction amplification, for portions of the ATPase-6 and CO-III mitochondrial genes in bees from 8 hived and 2 feral colonies from various parts of Australia. Only 2 alleles were found, differing by 6 base substitutions. The degree of nucleotide divergence observed (> 2%) suggests that divergence must have occurred well before honey bees inhabited Europe. The investigated bees were identified as either *Apis mellifera* caucasica or A. m. ligustica.

Koulianos, S. and R. H. Crozier (1997). "Mitochondrial sequence characterisation of Australian commercial and feral honeybee strains, *Apis mellifera* L. (Hymenoptera: Apidae), in the context of the species worldwide." Australian Journal of Entomology 36(4): 359-364.

The history of honeybee (*Apis mellifera*) importations and management in Australia is largely anecdotal and therefore a survey and characterization of this agriculturally important insect is of value. We give information on the genetic composition of 42 feral and commercial strains by sequencing sections of the ATPase 6, cytochrome oxidase III, cytochrome b and ND2 mitochondrial genes to determine the relationship of the strains to each other. Our phylogenetic analysis shows novel associations between A. m. mellifera, A. m. scutellata, A. m. ligustica and A. m. caucasica.

Kuhnert, M. E., et al. (1989). "Use of homogenized drone semen in a bee breeding program in Western Australia." Apidologie 20(5): 371-381.

Homogenized semen from a large number of drones was used in a breeding programme. During 5 years, insemination success averaged 85%. On average queens started to lay eggs 4.35 days after insemination. Over 4 years, brood viability ranged from 88 to 94% and colonies built up quickly. Honey production averaged 115 kg/colony in 1986 and 109 kg/colony in 1987. The lifespans of queens used in this study were not appreciably different from those previously reported for queens inseminated with non-homogenized semen.

Lamont, P. (1983). "Genetic improvement of honey bees through commercial breeding." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 221-229.

Langridge, D. F. (1974). "Crithidia mellificae of the honey bee." HARNAJ, V. (ED.). APIMONDIA SCIENTIFIC BULLETIN, 1972. SYMPOSIA. 1972. 535P. ILLUS. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 413-415.

Lew, Y. and C. Kim (1991). "Questionnaire survey on imported package bees from Australia." Korean Journal of Apiculture 6(2): 95-105.

Package honey bees (*Apis mellifera*) which were imported from Australia to Korea in 1991 were considered satisfactory by beekeepers replying to a questionnaire. Performance after hiving, honey-gathering capacity and temperament (docility) were good, but there were a few problems with resistance against disease and wintering ability.

Lowe, E. C., et al. (2011). "Worker heterozygosity and immune response in feral and managed honeybees (*Apis mellifera*)." Australian Journal of Zoology. 59(2): 73-78.

Genetic diversity in workers influences colony immunity in several species of eusocial insects. Much less work has been conducted to test for comparable effects of worker heterozygosity, a measure of genetic diversity within an individual. Here we present a field study using the honeybee (*Apis mellifera*) and sampled foraging workers throughout Western Australia. Samples were taken from feral and managed colonies, aiming to maximise the variation in worker and colony heterozygosity. We quantified worker heterozygosity using microsatellites, and tested the idea that individual worker heterozygosity predicts immune response, measured as the enzymatic activity of an antimicrobial peptide phenoloxidase (PO) and encapsulation response. We found substantial variation in worker heterozygosity, but no significant effects of heterozygosity on PO activity or encapsulation response, either on the

individual or colony level. Heterozygosity was found to be higher in workers of feral colonies compared with managed colonies. Colonies kept in husbandry, as compared with colonies from the field, had significantly higher levels of PO activity and encapsulation response, providing evidence for substantial environmental effects on individual and colony immunity.

Maeda, M., et al. (2018). "The complete mitochondrial genome of the dusky brown-gray-colored honeybee, *Apis mellifera* (insecta: Hymenoptera: Apidae) of New Zealand." Mitochondrial DNA Part B-Resources 3(2): 996-997.

We analyzed the complete mitochondrial genome of the dusky brown-gray-colored honeybee *Apis mellifera*, collected from North Island, New Zealand. We determined that the mitochondrial genome was a 16,336bp and predicted 13 protein-coding genes (PCGs), 22 tRNA genes, and two rRNA genes. The start codon ATA was found in two genes, ATG in four genes, ATT in six genes, and ATC in one gene, whereas the termination codon TAA was observed in all PCGs. The non-coding regions of tRNA-Leu and COII were consistent with the C haplotype of *A. mellifera* carnica. Phylogenetic analysis suggests a close relationship with the European *A. mellifera*.

Maleszka, R. (2018). "Beyond Royalactin and a master inducer explanation of phenotypic plasticity in honey bees." Communications Biology 1(1).

Distinct female castes produced from one genotype are the trademark of a successful evolutionary invention in eusocial insects known as reproductive division of labour. In honey bees, fertile queens develop from larvae fed a complex diet called royal jelly. Recently, one protein in royal jelly, dubbed Royalactin, was deemed to be the exclusive driver of queen bee determination. However, this notion has not been universally accepted. Here I critically evaluate this line of research and argue that the sheer complexity of creating alternate phenotypes from one genotype cannot be reduced to a single dietary component. An acceptable model of environmentally driven caste differentiation should include the facets of dynamic thinking, such as the concepts of attractor states and genetic hierarchical networks.In honeybees, genotypically identical females develop into queens or sterile workers, depending on their diets. In this review, Ryszard Maleszka discusses the controversial role of the royal jelly protein Royalactin in caste determination and provides a framework for moving beyond the master inducer concept.

Manning, R. (1990). "Environmental factors affecting queen bee matings at Rottnest Island." Australasian beekeeper 92(3): 114-116.

This island, which is west of Perth, W. Australia, has no feral honey bees and is used as a controlled mating station. For queens hatching on 11 different dates from September to December, their mating success (MS, i.e percentage that mated) ranged from 34.2 to 81.7%. For 6 of the dates, queens at a mainland mating station had from 71.0 to 89.5% MS. Weather conditions were recorded on the island during the study. The only significant correlation was a negative one between MS and rainfall 2 days after queens hatched. Although other correlations were not significant, the following may have had some effect on MS: wind speed on day 2, cloud cover and rainfall on day 3, rainfall on day 7, and cloud cover on day 8. Temperature apparently had no effect.

Manning, R. (1994). "Honey production from managed feral bee colonies." Australasian beekeeper 96(3): 110-112.

Honey bee (*Apis mellifera*) colonies were established in Western Australia using daughter queen bees reared from colonies collected from the wild (F) and queens reared as part of a bee breeding programme (BP). The F queens were open-mated in an area with a high population of feral stock and the BP queens raised from breeding programme stock and artificially inseminated with homogenized semen taken from the previous year's breeding trial. Colonies were established with 2 frames of honey and 4 of brood and moved to a light-medium nectar flow, and later to another light flow and then a heavy flow. All colonies were managed in the same way, and additional supers added to each hive as necessary. BP colonies produced significantly ($P < 0.05$) more honey than F colonies: 22% on a light nectar flow and 17% more on a heavy nectar flow. Survival of BP queens was significantly ($P < 0.05$) lower than for F queens (89% vs. 100% for light nectar flows, 93% vs. 100% for heavy nectar flows). The study confirms the benefits of programmed requeening with selected stock.

Manning, R. (1996). "Evaluation of an eleven year queen bee breeding program in Western Australia." Australasian beekeeper 97(8): 317-317.

Queens produced by instrumental insemination in the breeding programme described by Kuhnert et al. [Apidologie (1989) 20 (5) 371-381] have been evaluated. Honey production was recorded over 218 days (including 2

nectar flows) in 40 colonies belonging to beekeepers who regularly obtained queens from the programme. The average honey yield was 34% higher than in 40 control colonies (headed by queens from commercial sources).

Manning, R. (1996). "Evaluation of the Western Australian queen bee breeding program." Australian journal of experimental agriculture. 36(4): 513-518.

Manning, R. J. G. and A. Agriculture Western (1996). "Packaged honey bees."

Masterman, J. (1978). "The struggle to ensure queens are purely mated." Australasian beekeeper: 18-20.

Matheson, A. and N. Wallingford (1988). "New Zealand beekeeping - an industry profile." New Zealand beekeeping - an industry profile.: 29-pp.

Profiles of 3 'typical' New Zealand beekeepers preface an analytical description of the New Zealand beekeeping industry. The industry's chief products and services are: honey, with 10 091 t produced in 1986-87; pollination - crops reliant on bee pollination are worth over NZ$500 million p.a.; and bees, with exports of packages and queens worth over NZ$600 000 in 1986-87. Over 70 t of beeswax were exported in 1987-88, but only small quantities of pollen, royal jelly and propolis are produced, mainly to supply local market requirements. Statistics are given for the size of the industry and categories of beekeepers, and the names, functions and activities of various organizations are described. Relevant legislation is also listed. The 8 appendices give apiary and hive statistics by district, honey production, honey exports, production of other hive products, AFB incidence, overseas 'threats', contact names and addresses, and further sources of information.^CENTREQUAD~D. G. Lowe.

Michener, C. D. (1973). "Size and form of eggs of allodapine bees." Journal of the Entomological Society of Southern Africa 36(2): 281-285.

Eggs of allodapine bees from Africa and Australia are illustrated. Egg size was found not to be related to social level but to laying rate. Genera which mass-provision each egg before laying the next (Ceratina, Xylocopa, Halterapis) had an egg-length to body-length ratio (E/B) of 0.4-0.6. For bees which laid eggs at considerable intervals, with usually only one developing egg per ovariole (Braunsapis, Exoneurella, Macrogalea, Allodape, Nasutapis) E/B was at least 0.3. For those laying eggs in rapid succession and with 2-3 developing eggs per ovariole (Allodapula, Exoneura) E/B was less than 0.3.J.M. Gedye

Moller, H. and V. Butz Huryn (1996). "Beekeeping and conservation values of protected natural areas. A contract report (Project 853) for the Department of Conservation." Wildlife Management Report - University of Otago(51): 166-pp.

The New Zealand Department of Conservation (DOC) has adopted a flexible policy to beekeeping in conservation areas. Interim guidelines allow hive stocking rates of up to 30 hives per site at sites at least 1.6 km apart. A survey showed that only 2036 hives are kept in protected natural areas in New Zealand and there is little demand for establishing new apiary sites in these areas. A review of the literature showed that honey bees (*Apis mellifera*) forage on 224 native plant taxa, but only a small proportion are used intensively. Overall there is no quantified evidence that New Zealand native plants are being positively or negatively influenced by honey bee foraging. There are few potential effects on fauna using the same plant resources. Honey bees may be effective pollinators of certain weed species, but there is no evidence to indicate that lack of pollination by honey bees would limit weed populations. A survey of bellbird (Anthornis melanura) and tui (Prosthemadera novaeseelandiae) abundance and behaviour and honeydew standing crops in a beech (Nothofagus) forest near Nelson for over 5 years showed that wasps (Vespula spp.) dramatically reduced the honeydew standing crop in late summer and autumn. The need to control wasp populations is urgent. Feral honey bee colonies are at relatively low abundances and are unlikely to seriously affect the honeydew resource. In Canterbury forests, where most beekeeping occurs, the median estimate of honeydew intake by honey bee colonies predicts a reduction of honeydew standing crop by a maximum of 57%, which is much less than that required for honeyeaters (Meliphagidae) to alter their behaviour. Hive density recommendations by the DOC therefore adequately protect birds from competition for honeydew in almost all honeydew forests. It is concluded that reserve damage from beekeeping is negligible. Any short term deleterious effects can be rectified by simply removing the hives, and there is no reason to restrict beekeeping in conservation areas beyond the current flexible and pragmatic measures.

Moran, C. and B. P. Oldroyd (1983). "Genetic improvement of honeybees in closed populations." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 230-240.

Nakagawa, I., et al. (2018). "The complete mitochondrial genome of the yellow coloured honeybee *Apis mellifera* (Insecta: Hymenoptera: Apidae) of New Zealand." Mitochondrial DNA Part B 3(1): 66-67.

The complete mitochondrial genome of the yellow coloured honeybee *Apis mellifera* from North Island, New Zealand was analyzed using next-generation sequencing. The mitochondrial genome was a 16,349 bp circular molecule and was predicted to contain 13 protein-coding genes (PCGs), 22 tRNA genes and two rRNA genes. The initiation codon ATA was found in two genes, ATG in four genes, ATT in six genes, and ATC in one gene, while the termination codon TAA was observed in all the PCGs. Phylogenetic analysis using the sequence of 23 closely related taxa suggested a sister relationship with the Italian strain *A. mellifera* ligustica.

Nelson, D. L. (1975). "An evaluation a cross between New-Zealand and California USA honey bee stocks." American bee journal 115(6): 228-229.

Nelson, D. L. (1975). "An evaluation: a cross between New Zealand and California honeybee stocks." American bee journal.: 228-228.

Nunes, T. M., et al. (2015). "Emergency queens in Tetragonula carbonaria (Smith, 1854) (Hymenoptera: Apidae: Meliponini)." Austral Entomology 54(2): 154-158.

There is increasing interest in the management of stingless bees for crop pollination, honey production and recreational beekeeping. Colony propagation is based on the division of one colony into two smaller colonies. The process generates a queenless colony and requires that the new colony is successful in the production of a new queen. Three different mechanisms by which female larvae develop as queens have been described for stingless bees: (1) genetic determinism with no differentiation in the cells used for rearing queens and workers; (2) queen development is determined by large queen cells; and (3) queen cells are formed by the fusion of two worker-sized brood cells. Colonies of species that utilise specially constructed queen cells cannot be divided artificially unless there are queen cells present at the time of splitting. Here, we show that queenless colonies of the Australian stingless bee Tetragonula carbonaria (Smith, 1854) can construct queen cells by the fusion of two worker-sized cells. This phenomenon is unknown from any other stingless bee species with a spiral brood comb. It has the practical benefit that beekeepers can divide hives even when there are no queen cells present. Finally, it is shown that T.carbonaria workers remain completely sterile in queenless colonies.

O'Brien, L. C. (1988). "Demaree usage for arid and semi-arid areas of Australia." Australasian beekeeper 90(1): 21-23.

With a programme based on the use of nucleus colonies, honey production can be increased by 50% or more. To achieve the best results, 2 batches of nuclei are used during a season; in arid or semi-arid areas of NSW the best times have been found to be September/October and February/March. When the programme is started there must be a good nectar flow and a wide variety of pollens available so that colonies can develop rapidly. The queen cells to be used can be reared from a selected queen or obtained commercially. Details of the procedure are described and advantages and disadvantages are mentioned.^CENTREQUAD~ P. Walker.

Oldroyd, B. and C. Moran (1982). "Hawkesbury Agricultural College Apiary Section. Research progress report." Australasian beekeeper 84(6): 116-119.

Research on bee breeding and genetics.

Oldroyd, B. and C. Moran (1983). "The detection of genetic defects of honeybees (Particularly Africanisation) in imported queens." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 89-99.

Oldroyd, B. and C. Moran (1983). "Genetic improvement of honeybees by laboratory testing." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 210-219.

Oldroyd, B. (1987). "Detection of "Africanization" in imported queens." Australasian beekeeper 89(1): 6-10.

It is suggested that if Africanised bees ever became established in Australia, they would probably spread throughout the country, except in the highlands of the south-east. The risk of such an occurrence could be reduced by banning imports of queens from areas where Africanised bees are, or may be, present. Reasons for continuing queen imports are discussed. Under present import regulations, permits for queens are required; also, the progeny of any queen from a 'suspect' overseas area (N. America) are subjected to morphometric analysis to determine the race of the queen. It is considered that the risk of Africanised bees becoming established in Australia is very slight.

Oldroyd, B., et al. (1995). "Colony aggregations in *Apis mellifera* L." Apidologie 26(2): 119-130.

To date, natural aggregations of A.mellifera nests have not been reported, although they are known to be common in A. dorsata. A survey of the spatial distribution of 27 feral *A. mellifera* colonies in a national park in Victoria, Australia, showed that they were markedly clumped, with up to 10 colonies/ha. Genetic analysis of these colonies showed that some queens were potentially related and others were not. Several other observations of aggregations of *A. mellifera* colonies are mentioned, and hypotheses to explain them are discussed.

Oldroyd, B. P. (1988). "Genetic improvement for New Zealand beekeeping." New Zealand beekeeper(198): 12-15.

This article, which is based on a short series of lectures, explains first the aims and principles of honeybee breeding. Problems that have to be overcome include inbreeding, and the difficulty of controlling mating. The use of discriminant function analysis to classify races of honeybees is explained, as well as the effect of crossing two races of bees. The advantages and disadvantages of importing new races or lines of honeybees into New Zealand is discussed briefly. ^CENTREQUAD~ P. Walker.

Oldroyd, B. P., et al. (1995). "Racial admixture of *Apis mellifera* in Tasmania, Australia: Similarities and differences with natural hybrid zones in Europe." Heredity 74(3): 315-325.

Feral and domesticated honey bees were collected across the island state of Tasmania, Australia, and typed for malate dehydrogenase and a mitochondrial DNA polymorphism. They were also compared morphometrically with reference specimens of *Apis mellifera* ligustica and A. m. mellifera from Europe. These measures were correlated with temperature and elevation. In warmer coastal regions, the two subspecies readily hybridize and most samples showed evidence of considerable hybridization. In cooler mountain regions, there is much less hybridization, with the A. m. mellifera subspecies characteristics strongly predominating. There is no evidence for cytonuclear incompatibilities between these subspecies or for clines caused by direct selection. We hypothesize that A. m. ligustica and F-1 hybrids have lower fitness than A. m. mellifera in cooler regions, and that there may be assortative mating in cooler regions only. The significance of these results for the understanding of honey bee hybrid zones in Europe is discussed.

Oldroyd, B. P., et al. (1994). "Anarchy in the beehive." Nature (London) 371(6500): 749-749.

A honey bee colony [*Apis mellifera*] from Queensland, Australia, was normal except that most of the drone-sized cells above a queen excluder contained drone brood. Examination of DNA from 49 of the drone pupae and from worker brood (from below the excluder) showed the following: (A) the queen had mated with at least 12 drones; (B) 48 of the drones examined were the offspring of at least 3 workers, which were most probably from a single patriline. It is concluded that this 'anarchistic behaviour' is genetically determined: one of the drones (A) passed to worker offspring an ability to evade the colony's policing mechanism (worker-laid eggs are usually destroyed by other workers).

Oldroyd, B. P. and J. A. Stelzer (1992). "Genetic characterization of the bees of Kangaroo Island, South Australia." Journal of Apicultural Research 31(3-4): 141-148.

On Kangaroo Island, South Australia, an introduced population of *Apis mellifera* ligustica has reputedly not hybridized with other *A. mellifera* subspecies due to isolation. Bees were collected from each of 24 Kangaroo Island

colonies to confirm their subspecies. Electromorph relative frequencies for the Kangaroo Island population were: malate dehydrogenase enzyme system, Mdh65 = 0.13, Mdh80 = 0.11 and Mdh100 = 0.76; esterase system, Est100 = 0.95, and Est130 = 0.05. Such frequencies are similar to A. m. ligustica populations from southern Italy, but dissimilar to populations from northern Italy. Morphology of Kangaroo Island bees is similar to A. m. ligustica reference specimens. Mitochondrial DNA restriction mapping suggested that the Kangaroo Island population is of A. m. mellifera origin. It is concluded that available reference material is inadequate to conclusively determine the racial origin of the Kangaroo Island population, but that recent hybridization has not occurred. © 1992 International Bee Research Association.

Owen, R. (2015). "The Australian beekeeping manual." The Australian beekeeping manual.

The book is aimed at both the novice and experienced beekeeper in Australia and explains in detail the steps required to manage colonies of bees. Supported by over 350 photographs and drawings, each action to be performed is explained in detail with photographs showing the steps as well as the final result. In addition to chapters on keeping bees, there are detailed chapters on the life cycle of the honey bee, extracting honey, the bee-friendly garden, entering honey in competitions, native bees and rearing queens. The result is a comprehensive manual that includes material not available in other Australian, North American or European books and is the ultimate Australian reference source.

Oxley, P. R. and B. P. Oldroyd (2009). "Mitochondrial Sequencing Reveals Five Separate Origins of 'Black' *Apis mellifera* (Hymenoptera: Apidae) in Eastern Australian Commercial Colonies." Journal of economic entomology. 102(2): 480-484.

Establishment of a closed population honey bee, *Apis mellifera* L. (Hymenoptera: Apidae), breeding program based on 'black' strains has been proposed for eastern Australia. Long-term success of such a program requires a high level of genetic variance. To determine the likely extent of genetic variation available, 50 colonies from 11 different commercial apiaries were sequenced in the mitochondrial cytochrome oxidase I and II intergenic region. Five distinct and novel mitotypes were identified. No colonies were found with the *A. mellifera* mellifera mitotype, which is often associated with undesirable feral strains. One group of mitotypes was consistent with a caucasica origin, two with carnica, and two with ligustica. The results suggest that there is sufficient genetic diversity to support a breeding program provided all these five sources were pooled.

Oxley, P. R. and B. P. Oldroyd (2009). "Reveals Five Separate Origins of 'Black' *Apis mellifera* (Hymenoptera: Apidae) in Eastern Australian Commercial Colonies." Journal of economic entomology. 102(2): 480-484.

Establishment of a closed population honey bee, *Apis mellifera* L. (Hymenoptera: Apidae), breeding program based on 'black' strains has been proposed for eastern Australia. Long-term success of such a program requires a high level of genetic variance. To determine the likely extent of genetic variation available, 50 colonies from 11 different commercial apiaries were sequenced in the mitochondrial cytochrome oxidase I and II intergenic region. Five distinct and novel mitotypes were identified. No colonies were found with the *A. mellifera* mellifera mitotype, which is often associated with undesirable feral strains. One group of mitotypes was consistent with a caucasica origin, two with carnica, and two with ligustica. The results suggest that there is sufficient genetic diversity to support a breeding program provided all these five sources were pooled.

Page, J. R. and C. Roff (1978). "Beekeepers can improve their honey extraction system." Australasian beekeeper 79(9): 173-176.

The advantages of installing a centrifuge system for cappings are discussed, and the economics of operating such a system are compared with those of extracting by straining, which involves some honey wastage. In a 700-hive apiary in Queensland, a centrifuge was found to give a good return on investment. P. Walker

Palmer-Jones, T. (1968). "Nectar from karaka trees poisonous to honey bees." New Zealand Journal of Agriculture 117(2): 77-77.

The nectar of the karaka (Corynocarpus laevigata), an ornamental indigenous tree widely distributed in the North Island, is toxic to adult bees. It does not kill the brood as well, unlike the California buckeye (Aesculus californica) and locoweeds (Astragalus sp.) of the USA, which also produce poisonous nectar. Destruction of karakas

would not be feasible or warranted so it is recommended that apiaries should be re-sited or moved out of bee range of karakas during their flowering period, August to December. -D.B.

Pankiw, P. (1969). "New Zealand honey bees." 5-5.

Pankiw, P. (1969). "New-Zealand queen evaluation." American bee journal 109(5): 184-184.

Pankiw, T., et al. (1994). "Variation in worker response to honey bee (*Apis mellifera* L.) queen mandibular pheromone (Hymenoptera: Apidae)." Journal of Insect Behavior 7(1): 1-15.

Genetic and environmental influences on the worker honey bee retinue response to queen mandibular gland pheromone (QMP) were investigated. Worker progeny were reared from queens originating from four sources: Australia, New Zealand, and two locations in British Columbia, Canada (Simon Fraser University and Vancouver Island). Progeny from New Zealand queens responded significantly higher (P lt 0.05) than progeny from Australia in a QMP retinue bioassay. Retinue response was not related to queen production of pheromone or colony environment, and the strain-dependent differences in retinue bioassay responses were maintained over a wide range of dosages. Selected high- and low-responding colonies were bioassayed over the course of 1 year. High-responding colonies contacted QMP lures more frequently than low-responding colonies (P lt 0.05) throughout the year except in late summer. We conclude that there is a strong genetic component to QMP response by worker honey bees, as well as a seasonal effect on response.

Patsavee, U., et al. (2019). "Estimating the density of honey bee (*Apis mellifera*) colonies using trapped drones: area sampled and drone mating flight distance." Apidologie 50(4): 578-592.

Reliable information on Western honey bee colony density can be important in a variety of contexts including biosecurity responses, determining the sufficiency of pollinators in an agroecosystem and in determining the impacts of feral honey bees on ecosystems. Indirect methods for estimating colony density based on genetic analysis of sampled males are more feasible and cost efficient than direct observation in the field. Microsatellite genotypes of drones caught using Williams drone trap are used to identify the number of colonies (queens) that contributed drones to a mating lek. From the number of colonies, the density of colonies can be estimated based on assumptions about the area from which drones are drawn. This requires reliable estimates of drone flight distance. We estimated average minimum flight distance of drones from feral colonies along two 7-km transects in Southern NSW, Australia. We found that drones from feral colonies flew at least 3.5 km to drone traps. We then determined that the maximum distance that drones flew from a focal colony to a trap was 3.75 km. We conclude that a drone trap samples an area of 44 km2, and that this area should be used to convert estimated colony numbers to colony densities. This area is much greater than has been previously assumed. The densities of honey bee colonies in Grong Grong and Currawarna, NSW, are 1.38–2.73 and 1.31–3.06 colonies/km2 respectively.

Penm, J. (2007). "Improvement of beehive management practices in biology using kernel-based subset vector autoregressive modelling." International Journal of Services Technology and Management 8(4/5): 389-389.

Honey production in Australia is worth about $50 million a year, with the value of pollination being estimated at between $600 million and $1.2 billion a year. Other bee products such as wax and queen rearing earn about $65 million a year, much of that in export earnings. With reference to current circumstances of reduced production because of the prolonged drought, examination of this industry is crucial as it appears that Australia may be able to increase profitability by improving beehive management practices. In this paper we propose a kernel-based vector recursive algorithm to sequentially estimate subset vector autoregressive models (including full-order models). We apply this algorithm to test the direct causal relationships between the population of honeybee foragers and foraging types gathering nectar, pollen or water. The findings suggest that we may be able to predict the optimal conditions at any time to maximise the honey yield of colonies. [PUBLICATION ABSTRACT]

Petersen, G. (2018). "Applications for molecular breeding tools in honeybee populations." Journal of Animal Science 96(Suppl. 3): 121-122.

Petersen, G. E. L., et al. (2019). "Trait development for *Apis mellifera* in commercial beekeeping in New Zealand." Proceedings of the 23rd Conference of the Association for the Advancement of Animal Breeding and Genetics (AAABG), Armidale, New South Wales, Australia, 27th October-1st November 2019: 398-401.

Honeybee populations have been modified for centuries by selection and culling, but traditional selection criteria are no longer sufficient to address the needs of modern beekeeping and to counter threats such as spread of disease. While evaluating selected honeybee traits for their relevance and measurability in commercial beekeeping and their presumed heritability and their scale of variation, we encountered a dichotomy in the requirements of small-scale hobbyist beekeepers and large-scale commercial beekeeping operations. A number of traditional traits feasible for selection under commercial conditions could be identified, eight out of which can be considered high-priority traits in the design of an industry-wide honeybee breeding objective: honey production, gentleness, colony strength, brood viability, wintering ability and disease resistance. However, the costs of hive evaluations are often prohibitive to implementation of breeding and selection schemes in commercial operations. This can be overcome with the deployment of remote beehive monitoring equipment that provides continuous observations on colony status in conjunction with Machine Learning tools to evaluate change in trait expression in different environmental conditions. Simultaneously, image analysis and hive telemetry provide opportunities for the definition of novel traits such as nectar reactivity or the pattern of honey deposition. Using these recent technological advances, bee breeding can be made accessible to large-scale commercial beekeepers as well as dedicated small-scale queen breeders.

Petersen, G. E. L., et al. (2020). "Genotyping-by-sequencing of pooled drone DNA for the management of living honeybee (*Apis mellifera*) queens in commercial beekeeping operations in New Zealand." Apidologie 51(4).

The absence of a full pedigree can hinder selective breeding efforts. In honeybees, definitive maternity and especially paternity of queens is difficult to determine, even under managed mating schemes (e.g. using artificial insemination) due to the negative effects of single-drone mating on colony fitness. Here we genotyped 388 living queens from two beekeeping operations using Genotyping-by-Sequencing (GBS). We evaluate two methods to call single-nucleotide polymorphism (SNPs), Tassel 5 and Stacks, for their ability to supply SNPs that can recover known relationships. While Stacks discovered more SNPs (29,433), SNPs called with Tassel 5 (16,757) were found to be more accurate for the derivation of relationships. This methodology presents a low-cost genotyping approach and can be used to support commercial honeybee breeding schemes.

Phillips, C. (2014). "Following beekeeping: More-than-human practice in agrifood." Journal of rural studies. 36(36): 149-159.

Ongoing losses of pollinators challenge agrifood futures and highlight the need to examine beekeeping practices, and yet social sciences have little to say on the subject. This paper takes beekeeping, a fundamental if often overlooked aspect of contemporary agrifood production, as its subject. Beekeeping is examined through a combination of more-than-human studies and social practice theory, literatures with which agrifood scholars have yet to widely engage. The paper outlines connections and tensions between these fields, to develop a vital approach to more-than-human practice. The potential of such an approach is illustrated through ethnographic investigation of commercial beekeeping in Australia. Beekeeping is followed through three constituent activities: setting fruit; shifting hives; and, chasing honey. This exploration reveals shifting agency among practitioners, frictions among considerations of the practice and its practitioners, and new dis/connections among commodities, agendas, and places. This approach to contemporary beekeeping indicates other possible points of intervention important to future practice, with wider implications for agrifood production and research.

Pyke, G. (1983). "Australian Museum Report, Section 13. Page 45. Management of honeybees Kosciusko National Park." Australasian beekeeper 84(12): 249-251.

Several recommendations are made concerning the limitation of apiaries in order to reduce populations of honeybees in areas of Australia where they could cause serious reduction or even extinction of native bee populations by competing for floral resources. Methods for implementing the recommendations are also given.P. Walker.

Qin, Q.-H., et al. (2014). "The integrative analysis of microRNA and mRNA expression in *Apis mellifera* following maze-based visual pattern learning." Insect science 21(5): 619-636.

The honeybee (*Apis mellifera*) is a social insect with strong sensory capacity and diverse behavioral repertoire and is recognized as a good model organism for studying the neurobiological basis of learning and memory. In this study, we analyzed the changes in microRNA (miRNA) and messenger RNA (mRNA) following maze-based visual learning using next-generation small RNA sequencing and Solexa/Illumina Digital Gene Expression tag profiling (DGE). For small RNA sequencing, we obtained 13 367 770 and 13 132 655 clean tags from the maze and control groups, respectively. A total of 40 differentially expressed known miRNAs were detected between these two samples, and all of them were up-regulated in the maze group compared to the control group. For DGE, 5 681 320 and 5 939 855 clean tags were detected from the maze and control groups, respectively. There were a total of 388 differentially expressed genes between these two samples, with 45 genes up-regulated and 343 genes down-regulated in the maze group, compared to the control group. Additionally, the expression levels of 10 differentially expressed genes were confirmed by quantitative reverse transcription polymerase chain reaction (qRT-PCR) and the expression trends of eight of them were consistent with the DGE result, although the degree of change was lower in amplitude. The integrative analysis of miRNA and mRNA expression showed that, among the 40 differentially expressed known miRNAs and 388 differentially expressed genes, 60 pairs of miRNA/mRNA were identified as co-expressed in our present study. These results suggest that both miRNA and mRNA may play a pivotal role in the process of learning and memory in honeybees. Our sequencing data provide comprehensive miRNA and gene expression information for maze-based visual learning, which will facilitate understanding of the molecular mechanisms of honeybee learning and memory. Copyright © 2013 Institute of Zoology, Chinese Academy of Sciences.

Qiu-Hong, Q., et al. (2019). "The capping pheromones and putative biosynthetic pathways in worker and drone larvae of honey bees *Apis mellifera*." Apidologie 50(6): 793-803.

In honey bees (*Apis mellifera*), methyl palmitate (MP), methyl oleate (MO), methyl linoleate (ML), and methyl linolenate (MLN) are important pheromone components of the capping pheromones triggering the capping behavior of worker bees. In this study, we compared the amounts of these four pheromone components in the larvae of workers and drones, prior to be capped, in the process of being capped and had been capped. The amounts of MP, MO, and MLN peaked at the capping larval stage, and ML was highest at capped larvae in worker larvae, whereas in drone larvae, the amounts of the four pheromone components were higher overall and increased with aging. Furthermore, we proposed de novo biosynthetic pathways for MP, MO, ML, and ML, from acetyl-CoA. Besides, stable isotope tracer 13C and deuterium were used to confirm that these capping pheromone components were de novo synthesized by larvae themselves rather than from their diets.

Reid, M. (1979). "Requeening honeybee colonies without dequeening using protected queen cells." New Zealand beekeeper 40(3): 15-17.

This technique was reported in AA 209/79. The method used is now described in detail, and results are given, with special reference to management in New Zealand. P. Walker

Reid, M. (1990). "MAF quality management report." New Zealand beekeeper(207): 22-25.

This report gives beekeeping statistics (as at 31 May 1990) and honey production (from 1985 to 1990) for districts of New Zealand. Export figures for honey and beeswax, and for the incidence of AFB, are also given.

Remnant, E. J., et al. (2014). "Reproductive interference between honeybee species in artificial sympatry." Molecular ecology. 23(5): 1096-1107.

Reproductive isolation between closely related species is often incomplete. The Western honeybee, *Apis mellifera*, and the Eastern hive bee, *Apis cerana*, have been allopatric for millions of years, but are nonetheless similar in morphology and behaviour. During the last century, the two species were brought into contact anthropogenically, providing potential opportunities for interspecific matings. Hybrids between A.iu mellifera and A.iu cerana are inviable, so natural interspecific matings are of concern because they may reduce the viability of A.iu cerana and A.iu mellifera populations two of the world's most important pollinators. We examined the mating behaviour of A.iu mellifera and A.iu cerana queens and drones from Caoba Basin, China and Cairns, Australia. Drone mating flight times overlap in both areas. Analysis of the spermathecal contents of queens with speciesspecific genetic markers indicated that in Caoba Basin, 14% of A.iu mellifera queens mated with at least one A.iu cerana male, but we detected no A.iu cerana queens that had mated with A.iu mellifera males. Similarly, in Cairns, no A.iu

cerana queens carried A.iu mellifera sperm, but onethird of A.iu mellifera queens had mated with at least one A.iu cerana male. No hybrid embryos were detected in eggs laid by interspecifically mated A.iu mellifera queens in either location. However, A.iu mellifera queens artificially inseminated with A.iu cerana sperm produced inviable hybrid eggs or unfertilized drones. This suggests that reproductive interference will impact the viability of honeybee populations wherever A.iu cerana and A.iu mellifera are in contact.

Rhodes, J. (1998). "Beginning in bees." Agfact - Department of Agriculture, New South Wales(A8.1.1): 20-pp.
The basic knowledge needed to keep *Apis mellifera* in a small backyard or hobby apiary is provided. Information includes beekeeping laws in New South Wales, Australia, starting an apiary, obtaining bees, working with bees, apiary operation, harvesting honey, beekeeping problems, diseases and pests, exotic diseases and commercial beekeeping.

Rhodes, J., et al. (1994). "A survey of Australian queen bee users." Australasian beekeeper 96(4): 152-157.
A survey of 729 commercial and semi-commercial honey producers in 1988 (24% response rate) suggests that c. 56% of colonies were requeened annually. Queens were reared by beekeepers (26%), purchased as adult queens (51%) or purchased as cells (20%). Beekeepers rearing queens did so for reasons of quality (45%) and reduced cost (26%). Adult queens were introduced directly in a cage (64%) or first into a nucleus for later uniting with a full colony (32%). Figures are detailed by state and producer type, and information is given of rearing and introduction practices, seasonal demand and supply, and expectations of quality and service.

Rhodes, J. W. (2011). Quality of commercially reared queen and drone honey bees (*Apis mellifera* L.) in eastern Australia. PQDT - Global. Ann Arbor, University of Western Sydney (Australia): 236-236.
The reasons for undertaking this work were based on observations of commercial queen honey bee breeders rearing queen bees using current knowledge and technologies, followed by introduction of those queens into established honey producing hives with subsequent failures of the queens to survive or perform satisfactorily. An initial study on queen bees provided data which developed into more detailed drone studies.

Rhodes, J. W., et al. (2011). "Effects of age, season and genetics on semen and sperm production in *Apis mellifera* drones." Apidologie 42(1): 29-38.
Adult drone honey bees from 4 Australian breeding lines were reared under similar conditions and examined for semen and sperm production when 14, 21 and 35 days old, during spring, summer and autumn. Almost half (40.5%) of all drones examined did not release any semen when manually everted. For those that released semen, the average volume released per drone was 1.09 mu L (range 0.72 (+/-0.04)-1.12 (+/-0.04) mu L) and the average number of sperms in the semen per drone was 3.63 x 10(6) (range 1.88 (+/-0.14)-4.11 (+/-0.17) x 10(6)). The release of semen was dependent on breeding line and age ($P < 0.05$), but not on the rearing season. The volume of semen released per drone was dependent on season, age, and breeding line ($P < 0.05$), while the concentration of sperm in the semen was dependent on season and breeding line ($P < 0.05$). Hence our data indicate that genetics underpins the maturation of drone honey bees as well as the volume of semen they release and the concentration of sperm in that semen.

Rhodes, J. W., et al. (2004). "Queen honey bee introduction and early survival - effects of queen age at introduction." Apidologie 35(4): 383-388.
The survival of honey bee *Apis mellifera* queens to 14 days and 15 weeks after introduction into an established bee colony increases with increasing age of the queen at introduction. Survival rates increased strongly to high levels for queen bees introduced between 7 and 24 days of age and at a slower rate for queens introduced at ages up to 35 days. The survival rates were similar for sister queens introduced into two unrelated apiaries suggesting that apiary site and beekeeper management differences had minimal effect on survival rates. A year effect was found but the response to increasing age was similar for the three years.

Rice, N. (1980). "Obtaining the best results from newly purchased queen bees." Australasian beekeeper. 82(2): 46-47.

Rice, N. V. (1974). "Queen breeding under Queensland conditions." HARNAJ, V. (ED.). APIMONDIA SCIENTIFIC BULLETIN, 1972. SYMPOSIA. 1972. 535P. ILLUS. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 400-404.

Rice, N. V. (1981). "Supplementary feeding in apiaries." Australasian beekeeper. 82(7): 162-164.

Richards, G. (1981). "Report on the activities of the National Apicultural Research Centre, and the Australasian Honeybee Stock Centre." Australasian beekeeper 82(10): 238-239.

Ronai, I., et al. (2017). "The dynamic association between ovariole loss and sterility in adult honeybee workers." Proceedings of the Royal Society. Biological Sciences 284(1851): 20162693-20162693.

In the social insects, ovary state (the presence or absence of mature oocytes) and ovary size (the number of ovarioles) are often used as proxies for the reproductive capacity of an individual worker. Ovary size is assumed to be fixed post-eclosion whereas ovary state is demonstrably plastic post-eclosion. Here, we show that in fact ovary size declines as honeybee workers age. This finding is robust across two honeybee species: *Apis mellifera* and *A. cerana*. The ovariole loss is likely to be due to the regression of particular ovarioles via programmed cell death. We also provide further support for the observation that honeybee workers with activated ovaries (mature oocytes present) most commonly have five ovarioles rather than a greater or smaller number. This result suggests that workers with more than five ovarioles are unable to physiologically support more than five activated ovarioles and that workers with fewer than five ovarioles are below a threshold necessary for ovary activation. As a worker's ovariole number declines with age, studies on worker ovariole number need to take this plasticity into account.

Rowe, D. J., et al. (1997). "Seven polymorphic microsatellite loci in honeybees (*Apis mellifera*)." Insectes Sociaux 44(2): 85-93.

Seven microsatellite markers identified by probing clones made from a honeybee population from Victoria, Australia with a GA oligonucleotide are polymorphic in collections of honeybees from Iberia. Five of the microsatellites are GA repeats (three perfect repeats, two imperfect repeats, and one interrupted perfect repeat); of two others found in (GA)-n-containing clones, one is a perfect AT repeat and one a mononucleotide T repeat. A further perfect GA repeat is monomorphic in the Iberian bees. Primer sequences are given for each of these microsatellites, and for seven others either not amplifying or giving multiple bands under the conditions used, or which were not tested. In all, eighteen microsatellites were found in twelve clones. One clone contained a minisatellite repeat, not assayed for polymorphism.

Rua, P. d. l., et al. (2004). "Molecular diversity of honeybee *Apis mellifera* iberica L. (Hymenoptera: Apidae) from Western Andalusia." Archivos de Zootecnia 53(202): 195-203.

The molecular diversity of the honey bee *A. mellifera* iberica in Western Andalusia, Spain, has been analysed through the study of mitochondrial and nuclear DNA. The mitochondrial haplotype corresponding to the intergenic region tRNAleu-COII, and six microsatellite loci has been determined in hives distributed in 24 localities of the provinces of Malaga, Seville, Cadiz and Huelva. Six different haplotypes have been found, five of the African and one of the West European evolutionary lineage. These results corroborate the hybrid nature of the subspecies *A. mellifera* iberica, which has a predominant influence of the African lineage in the South, that is gradually or steeply replaced northwards by the West European lineage. The variability of the microsatellite loci is similar to that found in African populations in relation to the detected number of alleles and the values of genetic diversity. These observations show the genetic relationship between Andalusian honey bee populations and those ones from North Africa. Microsatellite data vary notably between the studied provinces. In the province of Cadiz the mitochondrial homogeneity contrasts with the microsatellite variability, what suggests a recent introgression event from African-like populations of unknown geographic origin.

Russell, S., et al. (2013). "Dynamic modelling of honey bee (*Apis mellifera*) colony growth and failure." Ecological modelling 265: 158-169.

Rates of honey bee colony failure have increased significantly across much of North America and Europe, which has directed attention to the need to better understand the process of bee colony growth and development, and the factors that can cause colony failure. Here we present a simple model of honey bee colony dynamics as a tool to explore what factors may have the strongest influence on colony growth and survival. Our model focuses on

how internal demographic processes within a colony interact with food availability and brood rearing to alter growth trajectories. The model is implemented as a series of difference equations operating at discrete time steps to model changes in bee population day by day. We base our rate equations on the analytic models of Khoury et al. (2013), and go further by simulating colony growth across three years to capture seasonal and annual growth cycles. Our resulting model successfully captures realistic seasonal variations in colony populations. Sensitivity analysis of the model suggests that colony survival is strongly influenced by rates of forager bee mortality, food availability and factors that influence the age at which worker bees transition from working inside the hive raising brood to working outside the hive as foragers. We discuss these findings with reference to known agents that can cause colony failure. The presented model is very simple, and makes minimal assumptions, but could easily be extended to more accurately simulate the performance of field honey bee colonies and/or specific environmental or pathogen pressures.

Ruttner, F. (1976). "Isolated populations of honeybees in Australia." Journal of apicultural research.: 97-104.

Ruttner, F. (1978). "Is queen rearing in Australia on the way to becoming an important factor in world apiculture?" Koniginnenzucht in Australien auf dem Weg zu einem wichtigen Faktor der Weltimkerei?: 49-54.

Schlipalius, D., et al. (2008). "Honeybee." Genome Mapping and Genomics in Arthropods: 1-16.

Shaw, D. E. (1998). "Species of Neurospora recorded in Australia, and the collection of Neurospora conidia by honey bees in lieu of pollen." Mycologist 12(4): 154-158.

Species of Neurospora (N. intermedia, N. sitophila and N. tetrasperma) are reported on various substrates in the wild in Australia. In addition, honey bees are reported collecting Neurospora conidia in lieu of pollen, this activity having now been recorded intermittently over a period of 20 years.

Simpson, J. and J. Zeil (2020). Development and Testing of a High Throughput Behavioural Monitoring System for the European Honeybee. PQDT - Global. Ann Arbor, The Australian National University (Australia): 131-131.

Behavioural monitoring of the European honeybee (*Apis mellifera*) has traditionally been achieved through manually marking and observing bees for long periods of time (Robinson, 1992). However, the labourious and time-consuming nature of this task, combined with the difficulty of observing multiple individual bees simultaneously makes longer-term studies extremely challenging. The purpose of this research was to develop an automated system for tracking the movements of honeybees within the hive. Two versions of the tracking software were developed over the course of this project. The first version focussed on tracking and identifying large groups of bees, while the second version implemented a system capable of uniquely recognising and tracking up to 50 individual bees. The accuracy of the tracking software was tested against the traditional technique of manually observing and tracking bee movements. The experimental methodology described in this thesis provides researchers with a relatively cheap and easy to use tool to investigate honeybee behaviour. The software system developed is freely available online via GitHub as an open source project. The tracking system was used to conduct a number of experiments investigating honeybee behaviour. These experiments were conducted in order to pilot the software, identify limitations, and develop new techniques and metrics to improve it. The first experiment investigated circadian rhythm utilising the first software version. It found evidence for socially acquired circadian rhythms amongst juvenile bees in the hive. However, the key limitation of this technique (it only tracked groups rather than individuals) spurred the development of version two of the software which added this capability. Version two of the software was piloted in an experiment examining the impact of caffeine on juvenile honeybees. While there is evidence that the caffeine potentially had a short-term effect, there was no significant difference between the control and treatment groups over the extended period that the experiment was run. A number of behavioural metrics, software visualisation tools and techniques were then explored and tested based on the data gathered from this experiment. These provide a template that future research utilising this tracking software can build on. Finally, future work and improvements to the tracking system are proposed, including what would be required to extend the capabilities of the tracking software.

Skillman, G. J. (1979). "Queen bee imports - a trial run." Animal Quarantine 6(2): 12-16.

In 1977 57 Austrian and Italian queens were imported with special Ministerial approval, by Sydney and Metropolitan Branch of the Commercial Apiarists Association of New South Wales. Safeguards imposed to prevent import of bee diseases were: health certificates (allowances for Braula coeca as widespread in Austrian hives); examination of imported workers, maintenance of imported queens in quarantine cages. Grafting was done in the cages, and only eggs and larvae were taken outside. Problems associated with maintaining bees in the quarantine cages and other confined spaces are discussed, and action taken to overcome them. M. Nixon

Skillman, G. J. (1983). "New quarantine facility for queen bee imports." Australasian beekeeper 84(9): 174-178.

In recent years the importation of queens to Australia has been very limited (by law) because of the risk of introducing diseases. With the opening of a quarantine facility in NSW, the import of queens from various countries can be revived. The design and operation of the facility are described; it has 12 flight cages, each large enough for 2 nucleus hives. Queens should be imported in pairs, and one is put into each of the hives; when the queen starts to lay, brood and workers are inspected regularly for abnormality and/or disease. Grafting is not started until 4 weeks after importation, and is continued for about 2 weeks, when the queen is destroyed; the queen cells are released to the importer. Importers have to pay for the inspection and handling of the queen while in quarantine, and for any equipment used.P. Walker.

Skillman, G. J. (1983). "Queen bee imports and the new quarantine facility at Eastern Creek." Australasian beekeeper 84(12): 256-258.

Somerville, D. (1992). "Developing package bees in Australia." Australian bee journal 73(8): 10-13.

Spinney, L. (2005). "Anarchy in the hive!" New Scientist 185(2482): 42-45.

This article reports that from the outside, a honeybee colony appears the epitome of social harmony. The queen produces offspring that are raised by loyal workers who forgo their own reproduction to keep the colony running smoothly. But in reality it is a dark world of conflict, infanticide and thwarted reproductive ambitions, kept in check by brutal policing. It's amazing said Ben Oldroyd from the University of Sydney, New South Wales, who is one of the few people to have witnessed it. Anarchy, in the world of the honeybee at least, is extremely rare. So rare in fact that it took Oldroyd a decade of advertising in beekeeping magazines to track down just two anarchic colonies. Oldroyd already has a shortlist and predicts that his team will publish the exact identity of the honeybee genes for altruism within a few months. If so, the announcement will come 40 years after British evolutionary biologist William Hamilton resolved the paradox of how such a gene can spread in a population, by showing mathematically that genes for altruism are actually as selfish as any other gene. INSET: How to get ahead in a hive.

Spiteri, M., et al. (2017). "Combination of 1H NMR and chemometrics to discriminate manuka honey from other floral honey types from Oceania." Food chemistry. 217(217): 766-772.

Manuka honey is a product produced essentially in New Zealand, and has been widely recognised for its antibacterial properties and specific taste. In this study, 264 honeys from New Zealand and Australia were analysed using proton NMR spectroscopy coupled with chemometrics. Known manuka markers, methylglyoxal and dihydroxyacetone, have been characterised and quantified, together with a new NMR marker, identified as being leptosperin. Manuka honey profiling using 1H NMR is shown to be a possible alternative to chromatography with the added advantage that it can measure methylglyoxal (MGO), dihydroxyacetone (DHA) and leptosperin simultaneously. By combining the information from these three markers, we established a model to estimate the proportion of manuka in a given honey. Markers of other botanical origins were also identified, which makes 1H NMR a convenient and efficient tool, complementary to pollen analysis, to control the botanical origin of Oceania honeys.

Srinivasan, M. V., et al. (1999). "Honeybee navigation: linear perception of short distances travelled." Journal of Comparative Physiology 185(3): 239-245.

Recent evidence indicates that honeybees measure distance flown to a food source by integrating, over time, the apparent visual motion of the environment that they experience en route to the goal. Is the bee's perception of distance travelled a linear function of distance, or is it some other function? This question was investigated by training bees to fly into a tunnel and receive a food reward. The walls and floor of the tunnel were lined with a random texture, and the reward was placed at one of two fixed distances, “near” or “far”, from the

tunnel entrance. The feeder containing the reward was placed in a box which could be accessed through one of two openings, one on the left side of the box, and the other on the right. When the box was at the “near” position, the reward could only be accessed through the left-hand opening; when the box was at the “far” position, the reward could only be accessed through the right-hand opening. When the trained bees were tested individually in an identical, fresh tunnel with the reward removed from the box, they showed a strong preference for the left-hand opening when tested at the “near” distance, and for the right-hand opening when tested at the “far” distance. At intermediate positions, the bees' preference for the two openings varies linearly with distance. These findings suggest that the honeybee's perception of distance travelled is linear, at least over the distances and range of image motions experienced in our experiments. The implications for navigation and for the encoding of distance information in the dance are discussed.

Srinivasan, M. V., et al. (1998). "Honeybee navigation: odometry with monocular input." Animal Behaviour 56(5): 1245-1259.

Stace, P. (1992). "Pollens suitable to collect, store and feed back to bees." Australasian beekeeper 94(6): 247-247.
A list of 14 plants which produce pollens with 20-33% crude protein is presented.

Stace, P. (1993). "Pollen - supplements or extenders: when do we feed?" Bee Briefs 9(4): 10-11.

Stace, P. and J. Hayter (1994). "Palatability of five protein feedstuffs by honey bees (*Apis mellifera*)." Australasian beekeeper 96(1): 23-25.
Five colonies of honey bees (*Apis mellifera*) in NSW, Australia, were each fed 5 times with patties of c. 100 g of a vegetable protein supplement made with 3 parts honey to 4 parts of one of the following: expeller-processed soyabean flour (A), Torula yeast (B), solvent-extracted soyabean flour (C), solvent-extracted sunflower flour (D) and solvent-extracted canola flour (E). Average daily consumption (g/day) was 4.65, 2.96, 2.26, 1.42 and 1.29 respectively, with A consumed at a significantly faster rate than the others. This product has 6-8% fat compared with 2% for C: it is suggested that a fat content of 6-10% in protein supplements could increase consumption.

Susanto, F., et al. (2018). "Addressing RFID misreadings to better infer bee hive activity." IEEE Access 6: 31935-31949.
This paper proposes a method to address misreadings and consequent inadequacy of radio-frequency identification data for social insect monitoring. Six-month worth field experiment data were collected to demonstrate the application of the method. The data are transformed into a linear combination of the Gaussian model and curve-fitted using an evolutionary algorithm. This results show that the proposed method allows us to improve the quality of data that infer honey bee behavior at the colony level. © 2013 IEEE.

Tang, J. S., et al. (2020). "Mānuka honey-derived methylglyoxal enhances microbial sensing by mucosal-associated invariant T cells (Electronic supplementary information (ESI) available. See DOI: 10.1039/d0fo01153c)." Food & Function 11(7): 5782-5787.
Methylglyoxal (MGO) is the main antimicrobial determinant associated with using Mānuka Honey as a topical dressing. While direct mechanisms of Mānuka honey MGO's antimicrobial activity have been demonstrated, such as disruption of bacterial fimbria and flagella, no interaction of Mānuka honey-derived MGO with antimicrobial effector cells of the immune system, such as mucosal-associated invariant T cells (MAIT cells), has yet been reported. MAIT cells are an abundant subset of human T cells, critical for regulating a diverse range of immune functions, including antimicrobial defense mechanisms but also mucosal barrier integrity. MAIT cells become activated by recognition of an important microbial metabolite, 5-amino-6-d-ribitylaminouracil (5-A-RU), which is produced by a wide range of microbial pathogens and commensals. Recognition is afforded when 5-A-RU condenses with mammalian-cell derived MGO to form the potent MAIT cell activator, 5-(2-oxopropylideneamino)-6-d-ribitylaminouracil (5-OP-RU). Formation of 5-OP-RU and its subsequent presentation to MAIT cells by major histocompatibility (MHC)-related molecule 1 (MR1) facilitates host–pathogen and host–commensal interactions. While MGO is a metabolite naturally present in mammalian cells, it is unclear whether exogenous dietary MGO sources, such as those obtained from Mānuka honey intake, can contribute to 5-OP-RU formation and enhance MAIT cell activation. In this work, we report that endogenous MGO is the rate-limiting substrate for converting microbial 5-A-RU to 5-OP-RU and that Mānuka honey-derived MGO significantly enhances MAIT cell activation in vitro. Our

findings posit a novel mechanism by which intake of a food item, such as Mānuka honey, can potentially support immune homeostasis by enhancing MAIT cell-specific microbial sensing.

Théotime, C., et al. (2018). "The development of honey bee colonies assessed using a new semi-automated brood counting method: CombCount." PLoS One 13(10).

Precise, objective data on brood and honey levels in honey bee colonies can be obtained through the analysis of hive frame photographs. However, accurate analysis of all the frame photographs from medium- to large-scale experiments is time-consuming. This limits the number of hives than can be practically included in honeybee studies. Faster estimation methods exist but they significantly decrease precision and their use requires a larger sample size to maintain statistical power. To resolve this issue, we created 'CombCount' a python program that automatically detects uncapped cells to speed up measurements of capped brood and capped honey on photos of frames. CombCount does not require programming skills, it was designed to facilitate colony-level research in honeybees and to provide a fast, free, and accurate alternative to older methods based on visual estimations. Six observers measured the same photos of thirty different frames both with CombCount and by manually outlining the entire capped areas with ImageJ. The results obtained were highly similar between both the observers and the two methods, but measurements with CombCount were 3.2 times faster than with ImageJ (4 and 13 min per side of the frame, respectively) and all observers were faster when using CombCount rather than ImageJ. CombCount was used to measure the proportions of capped brood and capped honey on each frame of 16 hives over a year as they developed from packages to full-size colonies over about 60 days. Our data describe the formation of brood and honey stores during the establishment of a new colony.

Thin, A. (1984). "Beekeeping on a coral atoll." Bee World 65(2): 57-57.

The Pacific nation of Tuvalu consists of a chain of low-lying coral atolls stretching between 5 degree and 10 degree S, with the atoll of Vaitupu lying approximately in the center of the group. In May 1983 a project was started by the Tuvalu Government, with the assistance of New Zealand Bilateral Aid, to introduce honeybees (*Apis mellifera*) to Vaitupu on a trial basis. Vaitupu was chosen for the trial, because it has the largest land mass of the group (5-9 km super(2)) and because its central lagoon is relatively small and easily crossed by flying honeybees. The trial is not yet finished. The absence of native honeybees provides an ideal environment for queen breeding, while careful screening of the original imported stock has ensured that any queens reared can confidently be described as "disease free". Inhabitants of other islands in the group want honeybees introduced and it remains to be seen whether these islands are as well suited to bees as Vaitupu.

Thompson, G. J., et al. (2006). "Towards a molecular definition of worker sterility: differential gene expression and reproductive plasticity in honey bees." Special issue: Honey bee genome sequence. 15(5): 637-644.

We show that differences in the reproductive development of honey bee workers are associated with locus-specific changes to abundance of messenger RNA. Using a cross-fostering field experiment to control for differences related to age and environment, we compared the gene expression profiles of functionally sterile workers (wild-type) and those from a mutant strain in which workers are reproductively active (anarchist). Among the set of three genes that are significantly differentially expressed are two major royal jelly proteins that are up-regulated in wild-type heads. This discovery is consistent with sterile workers synthesizing royal jelly as food for developing brood. Likewise, the relative underexpression of these two royal jellies in anarchist workers is consistent with these workers' characteristic avoidance of alloparental behaviour, in favour of selfish egg-laying. Overall, there is a trend for the most differentially expressed genes to be up-regulated in wild-type workers. This pattern suggests that functional sterility in honey bee workers may generally involve the expression of a suite of genes that effectively 'switch' ovaries off, and that selfish reproduction in honey bee workers, though rare, is the default developmental pathway that results when ovary activation is not suppressed.

Traynor, K. (2010). "New Zealand beekeeping at the Firth of Thames and the Bay of Plenty: conversations with a hobbyist and a new commercial beekeeper." American bee journal. 150(12): 1173-1176.

Tribe, G. D. (1989). "A drone congregation area in Perth, Western Australia." South African Bee Journal 61(4): 83-86.

Drones were seen above the congregation area (100 m x 50 m) on only one day; 2 'comets', each containing about 200 drones, were observed. When a eucalypt fruit capsule was thrown up among the drones, they followed it

almost to the ground. This behaviour resembles that of *Apis mellifera* scutellata (although the honeybees in Australia are of European origin; European *A. mellifera* drones follow a lure only down to a level of 4.6-10 m above ground). Swallows flew among the drones and appeared to be feeding on them. Using the classification of drone congregation areas proposed by Tribe [South African Bee Journal (1982) 54 (5) 99-100, 103-112] this one would be of the 'barrier' type.

Utaipanon, P., et al. (2019). "Estimating the density of honey bee (*Apis mellifera*) colonies using trapped drones: area sampled and drone mating flight distance." Apidologie. 50(4): 578-592.

Reliable information on Western honey bee colony density can be important in a variety of contexts including biosecurity responses, determining the sufficiency of pollinators in an agroecosystem and in determining the impacts of feral honey bees on ecosystems. Indirect methods for estimating colony density based on genetic analysis of sampled males are more feasible and cost efficient than direct observation in the field. Microsatellite genotypes of drones caught using Williams drone trap are used to identify the number of colonies (queens) that contributed drones to a mating lek. From the number of colonies, the density of colonies can be estimated based on assumptions about the area from which drones are drawn. This requires reliable estimates of drone flight distance. We estimated average minimum flight distance of drones from feral colonies along two 7-km transects in Southern NSW, Australia. We found that drones from feral colonies flew at least 3.5 km to drone traps. We then determined that the maximum distance that drones flew from a focal colony to a trap was 3.75 km. We conclude that a drone trap samples an area of 44 km2, and that this area should be used to convert estimated colony numbers to colony densities. This area is much greater than has been previously assumed. The densities of honey bee colonies in Grong Grong and Currawarna, NSW, are 1.38-2.73 and 1.31-3.06 colonies/km2 respectively.

Van Eaton, C. (1987). "Commercial queen production in New Zealand." American bee journal. 127(11): 773-773.

Vantoor, R. F. and R. P. Littlejohn (1994). "Evaluation of hive management-techniques in production of royal jelly by honey-bees (*Apis mellifera*) in New-Zealand." Journal of Apicultural Research 33(3): 160-166.

Two hive designs and two harvesting methods were evaluated in Otago, New Zealand, for their effect on yields and quality of royal jelly, and ease of management. Royal jelly yields from a queenright hive design, in which a queen excluder partially covered with a hardboard division confined the queen to the bottom brood chamber and away from the queen cells in the middle box where royal jelly was secreted, were similar to those obtained from a queenless hive design in which the queen was removed to a nucleus box. This was despite the bees clustering around the queen cells in the queenright hive having smaller hypopharyngeal glands than those in the queenless starter hive. The queenright design is recommended because of its simplicity and ease of conversion in alternating between honey and royal jelly production. Harvesting 66 h after grafting larvae resulted in similar yields to harvesting at 72 h and 78 h, indicating that beekeepers can harvest at any time on the third day without affecting production. A technique which used two harvests per graft is not recommended. The chemical components of royal jelly within certain quality standards were not affected by the treatments. Royal jelly production suppressed honey yields by 51%.

Walton, G. (1980). "The prospects for boosting queen bee production." New Zealand beekeeper 41(3): 30-31.

For export, especially to countries with import restrictions, e.g. UK, Canada.

Warhurst, P. and R. Goebel (1995). "The bee book: beekeeping in the warmer areas of Australia." The bee book: beekeeping in the warmer areas of Australia.

The authors give a strong emphasis to practical beekeeping techniques for commercial producers and hobbyists, with straightforward text including highlighted summaries, good quality photographs (136 black and white, 59 in colour), and 17 tables. Subjects covered include bee biology, beginning with bees, hive equipment, colony management, hive products, pollination, exotic and endemic pests and diseases, and Australian native bees (Apoidea). There are lists of Australian industry contacts, a glossary, reading list and index. This book is written from a Queensland perspective, but despite the inclusion of some material with only local interest much of its content will be useful to beekeepers in other tropical, subtropical and warm temperate areas of the world.

Watts, M. E., et al. (2018). "Hypoxia-Induced MicroRNA-210 Targets Neurodegenerative Pathways." Non-Coding RNA 4(2).

Hypoxia-regulated microRNA-210 (miR-210) is a highly conserved microRNA, known to regulate various processes under hypoxic conditions. Previously we found that miR-210 is also involved in honeybee learning and memory, raising the questions of how neural activity may induce hypoxia-regulated genes and how miR-210 may regulate plasticity in more complex mammalian systems. Using a pull-down approach, we identified 620 unique target genes of miR-210 in humans, among which there was a significant enrichment of age-related neurodegenerative pathways, including Huntington's, Alzheimer's, and Parkinson's diseases. We have also validated that miR-210 directly regulates various identified target genes of interest involved with neuronal plasticity, neurodegenerative diseases, and miR-210-associated cancers. This data suggests a potentially novel mechanism for how metabolic changes may couple plasticity to neuronal activity through hypoxia-regulated genes such as miR-210.

Wheen, G. (1988). "The use of the Australian quarantine facility for honey bees." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 57-58.

White, B. (1988). "Importation of queen bees - quarantine facility and procedures [in Australia]." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 65-67.

Whitten, M. J. (1979). "Genetics of the honeybee *Apis mellifera* in Australia." Genetics in relation to insect management. A Rockefeller Foundation Conference, March 31-April 5, 1978, Bellagio, Italy (Rockefeller Foundation Working Papers). 93-96.

In this review of practices among commercial apiarists in Australia with regard to re-queening colonies of *Apis mellifera* L., one of the 4 issues of major concern to Australian apiculture that are discussed is the establishment of rigorous quarantine procedures that maximise overseas breeding material yet minimise the risk of the introduction of exotic diseases and parasites such as *Acarapis woodi* (Rennie), *Varroa jacobsoni* Oudm. and *Tropilaelaps clareae* Delfinado & Baker.

Willesee, A. (2013). "Hive talking." Australian House & Garden: 124-124.

The article presents the author's views on setting up her families first bee hive and their efforts to produce their own honey. She says that they recently set up their first hive and they now want to learn how to extract honey from a hive. She says that one of the most famous Australian honey is produced by the Ligurian bees on Kangaroo Island, Australia. She also talks about Kangaroo Island honey producer Peter Davis.

Williamson, E., et al. (2019). "A new method to sample DNA from feral honey bee hives in trees." Transactions of the Royal Society of South Australia 143(1): 92-96.

Unmanaged, or feral, honey bees can be abundant in Australian agricultural landscapes and provide substantial, but unquantified, crop pollination services. This makes these production systems vulnerable to ecological disturbances. Quantifying the densities of feral honey bees is key to determining the reliance of free pollination services and system vulnerability. Current methods for estimating densities of feral honey bee hives are based on the number of haplotypes identified from drones caught using a pheromone lure. This method assumes that all hives contribute to the drone population, and that the area over which they are attracted is known. To test these assumptions the estimates based on drone capture should be compared to the genetic composition of hives in the same area. We developed a flag and pole method to sample worker sting DNA from feral hives in trees. We show that the use of alarm pheromone isopentyl acetate can significantly increase the efficiency of this method. We also demonstrate that the DNA collected from sting samples will amplify via PCR to a band intensity similar to that of leg tissue. In addition to providing a method to verify hive density estimates based on drone captures other applications of our method are discussed.

Winn, R. A. (1974). "Management of colonies for maximum honey production in South Australia." HARNAJ, V. (ED.). APIMONDIA SCIENTIFIC BULLETIN, 1972. SYMPOSIA. 1972. 535P. ILLUS. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 382-386.

Woyke, J. (1976). "Population genetic studies on sex alleles in the honey bee using the example of the Kangaroo Island Australia bee sanctuary." Journal of Apicultural Research 15(3-4): 105-123.

The common practice of crossing different races of honeybees [*Apis mellifera*] has created a demand for the establishment of isolated reserves for pure ecotypes of the main races. On Kangaroo Island, South Australia, the average survival rate of brood was found to be 75.6%. Mortality of 6.5% was caused by factors other than sex alleles, so the survival rate resulting from sex alleles was 82.1%. Equations are presented for calculation of survival rate of brood (S) in populations in equilibrium, S = (N - 1)/N, and in unstable populations, S = 1 - pfpm - gfqm - rfrm.... Equations are developed for calculating the frequencies of sex alleles in subsequent generations, and after the introduction of new alleles (and new queens), and also differences between the frequencies of sex alleles in the 2 sexes. In natural selection, sex alleles in honey bees represent an example of overdominance, with total elimination of all homozygotes in populations with multiple alleles and different frequencies of those alleles in the sexes. Calculations show that 36% of the drones that mated with the queens in the sanctuary carried the same sex alleles as the queens. Only 6 of 12 sex alleles known to occur in the honeybee were present among the bees in the sanctuary. An increase in the number of alleles above 8-10 in a population gives very little improvement in the percentage of surviving larvae. Theoretical calculations show that the frequencies of different sex alleles must be equal throughout the bee population on Kangaroo Island. When a new allele is introduced into a population with few alleles, even in a very low proportion, its frequency increases rapidly, and thus the survival of brood increases. The maximum survival rate of brood in a population is reached when the sex alleles are in equilibrium. Before reaching equilibrium for different sex alleles, any generation of queens produces virgins and drones with different frequencies of these alleles. When there are few alleles, there is a diminishing oscillation in the frequency of the same sex allele between the 2 sexes, in subsequent generations. The best way to increase the number of sex alleles in a population and to increase the survival of brood, with a minimal change of other characters, is to introduce one or very few queens inseminated by several (not many) different drones. Although the survival rate of brood on Kangaroo Island was rather low, after 100 yr of isolation, the colonies were still good honey producers.

Woyke, J. (1988). "Brood survival in productive bee apiaries in Australia as a test for breeding honeybees in closed populations." Journal of apicultural research. 27(1): 30-34.

Yagound, B., et al. (2017). "Subfamily-dependent alternative reproductive strategies in worker honeybees." Molecular Ecology 26(24): 6938-6947.

Functional worker sterility is the defining feature of insect societies. Yet, workers are sometimes found reproducing in their own or foreign colonies. The proximate mechanisms underlying these alternative reproductive phenotypes are keys to understanding how reproductive altruism and selfishness are balanced in eusocial insects. In this study, we show that in honeybee (*Apis mellifera*) colonies, the social environment of a worker, that is, the presence and relatedness of the queens in a worker's natal colony and in surrounding colonies, significantly influences her fertility and drifting behaviour. Furthermore, subfamilies vary in the frequency of worker ovarian activation, propensity to drift and the kind of host colony that is targeted for reproductive parasitism. Our results show that there is an interplay between a worker's subfamily, reproductive state and social environment that substantially affects her reproductive phenotype. Our study further indicates that honeybee populations show substantial genetic variance for worker reproductive strategies, suggesting that no one strategy is optimal under all the circumstances that a typical worker may encounter. (© 2017 John Wiley & Sons Ltd.)

Zareie, R., et al. (2013). "Long-term survival of high quality sperm: insights into the sperm proteome of the honeybee *Apis mellifera*." Journal of proteome research 12(11): 5180-5188.

In the social bees, ants, and wasps, females (queens) mate only during a brief period early in their lives and afterward store a lifetime supply of sperm in a specialized organ, the spermatheca. In some species, stored sperm can remain viable for several decades and is used by queens to fertilize millions of eggs. The physiological adaptations that allow this prolonged survival are unknown. To unravel them, we conducted proteomic analyses on the sperm of the honeybee *Apis mellifera* to define proteins that are bee-specific or highly divergent from sequences in the sperm proteomes of flies or mammals and might therefore be associated with long-term sperm survival. We identified a honeybee sperm proteome of 336 members and defined the subset of proteins or protein networks that cannot be discerned in the sperm proteomes of fruit flies and humans. This subset contained a significant number of

proteins that are predicted to act in enzyme regulation or in nucleic acid binding and processing. From our analysis we conclude that long-term survival of sperm in social insects could be underpinned by substantial changes in only a specific subset of sperm proteins that allow physiological adaptation to storage. The unexpected preponderance of proteins predicted to be involved in transcriptional processes and enzyme regulation suggest these are the primary targets of this adaptation.

PEST AND DISEASES

American foulbrood

(1995). "National pest management strategy - American foulbrood eradication. Public discussion document." National pest management strategy - American foulbrood eradication. Public discussion document.: 74-pp.

The New Zealand Beekeepers' Association has proposed a strategy for eradicating AFB, caused by Bacillus larvae [Paenibacillus larvae], and this discussion document deals with measures by which this might be achieved. Aspects discussed include inspection and diagnosis, registration of apiaries, treatment of colonies and destruction of equipment, management and funding of the strategy, and the statutory powers required to implement the strategy.

Allan, L. F. (1985). "Preventing the spread of American brood disease." Australasian beekeeper 87(2): 31-40.

This article is a reprint of Bulletin 4082 issued by the Department of Agriculture in an attempt to stop the recent increase in ABD [=AFB] in Western Australia. By using suitable management methods, a beekeeper can reduce the risk of cross-infection of ABD between colonies in an apiary and between apiaries. Methods are described, including the use of queen excluders. The interchange of hive equipment should be minimal, and careful apiary records should be kept including records of any such movements. Recording is also important when making nuclei, and a suitable system is explained. Good apiary hygiene, including the fumigation of unused equipment, is also important. Robbing by bees, which may spread infection, must be prevented.P.Walker.

Allan, L. F. (1996). "Preventing the spread of American foul brood disease through barrier management of hives." Bulletin - Western Australia Department of Agriculture(4318): 16-pp.

This illustrated booklet describes the causes, effects, propagation, control and economic impact of AFB in Western Australia, and sets out in detail the principles of 'barrier management' to control the disease. This system was introduced in the 1980s and is now used by about 80% of Western Australia's commercial beekeepers. Beekeepers may either use queen excluders to confine brood to the lower box, leaving supers free of brood for extracting, or they may manage their hives without excluders and extract honey on-site using a mobile extracting van. The merits and risks of the 2 methods are discussed. Numbering and colour coding of equipment can be used to ensure that frames can be returned to the same super, and the super to the hive which had it originally. The aspects of management discussed include making nuclei, honey extraction, autumn and winter management, keeping apiary records and hygiene.

Bolger, P. and H. Pharo (2014). "Control of American foulbrood in New Zealand." Bee health and veterinarians: 167-171.

Like many honey-producing nations, New Zealand has a control programme for American foulbrood (AFB). Unusually, this programme is run by the beekeeping industry without government funding. The programme prohibits the use of antibiotics, and requires the destruction of all hives with clinical signs of AFB. Over the past decade, the reported incidence of AFB in hives has been approximately 0.3%.

Clemson, A. A. (1981). "American foulbrood." Australasian beekeeper. 82(7): 164-171.

Desailly, N. (1988). "American brood disease - prevention using management techniques in Australia." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 97-98.

Djordjevic, S., et al. (1994). "DNA restriction endonuclease profiles and typing of geographically diverse isolates of Bacillus larvae." Journal of Apicultural Research 33(2): 95-103.

DNA isolated from each of 20 Bacillus larvae isolates of geographically diverse origin (17 from Australia, one each from Fiji, Mexico and New Zealand) and cultured on brain heart infusion agar was digested with a range of restriction endonucleases. Based upon the degree of similarity in restriction endonuclease fragment patterns (REFP) produced by the restriction endonuclease Cfo I, 5 clonal types of B. larvae were identified. REFP were resolved on 3.5% polyacrylamide gels and visualized by silver staining. All the isolates showed many similarities in their REFP,

however, those isolates cultured from geographically localized regions showed the greatest similarity. The superior resolving capabilities of polyacrylamide enabled these isolates to be further sub-typed according to minor variations in REFP.

Djordjevic, S. P., et al. (2000). "Genetic and biochemical diversity among isolates of Paenibacillus alvei cultured from Australian honeybee (*Apis mellifera*) colonies." Applied and environmental microbiology. 66(3): 1098-1106.

Twenty-five unique CfoI-generated whole-cell DNA profiles were identified in a study of 30 Paenibacillus alvei isolates cultured from honey and diseased larvae collected from honeybee (*Apis mellifera*) colonies in geographically diverse areas in Australia. The fingerprint patterns were highly variable and readily discernible from one another, which highlighted the potential of this method for tracing the movement of isolates in epidemiological studies. 16S rRNA gene fragments (length, 1,416 bp) for all 30 isolates were enzymatically amplified by PCR and subjected to restriction analysis with DraI, HinfI, CfoI, AluI, FokI, and RsaI. With each enzyme the restriction profiles of the 16S rRNA genes from all 30 isolates were identical (one restriction fragment length polymorphism [RFLP] was observed in the HinfI profile of the 16S rRNA gene from isolate 17), which confirmed that the isolates belonged to the same species. The restriction profiles generated by using DraI, FokI, and HinfI differentiated P. alvei from the phylogenetically closely related species Paenibacillus macerans and Paenibacillus macquariensis. Alveolysin gene fragments (length, 1,555 bp) were enzymatically amplified from some of the P. alvei isolates (19 of 30 isolates), and RFLP were detected by using the enzymes CfoI, Sau3AI, and RsaI. Extrachromosomal DNA ranging in size from 1 to 10 kb was detected in 17 of 30 (57%) P. alvei whole-cell DNA profiles. Extensive biochemical heterogeneity was observed among the 28 P. alvei isolates examined with the API 50CHB system. All of these isolates were catalase, oxidase, and Voges-Proskauer positive and nitrate negative, and all produced acid when glycerol, esculin, and maltose were added. The isolates produced variable results for 16 of the 49 biochemical tests; negative reactions were recorded in the remaining 30 assays. The genetic and biochemical heterogeneity in P. alvei isolates may be a reflection of adaptation to the special habitats in which they originated.

Eaton, C. v. (2000). "Control of American foulbrood in New Zealand without antibiotics." Honeybee Science 21(2): 61-67.

Recent findings of antibiotic-resistant strains of Paenibacillus larvae, the causative organism of American foulbrood (AFB) have called into question the continued profitability of *Apis mellifera* beekeeping without the development of new antibiotics to control the disease. However, New Zealand is an example of how non-drug methods can be used successfully to control AFB. New Zealand beekeepers do not use antibiotics because their residue-free bee products receive preferred access to countries such as Japan. They also do not believe that antibiotics can be a total replacement for beekeeping management methods, since AFB levels in countries where drug feeding is widespread are equal to or greater than in New Zealand, where antibiotic control of AFB is illegal. An independent cost-benefit study has also shown that antibiotic feeding programs would be more costly to New Zealand beekeepers than non-drug methods. New Zealand has an organized AFB disease control program, funded by the national beekeeping association, that includes annual registration of apiaries, the reporting of all AFB cases by beekeepers, disease control education, AFB research, and the random and targeted inspection of beehives by both government inspectors and volunteer beekeeper inspectors. The goal of the current control program is to eventually eliminate AFB from all managed beehives in New Zealand. Control of AFB in New Zealand is through the management of beehives to reduce the spread of the disease and destruction of colonies that are found to be infected. A case study, together with a recommended management plan taken from the author's book on non-drug AFB control, is included.

Goodwin, M. and C. v. Eaton (1999). "Elimination of American foulbrood without the use of drugs: a practical manual for beekeepers." Elimination of American foulbrood without the use of drugs: a practical manual for beekeepers.

A manual is presented to provide beekeepers with background information on American foul brood disease (AFB) and practical methods they can use to eliminate the disease from their beekeeping enterprises. It is designed to be useful to all beekeepers, whether they own one beehive, or manage a large-scale commercial beekeeping enterprise. It includes case studies, and describes management techniques New Zealand beekeepers have used to overcome large-scale AFB outbreaks and eliminate disease infections in their hives. Topics include AFB life history, symptoms, natural progression in a honey bee colony, disease spread, disease inspection and diagnosis, dealing with infected hives and equipment, elimination of the disease in beekeeping outfits, case studies and management plans.

Goodwin, R. M., et al. (1994). "Incidence of American foulbrood infections in feral honey bee colonies in New Zealand." New Zealand Journal of Zoology 21(3): 285-287.

Goodwin, R. M., et al. (1993). "American foulbrood disease part III: Spread." New Zealand beekeeper(219): 7-10.

In New Zealand 80 honey bee (*Apis mellifera*) colonies were assembled in 1 apiary: 20 were removed within 2 days, and 20 more 2 weeks later. Of the remaining 40 colonies, 88% contracted American foul brood (AFB) within 3 months. None of the first 20 colonies to be removed developed AFB, while 80% of the second group did. These events were assumed to have been caused by exposure to robbing of material infected with Bacillus larvae (BL). Trials were conducted to determine factors influencing the spread of AFB. A total of 48 colonies were placed in pairs: one in each contained a light (< 50 larvae with symptoms) infection of AFB and the other was uninfected. The level of drifting reached the equivalent of 50% of the colony population after 20 days. After 103 days only 2 (8%) of the uninfected colonies had developed AFB, so drifting may not be a significant cause of AFB spread when infection levels are light. Between 61% (incoming foragers, A) and 98% (brood combs before shaking, B) of adult worker bees in infected colonies carried detectable BL spores: the average number of BL colonies cultured per bee ranged from 0.5 (A) to 24 (B). Honey harvested from colonies with very light AFB infections (< 5 larvae with visible symptoms) contained BL spores. The empty honey supers were placed after extraction on uninfected colonies: bees collected 2 days later from those and all other colonies in that apiary all carried BL spores. Clinical symptoms of AFB began to develop 2 months after the supers were added. Extracted honey supers (and robbing) are important factors in spreading AFB.

Goodwin, R. M., et al. (1993). "American foulbrood disease. Part 1. The incidence of American foulbrood disease in New Zealand." New Zealand beekeeper(217): 19-20.

AFB incidence was surveyed by taking samples of honey bees from 355 randomly selected colonies belonging to hobbyist beekeepers (A), 1681 colonies belonging to commercial beekeepers with a history of high AFB incidence (B), and 106 feral colonies (C). Bacillus larvae spores were found in 11.1%, 8.3% and 6.0% of A, B, and C respectively. Spores were also found in 8 of 32 packs of retail honey examined. The results suggest that B. larvae spores are more common than the national AFB statistics suggest.

Goodwin, R. M., et al. (1993). "American foulbrood disease. Part II. Subclinical infections." New Zealand beekeeper(218): 7-9.

In a survey in New Zealand, 26.2% of adult honey bee (*Apis mellifera*) samples taken from colonies belonging to commercial beekeepers with a history of high AFB incidence contained Bacillus larvae spores, but when the colonies giving positive samples were inspected only 26.4% displayed clinical symptoms of AFB. One colony with clinical symptoms was monitored for nearly 1 year: for much of that time no symptoms showed even though adult bee samples were positive, but after 300 days from the beginning of the trial the number of diseased larvae increased dramatically. Another diseased colony monitored for nearly 2 years showed very few diseased larvae. Adult bee samples from nearly 3000 colonies showed a positive correlation between the number of B. larvae spores present in each sample and the likelihood of the colony showing AFB symptoms. The implications for disease inspection methods are discussed.

Hornitzky, M. (1983). "Gamma radiation in the control of American foulbrood and other honeybee diseases." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 76-80.

Hornitzky, M. A. Z. (1996). Aspects of the detection, epidemiology and control of Paenibacillus larvae (American foulbrood) in Australia. ProQuest Dissertations and Theses. Ann Arbor, University of New South Wales (Australia): 1-1.

The work reported in this thesis describes the development of new culture procedures for the isolation of Paenibacillus larvae, the cause of American foulbrood (AFB), from adult bees and honey samples, and the use of these techniques in the detection of clinical and sub-clinical AFB infections. These procedures initially involve homogenisation of adult bee samples, or dilution in the case of honey samples, followed by centrifugation, heat treatment and culture on solid media containing nalidixic acid. The culture of adult bees was also used to trace the

spread of P. larvae from hive to hive within an apiary where some hives had experimentally induced AFB. Adult bee culture also provided a novel means to determine the P. larvae carrier load of swarms and feral colonies which led to the assessment that they are unlikely to be important in the spread of AFB. Although the culture of P. larvae from honey samples has been reported by a number of workers, the culture of P. larvae from bulk honey samples described in this thesis provides the most sensitive culture procedure reported to date. The culture of bulk honey samples for P. larvae, coupled with the trace-back of positive samples to the hives of origin, was demonstrated to be an effective means of detecting AFB. This procedure was also used to demonstrate the higher prevalence of P. larvae in bulk honey samples from a State where antibiotic therapy is used to control AFB, compared to a State where hive destruction and/or irradiation of diseased equipment is practised. The reports that P. larvae vegetative cells cannot cause disease were confirmed, features of the lethal effect of royal jelly on P. larvae vegetative cells as well as the relatedness of geographically diverse P. larvae isolates are reported. The developments in AFB detection, which are reported in this thesis, prompted the beekeeping industry to request a cost-benefit analysis for the eradication of AFB from Australia. This analysis, which determined that there are economic benefits in pursuing such a strategy in Australia, and a scheme outlining the requirements for an eradication campaign, are presented.

Hornitzky, M. A. Z. and S. Clark (1991). "Culture of Bacillus larvae from bulk honey samples for the detection of American foulbrood." Journal of apicultural research. 30(1): 13-16.

Hornitzky, M. A. Z. and S. Karlovskis (1989). "A culture technique for the detection of Bacillus larvae in honeybees." Journal of apicultural research. 28(2): 118-120.

Hornitzky, M. A. Z., et al. (1996). "Bacillus larvae carrier status of swarms and feral colonies of honeybees (*Apis mellifera*) in Australia." Australian veterinary journal. 73(3): 116-117.

Hornitzky, M. A. Z. and B. White (1983). "Large scale application of gamma radiation in the control of American foulbrood." Australasian beekeeper 84(8): 151-153.

In 1982, following an AFB outbreak, about 1400 hive boxes with frames, and other hive parts, were taken from apiaries in New South Wales and Queensland to be irradiated at a commercial cobalt-60 plant in Victoria. Aluminium 'hoppers' each containing a 3-storey hive complete with roof and floorboard, were exposed to 1 megarad of gamma radiation in a radiation cell. After treatment the irradiated equipment was restocked with bees; 7 weeks later no AFB could be detected. The cost of transporting and irradiating equipment worth $A31 655 was $A8922.D.G. Lowe.

Kabay, M. J. (1995). "Evaluation of the culture of honey to detect American foul brood." Australian veterinary journal. 72(1): 33-34.

King, C. (2020). "Annual reports from national pest management strategies: American foulbrood." Surveillance (Wellington) 47(3): 42-42.

Manning, R. J. G. (2006). "Surveillance of swarms and feral honey bees (*Apis mellifera*) for the presence of American Foulbrood (Paenibacillus larvae sub. sp. larvae) spores and their habitat preferences in Western Australia."

Matheson, A. and M. Reid (1992). "Strategies for the prevention and control of American foulbrood. II." American bee journal. 132(7): 471-475.

Oldroyd, B. P., et al. (1989). "The effect on American foulbrood of standard oxytetracycline hydrochloride treatments for the control of European foulbrood of honeybees (*Apis mellifera*)." Australian Journal of Agricultural Research 40: 691-697.

Twenty honeybee colonies were treated with various oxytetracycline hydrochloride (OTC) preparations at the time of inoculation with Bacillus larvae spores or after AFB signs had developed. Treatment with 1 g OTC at the time of inoculation delayed the development of AFB in 4 colonies for periods between 2 months and 1 year. One colony so treated did not contract the disease. Colonies with a light AFB infection treated with 1 g of OTC recovered from the disease in 3-4 weeks, but AFB re-appeared in 3 of 5 colonies in the following season. Colonies with a well

established infection showed complete recovery from AFB after various OTC treatments. However, nearly all of these colonies developed AFB signs in the following season. B. larvae was cultured from adult bee samples from colonies that were AFB-free at the time of sampling but which subsequently developed disease signs, and from colonies that were AFB-free at the time of sampling but did not subsequently develop the disease. The results show that recommended treatments for EFB effectively mask AFB, making it likely that beekeepers treating EFB also suppress signs of AFB if it is present. As it is common practice in Australia to treat EFB prophylactically with OTC, an escalation of AFB in Australian hives is anticipated.

Reid, M. (2012). "American foulbrood." Surveillance (Wellington) 39(3): 39-40.

Sharland, E. (2016). "Brucella ovis accreditation scheme 2015." Annual Report 43(3): 38-38.

Swart, D. (2019). "American foulbrood." Surveillance (Wellington) 46(3): 40-40.

Taylor, B. (2014). "American foulbrood." Surveillance (Wellington) 41(3): 40-41.

White, B. (1997). "Code of practice for management of American foulbrood." Agnote - NSW Agriculture(DAI/41): 2-pp.

Witte, K. d. (2000). "American foul brood of honey bees." Agnote (Darwin)(577): 3-pp.

Biosecurity

(1976). "New Zealand insect pests." New Zealand Insect Pests.: 311-pp.

This book (to which various authors have contributed) on arthropod pests causing problems in New Zealand has been written primarily for undergraduate agricultural students but will also be of interest to advisory officers, farmers and horticulturalists. Agricultural pests are grouped according to the crop affected, household pests according to the activity of man affected and pests of medical importance according to the type of injury caused to man or livestock. Notes are provided on the external morphology, biology and control of each pest. Nematodes injurious to crops are also included. A chapter on bees and pollination includes information on honey bees (*Apis mellifera* L.) and other bee species that have been introduced as pollinators. There is a chapter on insecticides, their toxicity, formulation and application and one in which chemical control procedures for groups of pests (for example, subtropical fruit pests) are set out in tabular form. A glossary and an index that includes vernacular names of the pests are provided. ADDITIONAL ABSTRACT: This book on arthropod pests causing problems in New Zealand includes chapters by various authors in which notes are given on the external morphology, biology, habits and control of household pests (including Calliphora spp., Blattella germanica (L.) and other cockroaches, and Musca domestica L.), medically important pests (including wasps, venomous spiders, mites infesting man, Cimex lectularius L., fleas, mosquitoes, Austrosimulium spp. and Dermatophagoides pteronyssinus (Trt.), and livestock pests (including Acarina, lice and Diptera). There is a chapter on insecticides, their toxicity, formulation and application, and one in which chemical control procedures for groups of pests (for example, medically important pests) are set out in tabular form. ADDITIONAL ABSTRACT: This book on arthropod pests causing problems in New Zealand includes chapters by various authors in which notes are given on the external morphology, biology, habits and control of household pests (including Calliphora spp., Blattella germanica (L.) and other cockroaches, and Musca domestica L.), medically important pests (including wasps, venomous spiders, mites infesting man, Cimex lectularius L., fleas, mosquitoes, Austrosimulium spp. and Dermatophagoides pteronyssinus (Trt.), and livestock pests (including Acarina, lice and Diptera). There is a chapter on insecticides, their toxicity, formulation and application, and one in which chemical control procedures for groups of pests (for example, medically important pests) are set out in tabular form. ADDITIONAL ABSTRACT: Plant-parasitic nematodes are included in this text book for students of applied entomology in New Zealand. Separate chapters by different authors cover various types of crops and the insects and nematodes found on them, giving a brief description of the pest, its life history, economic importance and control. The nematodes included are Anguina agrostis, A. tritici, Aphelenchoides fragariae, A. ritzemabosi, Ditylenchus dipsaci,

Heterodera avenae, H. pallida, H. rostochiensis, H. trifolii, Meloidogyne hapla, M. incognita, Pratylenchus sp. and Deladenus as a parasite of Sirex noctilio. Sections on insecticides and on chemical control procedures include references to nematicides.

(1980). "Bibliography of bee disease articles published in the "A.B.K." June 1977 - April 1980." Australasian beekeeper 81(10): 212-213.

(1990). "Proceedings, Honeybee Diseases Workshop, April 1990." Proceedings, Honeybee Diseases Workshop, April 1990.: 97-pp.

The increase in incidence of endemic bee diseases in Australia and the threat of exotic diseases prompted a 2-day national workshop of industry representatives, scientists and extension workers, to identify the key issues relating to bee diseases and to propose areas for research and development. Papers were presented on the disease situation in each state, contingency plans for exotic diseases, certification and compensation schemes. There are 4 pages of recommendations. Endemic diseases and pathogens described include AFB, EFB, *Nosema* disease, sac brood chronic paralysis, black queen cell virus, Bacillus alvei, Kashmir bee virus, amoeba disease, stone brood. Pests include Braula coeca (Tasmania only), wax moths, ants, wasps, cane toads, birds, termites, the honey fly Cerioides ornata, and *Acarapis dorsalis*. Exotic parasites and diseases considered to be a threat are *Tropilaelaps clareae*, *Varroa jacobsoni*, *Acarapis woodi*, chalk brood. Two of the review papers have been published elsewhere [Hornitzky (1990) Australasian Beekeeper 92 (1) 20-28; Anderson (1990) Australasian Beekeeper 92(6) 227-231].

(1996). "Honey bee exotic diseases and pests." Honey bee exotic diseases and pests.: 4-pp.

The 6 overseas pests and diseases which could threaten New Zealand beekeeping are named as: European foul brood (Melissococcus pluton), varroa (*Varroa jacobsoni*), the Asian bee mite (*Tropilaelaps clareae*), the tracheal mite (*Acarapis woodi*), Africanized honey bees (*Apis mellifera* scutellata), and the bee louse (Braula coeca). Distinguishing features of these are described and precautions which can be taken by the Ministry of Agriculture and by beekeepers are outlined.

(1997). "Suspected exotic disease investigations." Surveillance (Wellington) 24(4): 23-25.

(2013). "Recognising the power of surveillance." Surveillance (Wellington) 40(3): 83-pp.

This annual report edition of Surveillance issue 40 (3) presents topics on animal, plants, and environmental surveillance intended for biosecurity. Topics on animals inludes: international animal trade, animal health and laboratory and surveillance, surveillance programmes for avian influenza, wildlife diseases, transmissible spongiform encephalopathies (TSE), Arboviruses, honey bee exotic disease, bovine tuberculosis, poultry health and American foulbrood. Other topics presented includes: Brucella ovis accreditation scheme, infectious bursal disease eradication programme, quarterly review of diagnostic cases: April to June 2013, quarterly report of investigations of suspected exotic diseases, marine surveillance annual report, quarterly report of investigations of suspected exotic marine and freshwater pests and diseases, national invasive ant surveillance programme annual report, national fruit fly surveillance programme, national saltmarsh mosquito surveillance programme 2012-2013, high risk site surveillance annual report 2012-2013, gypsy moth surveillance programme annual report, and plant and environment investigation report.

(2016). "Healthy bee population proves good for exports." Practical Hydroponics & Greenhouses(163): 8-8.

The article reports on the survey conducted in Australia based on the honey bee viruses which revealed that it has one of the healthiest honeybees called *Apis mellifera* which it can export.

(2016). "It's official: our honey bees are some of the healthiest in the world." Ecos(215): 1-2.

The article informs that a national bee survey led by Commonwealth Scientific & Industrial Research Organization's John Roberts, which screened 1,240 hives of 155 apiaries in various locations across Australia. The survey reveals that the healthiest European honey bee (*Apis mellifera*) populations in the world are found in Australia.

Anderson, D. (1987). "Amoeba disease confirmed in New Zealand." New Zealand beekeeper(194): 11-13.

During September and October, 1986, cysts of *Malpighamoeba mellificae* were detected in the Malpighian tubules of worker honeybees collected from 5 widespread localities in New Zealand. This confirms the presence of amoeba disease in New Zealand. Diagnosis, control, and other aspects of the disease are described. Author.

Anderson, D. (1990). "The disease and pest situation in the Pacific region; the threat of exotic diseases and pests from Papua New Guinea; diseases and disorders of queen bees." Australasian beekeeper 92(6): 227-231.

The situation in each of the following is summarized briefly: Fiji, Norfolk Island, Western Samoa and New Zealand. In Papua New Guinea (PNG), beekeeping in the Highland region has been developed with aid from New Zealand, and over 200 beekeepers now have 4000 *Apis mellifera* colonies in hives. However, this beekeeping is threatened by the continuing spread of *A. cerana* swarms (55-100 km/yr) which are infected with AFB and Kashmir bee virus. These pathogens have not previously been reported in PNG. The swarms are also infested with *Varroa jacobsoni* and possibly low numbers of *Tropilaelaps clareae*. The likely future directions of spread of *A. cerana* are suggested; if they reached Australia, the situation would be very serious. The last part of this article discusses research, just started, on diseases and disorders of *Apis mellifera* queens.

Anderson, D. (1997). "Disappearing disorder." Australasian beekeeper 99(5): 186-188.

In 1994, 3 outbreaks of disappearing disorder were examined in SE Queensland. Symptoms of the affected larvae are described; disorientated adult workers were also sometimes seen crawling on the ground near their hive entrances. Affected colonies were foraging on a variety of pollen and nectar sources. A few pathogenic microorganisms were isolated from larvae, but in most affected larvae no particular microorganisms were present, and many larvae contained none. The trace elements present in nectar and pollen samples collected from colonies were analysed. Levels of trace elements, particularly zinc, were significantly higher than in samples from healthy control colonies.

Anderson, D. and I. J. East (2008). "The latest buzz about colony collapse disorder." Science (Washington D C) 319(5864): 724-725.

Anderson, D. L. (1988). "Half-moon disorder of the honey bee (*Apis mellifera* L.) in New Zealand." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 77-79.

In this disorder (HMD), first described in 1982, larvae die while still in the coiled stage after first turning yellow. They dry into crescent or 'half-moon' shaped brown scales half-way up or around the lip of their cells. So far no causative organism has been isolated. In the studies described, no viruses were detected in dead larvae, and the only bacteria isolated were Bacillus coagulans (2 colonies) and B. larvae (2 colonies). There was no evidence that a bacterium is the sole causative agent of the disorder, nor was there any evidence of protozoan, rickettsial or fungal infections. Darkened fat-bodies and dark flecks on the ovaries were found in queens from colonies with HMD. Colonies into which brood combs containing HMD were introduced did not develop HMD, but when queens from affected colonies were introduced into healthy colonies, these also developed the disorder. It is concluded that HMD is probably due to a queen disorder. Additional symptoms for HMD are described.

Anderson, D. L. (1988). "Pathologist's report [to the New Zealand National Beekeepers' Association Conference 1988]." New Zealand beekeeper(199): 12-15.

In a study carried out in 1987 in 2 kiwifruit orchards in New Zealand, it was found that amounts of pollen collected by colonies artificially infected with *Nosema apis* or sac brood virus were significantly lower than those collected by healthy colonies. Results to date are reported from a survey of honeybee diseases in New Zealand, which was started in 1985. *Nosema* is the most serious disease found in adult bees, and spore levels are especially high in spring and early summer. The close association of this disease with black queen cell virus and Kashmir bee virus needs further investigation. The most serious brood disease is AFB; it seems likely that many beekeepers are not familiar with its symptoms. Although 4 species of harmless mites have been found during the survey, parasitic mites were not present in any samples. Amoeba disease was found in some samples, as was half-moon disorder. Results of the survey are still being evaluated.^CENTREQUAD~P. Walker.

Aughterson, W. H. (1970). "The diseases of bees." The diseases of bees.: 48-pp.

Diseases of brood and of adult bees are described with methods of treatment particularly relevant to Australian conditions.M. D. Seager

Beard, J., et al. (2008). "Procedure for submitting bee and beehive samples for testing."

Benko, M. and B. Harrach (2009). "8th International Congress of Veterinary Virology, Budapest, Hungary, 23-26 August, 2009. 20 years of ESVV: integrating classical and molecular virology, programme and proceedings." 8th International Congress of Veterinary Virology, Budapest, Hungary, 23-26 August, 2009. 20 years of ESVV: integrating classical and molecular virology, programme and proceedings: 243-pp.

These proceedings presents papers submitted at the 8th International Congress of Veterinary Virology, held in Budapest, Hungary, last 23-26 August, 2009. The subtitle of this anniversary congress is "20 years of ESVV: Integrating classical and molecular virology". The lectures and the posters will summarize the two-decade history of the Society (European Society for Veterinary). Virology and will illustrate the recent achievements in veterinary virology. Main topics presented includes: viral diagnosis; vaccines and viral immunology; host-virus interactions and pathogenesis; emerging viruses and zoonoses; epizootiology; evolution and genomics, viruses of wild and exotic animals.

Bercbnyi, O., et al. (2007). "Phylogenetic Analysis of Deformed Wing Virus Genotypes from Diverse Geographic Origins Indicates Recent Global Distribution of the Virus." Applied and environmental microbiology AEM. 73(11): 3605-3611.

Honeybees originating from 10 different countries (Austria, Poland, Germany, Hungary, Slovenia, Nepal, Sri Lanka, the United Arab Emirates, Canada, and New Zealand) located on four continents were analyzed for the presence of deformed wing virus (DWV) nucleic acid by reverse transcription-PCR. Two target regions within the DWV genome were selected for PCR amplification and subsequent sequencing, i.e., a region within the putative VP2 and VP4 structural-protein genes and a region within the RNA helicase enzyme gene. DWV nucleic acid was amplified from 34 honeybee samples representing all the above-mentioned countries with the notable exception of New Zealand. The amplification products were sequenced, and phylogenetic analyses of both genomic regions were performed independently. The phylogenetic analyses included all sequences determined in this study as well as previously published DWV sequences and the sequences of two closely related viruses, Kakugo virus (KGV) and *Varroa destructor* virus 1 (VDV-1). In the sequenced regions, the DWV genome turned out to be highly conserved, independent of the geographic origins of the honeybee samples: the partial sequences exhibited 98 to 99% nucleotide sequence identity. Substitutions were most frequently observed at the same positions in the various DWV sequences. Due to the high level of sequence conservation, no significant clustering of the samples in the phylogenetic trees could be identified. On the other hand, the phylogenetic analyses support a genetic segregation of KGV and VDV-1 from DWV.

Bingham, P. (2010). "Investigations of suspected exotic diseases." Surveillance (Wellington) 37(1): 22-29.

Bingham, P. (2010). "Quarterly report of investigations of suspected exotic diseases." Surveillance (Wellington) 37(3): 33-44.

Bingham, P. (2012). "Quarterly report of investigations of suspected exotic diseases." Surveillance (Wellington) 39(3): 55-65.

Bingham, P. (2013). "Quarterly report of investigations of suspected exotic diseases." Surveillance (Wellington) 40(3): 58-63.

Bingham, P. (2014). "Quarterly report of investigations of suspected exotic diseases." Surveillance (Wellington) 41(4): 15-18.

Bingham, P. (2015). "Quarterly report of investigations of suspected exotic diseases." Surveillance (Wellington) 42(2): 18-22.

Bingham, P. (2017). "Quarterly report of investigations of suspected exotic diseases: October to December 2016." Surveillance (Wellington) 44(1): 18-24.

Braybrook, L. H. (1970). "Bogong moths." Beekeepers' Bulletin 15(3): 3-3.

The moths infested flowers of certain early flowering *Eucalyptus* at night, and honeybees subsequently would not work the crop. This has contributed to the recent decline in honey yields. Bogong moths are now an annual pest in some areas of Victoria, due, it is thought, to the increase in irrigated pasture which has created favourable conditions for the moths to survive during the summer. D. G. Lowe.

Braybrook, L. H. (1977). "Controlling disease without drugs in Victoria." Proceedings of the XXVIth International Apicultural Congress, Adelaide.: 441-444.

Control of AFB in Victoria is by inspection, destruction of diseased stocks, and decontamination of equipment with soap and antiseptics.

Brenton-Rule, E. C., et al. (2018). "The origins of global invasions of the German wasp (Vespula germanica) and its infection with four honey bee viruses." Biological Invasions 20(12): 3445-3460.

A successful control or eradication programme using biological control or genetically-mediated methods requires knowledge of the origin and the extent of wasp genetic diversity. Mitochondrial DNA variation in the native and invaded range of the social wasp Vespula germanica was used to examine intra-specific genetic variation and invasive source populations. We also examined wasps for the presence of four viruses found in honey bees: Acute bee paralysis virus, Deformed wing virus, Israeli acute paralysis virus and Kashmir bee virus. German wasps showed reduced genetic diversity in the invaded range compared to that of their native range. Populations in the introduced range are likely to have arrived from different source populations. All four viral honey bee pathogens were found in V. germanica, although they varied in their distribution and strain. Multiple introductions of German wasps have occurred for most invaded regions, though some populations are genetically homogenous. The differing locations of origin will guide researchers searching for biocontrol agents and the reduced genetic diversity may make these wasps a potentially viable target for control via gene drives.

Briggs, L. (1984). "Megachile (leaf cutter bee) importation from New Zealand. Notes on some recent developments." Australasian Beekeper 85(10): 185-186.

Discusses evidence that these bees could carry Ascosphaera infections; A. apis may be present in New Zealand.

Brown, G. R. (1979). "The European wasp is a potentially dangerous import." Agricultural Gazette of New South Wales 90(5): 38-39.

In 1978, nests of Vespula germanica (F.) were found in New South Wales for the first time; since then, 20 nests have been found and destroyed, the wasp being confined so far to the Sydney metropolitan area with the greatest concentration near the mouth of the Georges River from where outbreaks possibly originated. The biology of the wasp is reviewed from observations in other countries. Notes and coloured illustrations are provided for distinguishing adults of V. germanica from honey bees [*Apis mellifera* L.] and for distinguishing the nests from those of the native paper wasps Polistes spp. and Rhopalidia spp. The pest status of V. germanica in New Zealand and Australia is discussed, with special reference to the wasp as a pest of bee-hives, and it is reported that it has already been observed in large numbers in the vicinity of one apiary at Oatley, New South Wales.

Brown, G. R. (1984). "European wasp." Agfacts(AE.31, Edn. 2): 3-pp.

Notes are provided on the recognition, biology, injuriousness and control of Vespula germanica in New South Wales, where this species has become established since about 1978 and is a nuisance and also a pest of apiaries [*Apis mellifera*], destroying the colonies.

Brown, M., et al. (2014). "Epidemiological surveillance and control of bee diseases." Bee health and veterinarians: 193-213.

Countries across the world have very different approaches to the control of honey bee pests and diseases in attempting to achieve the aims of apiary surveillance, from large-scale active programmes carried out by inspection services or Veterinary Services through to passive surveillance, relying mostly on reporting of suspect pests and diseases by beekeepers. While recognising that many different surveillance systems operate across the world, this paper details the functions and activities of two programmes: one from within Europe (England and Wales) and one from outside the European Community (New Zealand). It also covers the designation of a new European Union Reference Laboratory for honey bee health and its key role in the coordination of piloting harmonised pan-European surveillance initiatives.

Buczek, K. (2009). "Honey bee colony collapse disorder (CCD)." Annales Universitatis Mariae Curie-Skcpodowska. 64(1): 1-6.

Colony Collapse Disorder (CCD) is the most serious, abruptly die-off of European honey bee colonies across the world. The main symptom of CCD is simply no or a low number of adult honey bees present but with a live queen and no dead honey bees in the hive. Often there is still honey in the hive, and live brood is present. It is also characterized by delayed robbing and slower than normal invasion by common pests such as wax moth (Galleria mellonella) and small hive beetles (*Aethina tumida*). Now, in many countries CCD creates a very serious problem for beekeepers and threaten the pollination industry. CCD is economically significant because many agricultural crops worldwide are pollinated by bees. Beekeepers observed CCD in USA in 2006, then in Canada, Australia, Belgium, France, the Netherlands, Greece, Italy, Portugal and Spain. The reports have also come in from Switzerland, Germany, Finland and Poland.It is unlikely that a single factor is the cause of CCD; it is more likely that there is a complex of different components. The search for factors that are involved in CCD is focusing on few areas and the cause or causes of the syndrome are not yet fully understood. Many authorities attribute the problem to immunosuppression and biotic factors such as *Varroa destructor* mites, *Nosema apis* and *Nosema ceranae* and Israel acute paralysis virus (IABPV). Other proposed causes include environmental change-related stresses, malnutrition and pesticides, mainly neonicotinoids, migratory beekeeping. More speculative possibilities have included both cell phone radiation and genetically modified crops. Stress, in general, compromises the immune system of bees and may disrupt their social system, and individual immune response, making colonies more susceptible to diseases. The only pathogen found in almost all samples from honey bee colonies with CCD, but not in non-CCD colonies, was the Israeli acute paralysis virus (IABPV) that can be transmitted by the *Varroa destructor* mite. It was found in 96.1 percent of the CCD-bee samples. Some researchers have attributed the syndrome to the practice of feeding high fructose corn syrup to supplement winter stores. Affliction with Varroa mites also tends to weaken the immune system of the bees. However not all dying colonies are parasitized by these mites. Some genetically modified crops produce the natural insecticide Bt toxin, which was hypothesised to affect bees. No experiments have found evidence of any negative effect whatsoever on honey bee populations. The continuous movement and re-settlement render bee colonies less resistant to disorders. It was also suggested that climate change can make bee hives more vulnerable to CCD, and that the closerange electromagnetic field may reduce the ability of bees to return to their hive. Therefore, it seems that CCD may be due to a combination of many factors and that no single factor is the cause.

Cabral, L. and A. E. Jackson (2014). "Scientific and clinical-Challenges of BVDV control in Australia. Movements of Australian beekeepers. Echinococcus granulosus infection in rural dogs. Canine leucocyte adhesion deficiency III. Wastage in the racing industry." Australian Veterinary Journal 92(8): 275-276.

Ceballo, F. A. and G. H. Walter (2005). "Why is Coccidoxenoides perminutus, a mealybug parasitoid, ineffective as a biocontrol agent - Inaccurate measures of parasitism or low adult survival?" Biological Control 33(3): 260-268.

Coccidoxenoides perminutus achieves only low levels of parasitism of its host Planococcus citri in southeast Queensland citrus. Two possible causes were investigated. Adult survival under natural conditions was assessed to determine whether providing adult food sources could enhance survival. Behavioural changes of hosts, induced by C perminutus parasitism, was also investigated to establish if parasitised P. citri move from their feeding site to seek protected shelters some distance away and are thus not accounted for in field assessments of parasitism rates. Unparasitised mealybugs placed in the field for two periods were retrieved before the effects of parasitism were manifested and parasitism rates were still low (0.3% at 5 days and 1.2% at 10 days). Levels of locomotion of P. citri exposed to C perminutus were compared with those of "unexposed" ones. Parasitised mealybugs, regardless of

instar, undergo behavioural changes. In comparison to unparasitised controls, the mealybugs become highly active 7-14 days after exposure to wasps. All parasitised mealybugs undergo physical changes, their body becomes cylindrical, their legs go so rigid that the mealybugs become immobile, and this signifies the typical mummy appearance. All mealybugs that became mummies eventually fell from the host lemon fruit because of impaired locomotion and were caught on sticky traps that had been placed beneath the lemons. Consequently, their final site of mummification was not established. C perminutus adults provided with nectar or honey survived longer (about 5 days) in the field than those without food (about a day). Nectar from two plant species, Alpinia zerumbet and Datura candida, proved to be good sources of food for the adult wasps, and were comparable in quality to honey. The low level of parasitism achieved by C perminutus in southeast Queensland citrus thus appears to be a consequence of the short adult life and the negative effects of a harsh environment. Provision of a suitable food source (e.g., nectar) may well enhance levels of parasitism in the field.

Chambers, S. R. (1977). "Western Australian border closed to import of honeybees." Australasian beekeeper: 120-121.

Clapperton, B. K., et al. (1989). "The impact of common and German wasps (Hymenoptera: Vespidae) on the New Zealand beekeeping industry." New Zealand Journal of Zoology 16(3): 325-332.

The proportion of common wasps Vespula vulgaris were compared in samples sent to the authors by members of the public in New Zealand with the proportion in samples sent by beekeepers from their apiaries. V. vulgaris robbed beehives less frequently than V. germanica relative to their population levels in the environment. A questionnaire was sent to 600 beekeepers throughout New Zealand asking for information on the impact of wasps on their operations in the 1985/86 and 1986/87 seasons. The majority (83.8%) of the 278 respondents considered wasps to be a nuisance. Beekeepers found more wasps nests in areas with (referred to as "vulgaris" areas) than without the common wasp ("non-vulgaris" areas), even though they spent no more time in wasp control. Similar numbers of overwintering nests were found in vulgaris and non-vulgaris zones. Overwintering nests were more common, and wasps caused more problems during spring buildup in North Island than South Island. Wasps totally destroyed or seriously affected 8.13% of hives in 1985/86 and 9.35% in 1986/87. South Island beekeepers in honeydew beech forests where V. vulgaris were present faced greater hive damage levels than beekeepers elsewhere in the country. However, the increase in damage between the 2 seasons was much lower than the increase in the wasp population over the same time. Further, the number of hives totally destroyed by wasps in V. vulgaris infested regions of the South Island changed little between seasons. The increased damage levels resulted mostly from an increase in seriously affected hives. It is concluded that high wasp abundance was probably the reason for the high hive damage levels in the honeydew forests in 1986/87. This was offset by the low rate of robbing and lack of overwintering nests of V. vulgaris, which poses less of a threat than V. germanica to the New Zealand beekeeping industry. ADDITIONAL ABSTRACT: The majority (84%) of the 278 beekeepers (mainly commercial and semi-commercial) who replied to a questionnaire considered that wasps were a nuisance during the seasons surveyed, 1985-86 and 1986-87. Wasp samples collected from hives contained lower proportions of Vespula vulgaris than samples collected by the public in the same areas. One urban hive sample contained 23 V. germanica individuals. Overwintering nests were more common, and wasps caused more problems during spring build-up, in North Island than in South Island. Overall, wasps totally destroyed or seriously affected 8% and 9% of colonies in the 2 seasons, respectively. But this increase in wasp damage was less than the increase in wasp populations, especially those of V. vulgaris. Wasp damage in the South Island honeydew beech forests where V. vulgaris is present is higher than elsewhere in the country. The economic effects of wasp damage are discussed.

Clinch, P. G. (1979). "Control of *Acarapis externus* Morgenthaler: further tests to determine the efficacy of pesticides fed in sugar syrup to infested honey bees." New Zealand journal of experimental agriculture 7(4): 407-409.

In further tests in the laboratory in New Zealand, 16 pesticides were fed in sugar syrup to infested honeybees (*Apis mellifera* L.) at one-tenth of their oral LD50 to the bees, for the control of *Acarapis externus* Morgenthaler [see RAE/A 66, 1209]. The 4 most effective compounds were tested on colonies of bees in the field in 1977 and 1978. Fenbutatin oxide at 10 000, amitraz at 120 and cyhexatin (tricyclohexyltin hydroxide) at 3500 mg/2 litres syrup were significantly more effective than endosulfan at 40 mg/2 litres syrup. It is suggested that the feeding method could be effective against other mites, including A. woodi (Rennie) and *Varroa jacobsoni* Oudm. It is preferable to undertake treatment against *Acarapis* spp. in winter, so that honey frames do not become

contaminated, and it is essential that treatment against V. jacobsoni be carried out at this time because only then are the mites confined to adult bees.

Coffey, I. A., et al. (1991). "Report on Australian mission to USSR on genetic improvement of honey bees, 26 August to 9 September 1990." Australasian beekeeper 92(8): 322-330.

Beekeeping statistics for the USSR are given. The mission, which visited Rybnoe Bee Research Institute and also inspected queen breeding programmes in the Caucasian region, obtained 10 Mountain Grey Caucasian queens for evaluation in Australia. Further exchanges of information and material were agreed.

Cook, A., et al. (2002). "The impact of exotic insects in New Zealand." Biological invasions: economic and environmental costs of alien plant, animal, and microbe species: 217-239.

This paper explores New Zealand's transition from "virgin soil" status to participant in the global exchange of organisms. The impacts of these incursions are assessed, and the associated risks and costs of such events are illustrated using three recent case studies involving the southern saltmarsh mosquito, honeybee mite (*Varroa jacobsoni*) and painted apple moth (Teia anartoides).

Cook, D. C., et al. (2007). "Predicting the economic impact of an invasive species on an ecosystem service." Ecological applications. 17(6): 1832-1840.

Quantifying the impact of alien invasive species on ecosystem services is an essential step in developing effective practices and policy for invasive species management. Here we develop a stochastic bioeconomic model that enables the economic impact of an invasive pest to be estimated before its arrival, based on relatively poorly specified ecological and economic parameters. We developed the model by using a hypothetical invasion of the varroa bee mite (*Varroa destructor*) into Australia and the negative flow-on effects that it would have on pollination by reducing honey bee populations, giving rise to a loss of pollination services, reduced crop yields, and additional production costs. If the mite were to continue to be prevented from entering the country over the next 30 years, we estimate that the economic costs avoided would be US$16.4-38.8 million (Aus$21.3-50.5 million) per year. We suggest that current invasion response funding arrangements in Australia, which do not acknowledge these avoided damages, require amendment.

Cox-Foster, D., et al. (2008). "The latest buzz about colony collapse disorder - Response." Science (Washington D C) 319(5864): 725-725.

Cox-Foster, D. L., et al. (2007). "A metagenomic survey of microbes in honey bee colony collapse disorder." Science (Washington) 318(5848): 283-286.

In colony collapse disorder (CCD), honey bee colonies inexplicably lose their workers. CCD has resulted in a loss of 50 to 90% of colonies in beekeeping operations across the United States. The observation that irradiated combs from affected colonies can be repopulated with naive bees suggests that infection may contribute to CCD. We used an unbiased metagenomic approach to survey microflora in CCD hives, normal hives, and imported royal jelly. Candidate pathogens were screened for significance of association with CCD by the examination of samples collected from several sites over a period of 3 years. One organism, Israeli acute paralysis virus of bees, was strongly correlated with CCD.

Crosland, M. (1990). "The present and future impact of European wasps on beekeeping in Australia." Australian bee journal 71(1): 18-23.

D'Adamo, P. and M. Lozada (2003). "The importance of location and visual cues during foraging in the German wasp (Vespula germanica F.) (Hymenoptera: Vespidae)." New Zealand Journal of Zoology 30(3): 171-174.

The way in which foraging wasps use cues for prey location and choice appears to depend on both the context and on the type of prey. Vespula germanica is an opportunistic, generalist prey forager, and individual wasp foragers often return to hunt at sites of previous hunting success. In this paper, we studied which cues are used by this wasp when relocating a food source. Particularly we analysed the response to a displaced visual cue versus a foraging location at which either honey or cat food had been previously presented. We conclude that location is used over a displaced visual cue for directing wasp hovering, although the landing response is directed differently

according to bait type. When wasps are exploiting cat food, location also elicits landing, but if they are exploiting honey, a displaced visual cue elicits landing more frequently than location.

Daniels, G. (1978). "A new species of Dakinomyia from Queensland (Diptera: Asilidae)." Proceedings of the Linnean Society of New South Wales 103(4): 275-281.

Dakinomyia secuta sp.n. is described from central Queensland. Foraging and predacious behaviour of the asilid is described, the prey taken including honey bee (*Apis mellifera* L.), various other Hymenoptera, 2 other asilids, and a cicadid.

Dearden, P. K., et al. (2018). "The potential for the use of gene drives for pest control in New Zealand: a perspective." Journal of the Royal Society of New Zealand 48(4): 225-244.

Genetic technologies such as gene editing and gene drive systems have recently emerged as potential tools for pest control. Gene drives, in particular, have been described as potential solutions to the pest problems that beset New Zealand. Here we describe the current state of gene drive technologies and present a series of examples to examine the potential benefits and problems arising from gene drive approaches for pest control in New Zealand. We consider the risks and barriers, both biological and social, that would need to be addressed to deploy such systems against our key pests with particular reference to the unique characteristics of New Zealand's biota, environment and peoples. Gene drives are a potentially useful technology for the eradication of pests in New Zealand but a great deal of research and understanding, as well as public acceptance, is required before they can be implemented.

Donovan, B. J. (1984). "Occurrence of the common wasp, Vespula vulgaris (L.) (Hymenoptera: Vespidae) in New Zealand." New Zealand Journal of Zoology 11: 417-427.

After occurring sporadically in New Zealand since 1921, V. vulgaris was found in March and April 1983 to be established in Dunedin, where 6 nests were discovered. Subsequent examination of museum specimens showed that queens had been collected in Wellington in 1978, and nests by January 1982. Christchurch was invaded in early 1984, several workers were collected near Auckland in March and April 1984, and workers were reported at Nelson in March and May 1984. The Dunedin nests were up to 6 times as large as nests recorded from the Northern Hemisphere, and produced up to 23 times as many new queens. Workers, nest size, and nest productivity were sufficiently different from those reported in western North America to suggest that the New Zealand population originated elsewhere. Colour patterning of the head and pronotum readily separate New Zealand V. vulgaris from New Zealand V. germanica. The nest envelope of V. vulgaris is brown; that of V. germanica is grey. Conditions in New Zealand appear to be favourable for V. vulgaris; it can be expected to spread and it may at times reach the high population levels experienced in Europe and the western United States. Possible effects of the wasps as pests of honeybees are discussed.Author.

Donovan, B. J. (1992). "Problems caused by immigrant German and common wasps in New Zealand, and attempts at biological control." Bee world. 73(3): 131-148.

Donovan, B. J. (1996). "Progress with biological control of wasps." New Zealand beekeeper 3(4;5): 13-14.

Vespula germanica, a pest of honey bees, has been present in New Zealand for over 50 years, and V. vulgaris arrived and spread in the 1980s; its numbers are especially high in S. Island beech forests. Part I describes the introduction, breeding and establishment of Sphecophaga vesparum vesparum, a parasite of the wasps; this and another introduced subspecies, S. v. burra, do not attack honey bees. Part 2 considers other wasp predators which may be considered for introduction: an Israeli Sphecophaga, a European beetle Metoecus paradoxus and Bareogonalos species of parasitoids, but further importations will be limited by lack of funding.

Donovan, B. J., et al. (1992). "Comparative characteristics of nests of Vespula germanica (F.) and Vespula vulgaris (L.) (Hymenoptera: Vespinae) from Christchurch City, New Zealand." New Zealand Journal of Zoology 19(1-2): 61-71.

From July 1987 to June 1989, 141 nests and 365 nests, respectively, of the adventive social vespines the German wasp, Vespula germanica (F.), and the common wasp V. vulgaris (L.), from the City of Christchurch, New Zealand, were evaluated for seven major characteristics. There were few, if any, differences in nest sites, and from spring to early summer in nest traffic, nest size, and numbers of combs. However, German wasps showed no

preference for direction of nest entrances, while common wasp nests were more numerous in areas most exposed to the morning sun. Some German wasp nests survived the winter and began producing new worker cells by late June, but all common wasp nests died by June. Because common wasp nests have been reported surviving the winter in beech forest, which produces honey dew, and honey dew is not available in Christchurch City, common wasp nest survival over winter may be more dependent upon carbohydrates and/or prey dependent upon carbohydrates than the survival of German wasp nests. The presence of large, expanding wasp nests from early spring must impose localised predation pressures virtually unknown in the Northern Hemisphere where overwintering nests are rare. Wasp population dynamics, and impacts of wasps on fauna, are likely to vary between different geographical areas of New Zealand, but as targets for biological control, the two wasp species can generally be considered to be quite similar.

Doull, K. M. (1976). "Termination of the leafcutter bee project." Australian bee journal: 24-25.

Doyle, K. A. (1993). "Recommended suspension of exports of bees to Korea." Bee Briefs 10(2): 8-9.

The Korean National Animal Quarantine Service detected 7 Melittiphis mites in 15 packages of honey bees imported from 2 Australian apiaries. According to a study in Korea, these mites are harmful to bees (although research in New Zealand has indicated that they are not). The Korean authorities have therefore imposed a 2-yr prohibition on imports from the apiaries involved. It is recommended that, until the situation is clarified, exporters should voluntarily refrain from sending honey bees to Korea.

Earp, E. A. (1925). "The Wax-moth and its Control." New Zealand Journal of Agriculture 31(1): 26-pp.

Of the two wax moths occurring in bee-hives in New Zealand, Achroia grisella and Galleria mellonella, the latter is the more destructive. The moths lay their eggs in any place in the hive from which the larvae can find their way to the combs. The larvae prefer the brood combs, burrowing through them under cover of strong silken galleries, which they spin as a protection from the bees. In the warmer parts of New Zealand, breeding continues throughout the year. The remedial measures recommended are fumigation of the combs with sulphur or carbon bisulphide. Hive-boxes, etc., that have contained infested combs should be treated by scorching corners and crevices with a blow-lamp to destroy any eggs or larvae present.

Eaton, C. v. (1992). "New developments in the control of honey bee diseases in New Zealand." Surveillance (Wellington) 19(1): 8-9.

Edwards, E. D., et al. (2018). "Non-detection of honeybee hive contamination following Vespula wasp baiting with protein containing fipronil." PLoS One 13(10): e0206385-e0206385.

Introduced wasps (Vespula germanica and V. vulgaris) are costly invertebrate pests in New Zealand, with large impacts on the local ecology and economy. Wasps eat honeybees (*Apis mellifera*), which has potentially devastating effects on hive health, as well as agricultural and horticultural industries. Vespex bait, which contains fipronil in a proteinaceous carrier, has recently been introduced for wasp control. In over a decade of reported trials, honeybees have never been observed foraging on Vespex, likely because the bait contains no sugars to serve as a bee food source. However, the potential for the control agent fipronil to enter beehives has not been tested. Therefore, here, we investigated this using a liquid chromatography-mass spectrometry assay of fipronil and two of its environmental break-down and metabolic derivatives, fipronil desulfinyl and fipronil sulfone. We did not detect fipronil in any of the worker bee, bee larva, honey or pollen samples (n = 120 per product) collected from 30 hives over a 2-year period. Furthermore, although we detected fipronil desulfinyl in one honeybee sample, this is thought to have originated from a single individual, representing a rare occurrence of intoxication, and there was no evidence that Vespex was the toxicant source. There was also no evidence of trophallactic transfer of fipronil or its derivatives in any of the hives sampled. Previous studies have reported the impairment of individual bee performance at fipronil doses similar to the detection limit of our study. However, our results provide confidence that if undetectable intoxication was occurring, it would involve an acute exposure for those few individuals affected, with minimal impairment to colonies. Therefore, we conclude that the use of Vespex in the vicinity of honeybees does not result in significant hive uptake while effectively reducing wasp pressure on honeybee colonies.

Fain, A. (1987). "Observations on the hypopi of the genus Forcellinia Oudemans, 1924 (Acari, Acaridae)." Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Entomologie(57): 111-120.

A key to the hypopi of species of Forcellinia collected from various ants is given. The hypopus of F. wasmanni (collected from the ants Camponotus ligniperdus, Lasius fuliginosus and Formica spp.) is redescribed, and that of Forcellinia galleriella (of which adults had previously been found in hives of honeybees [*Apis mellifera*] infested by the pyralid Galleria mellonella in Australia) is described for the first time from hypopi collected from the ant Iridomyrmex humilis, also in Australia.

Fan, Q. H., et al. (2016). "New Zealand Pneumolaelaps Berlese (Acari: Laelapidae): Description of a new species, key to species and notes on biology." Systematic and Applied Acarology 21(1): 119-138.

Mites of the genus Pneumolaelaps Berlese are often found in association with bumble bees (Hymenoptera: Apidae). Approximately sixty species of the genus have been described worldwide but only two of them have been recorded in New Zealand, viz. Pneumolaelaps bombicolens (Canestrini, 1885) and P. breviseta (Evans & Till, 1966). A new species, Pneumolaelaps niutirani, collected from hives of honeybee *Apis mellifera* (Apidae) and nests of the German wasp Vespula germanica (Vespidae) brings the number of species in New Zealand to three. We herein review P. bombicolens and P. breviseta, describe the new species, Pneumolaelaps niutirani, with notes on its biology, and provide a key to the species known in New Zealand. This is the first report of Pneumolaelaps in association with a vespid wasp. © Systematic & Applied Acarology Society.

French, C. (1933). "New Records of Plants attacked by Native Insects." Vietnam Naturalist 1(2-3): 47-56.

The first of these notes deals with the Pyrrhocorid, Dindymus versicolor, H.-S. (harlequin bug), which in recent years has become an important pest in Victoria. It causes serious injury to grape-vines and also attacks apple, fig, pear, almond, raspberry, currant, gooseberry, apricot and peach, as well as many flowering plants and vegetables. It is uncertain what are its natural food-plants, but it breeds readily on the introduced weed, Malva rotundifolia and on hollyhock. The adults have also been observed feeding on dead larvae of the Lymantriid, Orgyia (Teia) anartoides, Wlk., and on old bones, and sometimes enter beehives. In the second note, the adults of the Melolonthid, Diphucephala colaspidoides, Gyll. [cf. R.A.E., A, viii, 410], are stated to be very destructive in Victoria to the foliage of apple, peach, cherry, plum and quince. They also attack rose, hawthorn, Leptospermum, spp., and wattle [Acacia] and the larvae have become serious pests of strawberries, completely destroying the roots.

Fulton, G. R. and A. B. Rose (2007). "Food remains in nests of Rainbow Bee-eaters Merops ornatus in old-growth woodland of south-western Australia." Australian Field Ornithology 24(1): 37-43.

Rainbow Bee-eaters Merops ornatus nest in burrows where they accumulate arthropod remains, in their nest-chambers, throughout the breeding season. We report on the food remains in seven nest-chambers, from Dryandra in south-western Australia. Dryandra encompasses 27 000 ha of old-growth woodland that has been identified with a greater richness and abundance of native arthropods than the surrounding agricultural region in which it is located. Honeybees *Apis mellifera* were the most frequent prey taken by Rainbow Bee-eaters, accounting for 94% (by number) of the total food remains found in their nests. The proportions of prey taken were found to vary significantly between some nests, although there was no consistent pattern between and within sites. The dominance of Honeybees in the food remains indicates both that the bees are present in this large reserve and that they are the preferred prey of Rainbow Bee-eaters, at this site, during the Bee-eater's breeding season.

Gloag, R., et al. (2017). "An invasive social insect overcomes genetic load at the sex locus." Nature Ecology & Evolution 1(1): 6-6.

Some invasive hymenopteran social insects found new populations with very few reproductive individuals. This is despite the high cost of founder effects for such insects, which generally require heterozygosity at a single locus-the complementary sex determiner, csd-to develop as females. Individuals that are homozygous at csd develop as either infertile or subfertile diploid males or not at all. Furthermore, diploid males replace the female workers that are essential for colony function. Here we document how the Asian honey bee (*Apis cerana*) overcame the diploid male problem during its invasion of Australia. Natural selection prevented the loss of rare csd alleles due to genetic drift and corrected the skew in allele frequencies caused by founder effects to restore high average heterozygosity. Thus, balancing selection can alleviate the genetic load at csd imposed by severe bottlenecks, and so facilitate invasiveness.

Gonzales, M. (2016). "Honey bee exotic pest and disease surveillance report." Annual Report 43(3): 31-32.

Gonzalez, L. and B. V. Brown (2004). "New Species and Records of Melaloncha (Udamochiras) Bee-Killing Flies (Diptera: Phoridae)." Zootaxa(730): 1-14.

Nine new species of Neotropical Melaloncha (Udamochiras) bee-killing flies are described: M. altobenia, atribiseta, concavella and sarmientoi from Bolivia, M. ancistra from Colombia, M. corniculata and schiaffinoae from Argentina, M. cucharella from Honduras, and M. stenotes from Costa Rica. The first host information is given for M. (U.) colossia, which attacks introduced honey bees (*Apis mellifera* L.) in northern Argentina.

Goodacre, W. A. (1923). "A Casual Enemy oi the Bee. The Dragon Fly (Hemianax papuensis)." Agricultural Gazette of New South Wales 34(5): 373-pp.

During 1921-22 Hemianax papuensis became a serious pest to apiaries. Under ordinary conditions of life this dragonfly lives on small flies and gnats, but when its natural food is scarce, it may frequent beehives and capture many bees.

Goodman, R. D., et al. (1990). "Studies on the use of phosphine gas for the control of greater wax moth (Galleria mellonella) in stored honey bee comb." American bee journal 130(7): 473-477.

Following the withdrawal in 1983 of ethylene dibromide for fumigating stored honey comb in Australia, the effectiveness of phosphine has been investigated as an alternative control for G. mellonella. When applied at the rate of one 0.6-g Phostoxin pellet (0.2 g phosphine) per super of combs, phosphine was lethal to eggs, larvae and pupae in supers contained within sealed plastic bags or under modular gas-tight covers. It was effective in stacks taped with PVC, but only if all gaps, cracks and joints were thoroughly sealed. It was ineffective in untaped stacks of supers.

Gordon, R., et al. (2014). "Nomadic beekeeper movements create the potential for widespread disease in the honeybee industry." Australian veterinary journal. 92(8): 283-290.

OBJECTIVE: To examine the nomadic movements of Australian beekeepers and determine their potential to assist the spread of pests and diseases. METHODS: A questionnaire was mailed to all beekeepers in Australia who maintained >100 hives, requesting information on the location of their home base, locations used throughout the year and the crops that the bees fed on in each location. The information was analysed using network analysis software and a geographic information system. RESULTS: Nomadic Australian beekeepers formed a connected network linking 288 locations from central Queensland to western Victoria. A second, smaller network included 42 locations in southeastern South Australia. Almond orchards in Robinvale and Boundary Bend and lucerne seed production in Keith were locations of major hive congregations driven by the opportunity to provide paid pollination services. In the 3months after completion of almond pollination in August 2008, movement of hives occurred from Robinvale and Boundary Bend to 49 locations, ranging from southeast Queensland to southwest Victoria. DISCUSSION: The movements identified in this study highlight the potential for rapid spread of disease or pests throughout the beekeeping industry should an incursion occur.

Grassl, J., et al. (2018). "Synergistic effects of pathogen and pesticide exposure on honey bee (*Apis mellifera*) survival and immunity." Journal of Invertebrate Pathology 159: 78-86.

Declines in native insect pollinator populations and substantial losses in managed honey bees have been reported on a global scale and become a widespread concern because of the importance of these insects for human food production and ecosystem stability. Several potential factors have been studied as possible causes of declining pollinator health, such as parasites and pathogens, exposure to agricultural pesticides, habitat loss and/or climate change. More recently, a combination of these factors rather than a single cause have been blamed for observed pollinator losses, but field studies of such interactions are challenging, especially in the presence of confounding environmental stressors. We therefore examined the impact of single and combined stressors on the honey bee (*Apis mellifera*) in a generally healthy Australian population. We exposed workers during their larval development and drones until they reached sexual maturity to the neonicotinoid pesticide Thiamethoxam, at concentrations more than 20 times lower than we initially measured in the field, the microsporidian gut pathogen *Nosema apis* or both stressors at the same time. We found that simultaneous exposure significantly reduced bee health. We observed a

substantial increase in mortality and a reduction of immunocompetence in workers exposed to both the pathogen and the pesticide. We conclude that the exposure of generally healthy bees to multiple environmental stressors results in synergistic effects where the effects are expected to negatively impact performance and could be sufficient to trigger colony collapse. We found that the vast majority of males did not survive to sexual maturity after exposure to very low levels of Thiamethoxam. This would not only reduce the reproductive success of individual colonies, but can also impact gene flow and genetic diversity at the population level, which are both known as key components of honey bee health.

Gross, C. L., et al. (2019). "Interactions between two species of recently-sympatric invasive honeybees: *Apis cerana* induces aggression in *Apis mellifera* during foraging." Biological invasions. 21(12): 3697-3706.

Honeybees *Apis mellifera* (European honeybee) and *Apis cerana* (Asian honeybee) are cosmopolitan, having colonized continents beyond their natural ranges. In tropical Australia, these alien species have recently become sympatric. The environmental and economic impacts of these species when in sympatry remain to be seen; however, any interspecific competition may be of significance. We examined conspecific and heterospecific interactions between honeybees foraging at the nectar- and pollen-providing flowers of Antipogon leptopus (Polygonaceae). We cross-classified 554 encounters by three variables; incoming bee species, resident bee species, and one of four potential responses: (1) incoming defers to resident; (2) incoming procures the flower from resident; (3) incoming and resident share the flower; or (4) both incoming and resident abandon the flower. We also measured aggression and foraging rates of workers at flowers. Both species visited similar numbers of flowers in a foraging bout and spent similar foraging times on individual flowers. Incoming *A. mellifera* were more likely to procure flowers from resident *A. cerana*, and incoming *A. cerana* were more likely to defer to resident *A. mellifera*. *A. mellifera* were more aggressive toward heterospecifics than conspecifics, with heterospecifics 4.5 times more likely to provoke an aggressive response. However, no significant difference between conspecific and heterospecific aggression was observed for incoming *A. cerana*. *A. mellifera* were less abundant, yet overall more likely to acquire flowers and use aggression to do so. Costs of aggression may help explain the population-scale dominance of *A. cerana* over *A. mellifera* in this study.

Guez, D., et al. (2017). "Colour and shape preferences of *Apis cerana* (Java genotype) in Australia." Bulletin of Insectology 70(2): 267-272.

The biology of *Apis cerana* F., the Asian honey bee, is far less known than that of its sister species *Apis mellifera* L. The arrival of *A. cerana* in North Queensland has prompted the need to better understand the ecology and biology of this species in an invasive context. We evaluated the colour, shape and spontaneous landing preferences of free flying *A. cerana* using artificial shape of equal surface. *A. cerana* displayed a stable and marked preference toward yellow regardless of the season (wet or dry). However, for other colours, different preference patterns were observed depending on the season suggesting a learned preference. Bees had a strong preference for star shaped U.V. nectar guides regardless of the season. Conversely to *A. mellifera*, *A. cerana* appeared to minimise the perimeter surface ratio in its landing choice choosing circular over jagged surfaces. However, when tested using polygons and circle of same area and thus very similar perimeters the choice pattern showed no minimisation of perimeter/surface ratio. Surprisingly, bees had a clear preference towards odd number apex shapes and 3/4 of landings occurring on the heptagon, despite the rarity of such 7-lobed flowers in nature.

Gulliford, R. B. (1987). "Bees - abandoned, neglected and a nuisance." Bee Management Series, New South Wales Department of Agriculture: 16-pp.

Outlines the requirements of the New South Wales 1985 Apiaries Act, regarding situations where bees are a nuisance.

Harman, A. (2009). "*Apis cerana* in Australia." Bee Culture: 67-67.

The article reports on the effort of Biosecurity Queensland to find and destroy as many *Apis cerana* or Asian honey bee nests and swarms as it can before the wet season. According to Primary Industries and Fisheries Minister Tim Mulherin, Australia dread the appearance of mites that are destroying commercial and hobbyist hives. Since the incursion was detected, 17 bee nests and swarms were already destroyed by Biosecurity Queensland. Mulherin encourages the public to help find swarms and nests through a joint backyard blitz involving surveillance teams.

Harman, A. (2009). "What's With Those ASIAN HONEY BEES." Bee Culture 137(6): 34-36.
The article focuses on the campaign of Biosecurity Queensland to eliminate an invasion by Asian honey bees in far north Australia. According to the article, help from the community and scientific knowledge regarding the pest bee are proving invaluable to Biosecurity Queensland's effort. The Asian honey bee is a threat because it is a carrier of the Varroa mite, which could threaten the Queensland honey industry because the European bees in the area have no tolerance for the mite. INSET: SMALL HIVE BEETLE.

Harman, A. (2010). "Australia steps up search for invading bees." Bee Culture 138(10): 65-65.
The article reports that the Biosecurity Queensland has expanded its restricted area to hunt for invading Asian honey bees.

Harman, A. (2011). "Asian bee problems continue in Australia." Bee Culture 139(5): 73-75.
The article reports on the problems of beekeepers about the emergence of Asian bee that spread in Queensland. It states that beekeepers make a protest rally against the Asian Honeybee National Management Group due to its decision to end the eradication program on March 21, 2011. It explains beekeepers' claim on the threats of Asian bees to the number of European honeybees resulting to the reduction of volume and variety of food.

Harman, A. (2012). "Asian bee - Australia." Bee Culture 140(1): 70-71.
The article reports that the Australian government accepted the decision of Consultative Committee on Emergency Plant Pests to manage Asian honey bees instead of eradicating it. Liberal Senator Richard Colbeck says that the decision is based on the assumption that the bees would move into the dense rainforest around Cairns. Australian Greens Deputy Leader Christine Milne notes that the government must consider the possible consequences of not eradicating the bees to Australia's biodiversity.

Heiling, A. M., et al. (2006). "Picking the right spot: crab spiders position themselves on flowers to maximize prey attraction." Behaviour 143(8): 957-968.
In plant-pollinator interactions, pollinating insects provide reproductive service to plants and receive food rewards. Flowers advertise the presence of nectar or pollen through various characteristics, including visual displays. In daisies (Chrysanthemum frutescens), the center of the inflorescence appears as a UV-absorbing bull's-eye that attracts pollinators, for example honeybees. Thomisus spectabilis crab spiders occupy daisies and prey on honeybees. They typically position themselves on the lingulate florets of daisies and create a color contrast that deceives honeybees. Honeybees prefer daisies with a T. spectabilis on the lingulate florets to vacant daisies. In contrast, when offered the choice between a vacant daisy and a daisy whose center was covered by a T. spectabilis, honeybees preferred the vacant daisy. Similarly, honeybees were deterred by daisies whose center was covered by lingulate daisy florets making a rectangle about the size of a T. spectabilis. Covering the lingulate florets of daisies by a rectangle of lingulate daisy florets, however, neither attracted nor repelled honeybees. Honeybees seem to rely on the visibility of the daisy center to locate food reward and, by positioning themselves on the lingulate florets of daisies, T. spectabilis exploit these sensory biases of prey.

Hornitzky, M. (1984). "Developments in bee disease research." Australasian beekeeper 86(3): 46-49.
Discusses viral diseases, the use of gamma-radiation in the control of bee diseases, future research at the NSW Regional Veterinary laboratory.

Hornitzky, M. (1990). "Honey bee diseases in Australia 1990-overview." Australasian beekeeper 92(1): 20-28.
American and European brood diseases [foul brood] are considered to be the most important bee diseases in Australia.

Hornitzky, M., et al. (1989). "A case of stonebrood in Australian honey bees (*Apis mellifera*)." Australian veterinary journal. 66(2): 64-64.

Hornitzky, M. A. Z. (1985). "Major honey bee diseases in Australia." Australian Standard Diagnostic Techniques for Animal Diseases(35): 17-pp.

The 4 major honeybee diseases in Australia are EFB, AFB, *Nosema* disease and sac brood. For each of these diseases, details are given of pathogenesis, epidemiology, clinical signs and laboratory diagnosis. An appendix gives details of a medium for the cultivation of Melissococcus pluton.

Hornitzky, M. A. Z. (1987). "Australian standard diagnostic techniques for animal diseases. No. 35. Major honey bee diseases in Australia [incl IFAT S. pluton]." Australian standard diagnostic techniques for animal diseases. No. 35. Major honey bee diseases in Australia [incl IFAT S. pluton]. 17-pp.

Hornitzky, M. A. Z. (1994). "Commercial use of gamma radiation in the beekeeping industry." Bee World 75(3): 135-142.

The greatest use of gamma radiation in the beekeeping industry is in the control of AFB by sterilizing hive equipment contaminated with Bacillus larvae. Doses of 1-10 kGy have been recommended. In Australia, gamma irradiation treatment has been recognized legally as an alternative to burning contaminated hives; the instructions which are given to beekeepers in New South Wales are listed. Combs exposed to up to 8 kGy of gamma radiation still contain viable Melissococcus pluton, the causative agent of EFB, and the dose required for decontamination has not yet been determined. It is likely that spores of *Nosema apis* and other protozoa would be killed by comparatively low doses of gamma radiation, but the effects on fungal pathogens (e.g. Ascosphaera apis) and bee viruses have not yet been determined. Gamma radiation treatment of honey can cause a foamy scum and cloudiness; no significant deterioration in quality has been found, but further work is necessary. Gamma radiation can also be used for the decontamination of sugar 'candy' and pollen used for feeding bees. A limitation of the use of gamma radiation in beekeeping is the small number of treatment plants that exist worldwide.

Jamaludin, R., et al. (2002). "Apicultural exotic disease surveillance report." Surveillance (Wellington) 29(3): 19-21.

Koetz, A. H. (2013). "Ecology, Behaviour and Control of *Apis cerana* with a Focus on Relevance to the Australian Incursion." Insects. 4(4): 558-592.

Apis cerana Fabricius is endemic to most of Asia, where it has been used for honey production and pollination services for thousands of years. Since the 1980s, *A. cerana* has been introduced to areas outside its natural range (namely New Guinea, the Solomon Islands, and Australia), which sparked fears that it may become a pest species that could compete with, and negatively affect, native Australian fauna and flora, as well as commercially kept *A. mellifera* and commercial crops. This literature review is a response to these concerns and reviews what is known about the ecology and behaviour of *A. cerana*. Differences between temperate and tropical strains of *A. cerana* are reviewed, as are *A. cerana* pollination, competition between *A. cerana* and *A. mellifera*, and the impact and control strategies of introduced *A. cerana*, with a particular focus on gaps of current knowledge.

Lach, L., et al. (2015). "Parasitized honey bees are less likely to forage and carry less pollen." Journal of Invertebrate Pathology 130: 64-71.

Research into loss of pollination capacity has focused primarily on documenting pollinator declines and their causes with comparatively little attention paid to how stressors may affect pollinating behavior of surviving pollinators. The European honey bee, *Apis mellifera* is one of the world's most important generalist pollinators, and *Nosema apis* is a widespread microsporidian gut parasite of adult *A. mellifera*. We individually fed 960 newly eclosed *A. mellifera* workers either a sucrose solution or 400 *N. apis* spores in a sucrose solution and tagged them with a unique radio frequency identification (RFID) tag to monitor their foraging behavior. We found spore-fed bees were less likely to forage than those fed sugar only. Those that did forage started foraging when they were older and stopped foraging when they were younger than bees fed sugar only. However, inoculated and non-inoculated bees did not significantly differ in the number of foraging trips taken per day, the total hours foraged over their lifetime, or homing ability. Inoculated returning foragers were 4.3 times less likely to be carrying available pollen than non-inoculated returning foragers and the number of pollen grains carried was negatively correlated with the number of *N. apis* spores. In an arena of artificial flowers, inoculated bees had a tendency ($p=0.061$) to choose sugar flowers over pollen flowers, compared to non-inoculated bees which visited pollen and sugar flowers equally. These results demonstrate that even a relatively low dose of a widespread disease of *A. mellifera* may adversely affect bees' ability to pollinate.

Lavigne, R. J. (1992). "Ethology of *Neoaratus abludo* Daniels (Diptera: Asilidae) in South Australia, with notes on N. pelago (Walker) and N. rufiventris (Macquart)." Proceedings of the Entomological Society of Washington 94(2): 253-262.

The predatory and mating behaviours of *Neoaratus abludo* [*Colepia abludo*] were studied in paddocks south of Aldinga, SA. Although prey taken by N. abludo represented 5 insect orders, 62.5% of the prey were honey bees [*Apis mellifera*]. The majority of matings, in the tail-to-tail position, took place in the afternoon. Incidental data are included on the distribution and behaviour of Neoaratus pelago [Mauropteron pelago] and N. rufiventris [C. rufiventris]. ADDITIONAL ABSTRACT: The predatory and mating behaviours of *Neoaratus abludo* [*Colepia abludo*] were studied in paddocks south of Aldinga, South Australia. Although prey taken by N. abludo represented 5 insect orders, 62.5% of the prey was *Apis mellifera*. The majority of matings, in the tail-to-tail position, took place in the afternoon. Incidental data are included on the distribution and behaviour of *N. pelago* [*Mauropteron pelago*] and N. rufiventris [*C. rufiventris*].

Lawrence, L. and D. Anderson (2006). "Exotic invaders threaten pollination services in Australia." Outlooks on Pest Management 17(6): 228-276.

This paper discusses the threat to honey bees posed by exotic alien species that are approaching Australia. Some of the invaders include varroa mite (*Varroa destructor*), Asian honey bee (*Apis cerana*) and the Asian bee mite (*Tropilaelaps* spp). Some of the recommended control or prevention measures are briefly mentioned.

Lazar-Baker, E. E., et al. (2011). "Evaluation of commercial essential oil samples on the growth of postharvest pathogen Monilinia fructicola (G. Winter) Honey." Letters in applied microbiology 52(3): 227-232.

Aim: To assess the effect of several commercial essential oils samples Australian lemon myrtle (Backhousia citriodora), cinnamon bark (Cinnamomum zeylanicum), oregano (Origanum vulgare), thyme oil (Thymus vulgaris), clove bud (Eugenia caryophyllata), valerian (Valeriana officinalis) and Australian tea tree oil (Melaleuca alternifolia) on mycelium growth and spore germination of Monilinia fructicola. The effectiveness of lemon myrtle essential oil as a fumigant for the control of brown rot in nectarines was evaluated. Methods and Results: Monilinia fructicola exhibited a different level of sensitivity to each tested essential oil with results suggesting that the essential oils provide excellent control of the pathogen with respect to mycelium growth and spore germination at very low concentrations, whereas for others higher concentrations are needed to reduce significant fungal growth. In vivo application of lemon myrtle essential oil effectively reduced the incidence of M. fructicola on noninoculated fruit. Fumigation of nectarines following inoculation did not reduce the incidence of brown rot in comparison with the inoculated control treatment. No evidence of phytotoxicity on the fruit was recorded. Conclusions: Lemon myrtle essential oil exhibited the strongest antifungal activity against M. fructicola, in vitro and to a lesser extent, under in vivo conditions. Significance and Impact of the Study: The results demonstrate that lemon myrtle essential oil, in particular, has potential as an antifungal agent to control M. fructicola. © 2011 NSW Industry & Investment, Australia. Letters in Applied Microbiology © 2011 The Society for Applied Microbiology.

Liu, T. P. and D. McRory (1994). "The use of gamma radiation from cobalt-60 in a commercial facility in Ontario to disinfect honey bee equipment. 1. American foulbrood disease." American bee journal 134(3): 203-206.

Hive equipment contaminated with spores of Bacillus larvae (BL), the cause of AFB in honey bees, was treated with 12 kGy of gamma radiation. Package bees were installed in an isolated apiary in 20 hives containing 1 super and 9 frames of irradiated equipment (A): 20 similar hives at another apiary containing contaminated equipment that had not been irradiated served as controls (B). Colonies were fed on 6 occasions, with a total of 13.3 litres of 50% sucrose solution and 1.14 kg of a mixture of pollen (irradiated in the case of A), soyabean flour and sucrose solution. The area of brood was measured with a grid fitted with a digitizing tablet, and recorded as apparently healthy or showing symptoms of AFB. Bee numbers were also measured. No AFB was apparent in A during the 9 weeks of the experiment or in the following year, and no BL spores from the equipment could be germinated, but in B diseased brood quickly became apparent, constituting 61% of brood 3 weeks after establishment, 90% after 6 weeks and 84% after 9 weeks. In B, bee numbers dwindled to 15% of the average for A after 9 weeks. The authors suggest that gamma irradiation of contaminated hive parts would be a useful part of AFB control in Canada, as it currently is in Australia.

Macfarlane, R. P., et al. (1995). "Bumble bee pathogens and internal enemies." Bee World 76(3): 130-148.

MacIntyre, P. and J. Hellstrom (2015). "An evaluation of the costs of pest wasps (Vespula species) in New Zealand." International Pest Control 57(3): 162-162.

This study assessed the economic impact of German wasps and common wasps across industries, society and the natural environment in New Zealand. This study was based on a literature review, the use of total economic value and natural capital/ecosystem services frameworks to identify knowledge gaps, surveys, and the quantification of net effects and trends where possible. While the study focus was on sectors in which the impact of wasps appeared largest, there were some areas of investigation in which further work might also yield useful quantifiable benefits and costs. The value of bequeathing a wasp-free biodiverse environment and knowing that such an environment exists is unknown. However, the option value of honeydew honey apiculture and the findings of Kerr & Sharp's study of South Island households willingness-to-pay for better management of wasps indicate that New Zealanders could get considerable value from the suppression of wasps.

Malfroy, S. F., et al. (2016). "A pest and disease survey of the isolated Norfolk Island honey bee (*Apis mellifera*) population." Journal of Apicultural Research 55(2): 202-211.

Norfolk Island is one of Australia's most remote communities, located about 1,400 km east of the mainland. This report is the first documented survey of pests and diseases affecting the honey bee (*Apis mellifera* L.) population on Norfolk Island. The only invertebrate pest detected during the survey was the lesser wax moth (Achroia grisella), and only one honey bee virus was identified (Lake Sinai virus 1). The microsporidian parasite *Nosema ceranae* was also detected in the majority of adult bee samples, but *Nosema apis* was not present in any of the samples analyzed. Given that honey bee imports to Norfolk Island ceased in 1992, we discuss possible scenarios for *N. ceranae* introduction to the island. Lineage analysis also determined that Norfolk Island's honey bees are for the most part from Eastern Europe (probably A. m. ligustica and A. m. carnica) with a small percentage from Western Europe (probably A. m. mellifera). This survey has identified a remote and isolated honey bee population that is relatively free from major pests and diseases that affect honey bees around the world. This knowledge will help inform trade policy and management strategies for maintaining the unique health status of honey bees on Norfolk Island.

Markwick, N. P., et al. (2010). "The infectivity and host range of Orgyia anartoides nucleopolyhedrovirus." Journal of applied entomology. 134(1): 61-71.

The painted apple moth (PAM), Teia anartoides (Walker) (Lepidoptera: Lymantriidae) made a recent incursion into New Zealand. A nucleopolyhedrovirus (NPV), Orgyia anartoides NPV (OranNPV), originally isolated from PAM in Australia, was tested for its pathogenicity to PAM and a range of non-target insect species found in New Zealand, to evaluate its suitability as a microbial control for this insect invader. Dosage-mortality tests showed that OranNPV was highly pathogenic to PAM larvae; mean LT values for third instars ranged from 17.9 to 8.1 days for doses from 10po to 10e polyhedral inclusion bodies/larva, respectively. The cause of death in infected insects was confirmed as OranNPV. Molecular analysis established that OranNPV can be identified by PCR and restriction digestion, and this process complemented microscopic examination of infected larvae. No lymantriid species occur in New Zealand; however, the virus had no significant effects on species from five other lepidopteran families (Noctuidae, Tortricidae, Geometridae, Nymphalidae and Plutellidae) or on adult honeybees. Thus, all indications from this initial investigation are that OranNPV would be an important tool in the control of PAM in a future incursion of this species into New Zealand.

Matheson, A. (1987). "Hot news from Sydney." New Zealand beekeeper(194): 25-27.

Early trials of the use of gamma radiation (at a plant in Victoria, Australia) to kill Bacillus larvae spores in hive parts have been reported [e.g. AA 601, 602/84]. A plant has now been constructed in Sydney, mainly for sterilizing medical equipment, and beekeeping equipment is also treated. The procedure is described. Hives must be free of bees and honey. Afterwards, sterilized hives can be immediately restocked with bees, which remove the irradiated AFB scales. Provided a beekeeper has paid a registration fee, the cost of irradiation is paid for by the state government bee diseases compensation scheme.P.Walker.

Matheson, A. (1993). "World bee health report." Bee World 74(4): 176-212.

Matheson, A., et al. (1989). "The impact of wasps on New Zealand beekeeping - the 1986/87 wasp survey." New Zealand beekeeper(203): 28-31.

Of the 280 beekeepers throughout the country who replied to a questionnaire, over 80% reported that wasps were a nuisance to their operations. In the 1986/87 season, wasps destroyed 2.6% of these beekeepers' colonies and caused a reduction in honey yields in a further 6.5% of colonies. Wasps, especially the common wasp [Vespula vulgaris], are more troublesome than 5 years ago. Almost all replies reported some form of wasp control: over 80% of the beekeepers destroy nests, and nearly half kill hibernating queens and put out wasp baits. The common wasp predominates in the beech forests of northern South Island, where it forages on honeydew, but elsewhere it appears to be less of a problem than the German wasp [Vespula germanica].

Matheson, A. G. (1980). "Wax moths and the beekeeping industry in New Zealand." Wax moths and the beekeeping industry in New Zealand.: 84-pp.

Literature concerning the economic status of Galleria mellonella and Achroia grisella in New Zealand and other countries is reviewed, and the introduction of both species to New Zealand is documented. All known control measures for wax moths are discussed; in New Zealand the fumigation of apiary appliances and comb honey with methyl bromide gas is common, but there are several problems with this technique, including the presence of bromine residues in wax and honey. To test the effectiveness of ethylene oxide against wax moth in apiary appliances and comb honey, it was applied as a mixture of 10% ethylene oxide and 90% CO2 to equipment standing on concrete pads and covered with polythene sheeting. As little as 7500 ppm ethylene oxide was effective in killing all stages of wax moths. Author

Matheson, A. G. (1984). "Wasps: social species, description and control." Farm Production and Practice, Ministry of Agriculture and Fisheries, New Zealand(FPP 196): 4-pp.

Vespula germanica can cause financial losses to beekeepers in New Zealand; V. vulgaris, Polistes humilis and P. chinensis are minor pests.

McKee, B. A., et al. (2003). "The detection of Melissococcus pluton in honey bees (*Apis mellifera*) and their products using a hemi-nested PCR." Apidologie 34(1): 19-27.

A hemi-nested polymerase chain reaction (PCR) was further developed for the detection of Melissococcus pluton in adult bees and honey bee products. A chloroform:isoamyl alcohol DNA extraction method was used to provide template from 154 samples of adult bee tissues, honey, pollen, whole larvae and comb cells. All 36 honey bee samples tested from a diseased colony were shown to contain M. pluton and sub-clinical infections were detected in adult bee tissues, larvae and honey (49/98; 50.0%) collected from all 9 healthy colonies from areas where EFB was endemic. All 20 adult bee tissue samples from a healthy colony from Western Australia where EFB has never been reported were negative. Of 80 bulk honey samples from six Australian states, 55 of 80 (68.8%) samples were shown to contain M. pluton whereas culture techniques detected M. pluton in 22 of 80 (27.5%) of these samples. M. pluton was detected in honey from all Australian states except Western Australia.

McKillup, S. C. and D. G. Brown (1991). "Evaluation of a formulation of Bacillus thuringiensis against waxmoths in stored honeycombs." Australian Journal of Experimental Agriculture 31(5): 709-712.

Waxmoths cause significant damage to stored honeycombs of the Western honeybee *Apis mellifera* in Australia. A field experiment was designed to evaluate the effectiveness of a commerical formulation (Certan) of the biological control agent Bacillus thuringiensis in preventing this damage. Treatment applied at the manufacturer's recommended rate of 855 units per cm2 of honeycomb almost completely prevented damage, while untreated combs showed an average of 76% damage. The cost and practicality of applying the formulation of B. thuringiensis are discussed, together with the recommendation that new control methods for waxmoths should be researched.

McMillan, D. (2005). "Apicultural exotic disease surveillance report." Surveillance (Wellington) 32(4): 9-10.

The New Zealand Ministry of Agriculture and Forestry's honey bee exotic disease surveillance activity for the period 1 July 2004-30 September 2005 is reported. Exotic diseases include pests and undesirable genetic strains such as Melissococcus plutonius, *Aethina tumida*, Braula coeca, *Acarapis woodi*, *Tropilaelaps* clareae, T. koenigerum, *Varroa destructor*, V. jacobsoni, V. underwoodi, Euvarroa sinhai, *Apis mellifera* scutellata, *Apis mellifera* capensis and other species other than *Apis mellifera*. Surveillance involves hive inspection and sampling, especially in high-risk

areas, and in apiaries for export. Yearly reports are published, an apiary database is maintained and extension and education for beekeepers and technical development are implemented.

Meyrick, E. (1913). "A Revision of Hew Zealand Pyralidina." Transactions & Proc. New Zealand Inst. 45: 30-pp.

The PYRALIDINA form 22 per cent. of the entire lepidopterous fauna of New Zealand, probably a larger proportion than in any other region, and a few of them are of great economic interest. Meliphora grisella, F, was found at Nelson and Christchurch, the larvae feeding on was in beehives, to which they are often injurious, and on dried apples. The larva of Hymenia fascialis, Cram., occurring in Auckland, also in Australia and throughout the warmer parts of Asia, Africa and America, feeds on Cucurbi-taceae (melons, &c.) in gardens. Diplopseustis perieresalis occurs near towns (Auckland, Wanganui, Christchurch) and is probably attached to some cultivated plant. Pyralis farinalis, the larva of which lives on flour and corn-refuse, was found near Christchurch.

Mutinelli, F. (2014). "Honey bee health regulation in Oceania and Australia." Bee health and veterinarians: 307-311.

Oceania consists of numerous islands in the Pacific Ocean and nearby regions. Virtually nothing is known about honey bees or their pests and diseases in Micronesia, while in Melanesia *Varroa destructor*, *Varroa jacobsoni*, *Tropilaelaps mercedesae*, nosemosis (*Nosema apis* and *Nosema ceranae*), American foulbrood, chalkbrood disease and bee viruses are present. European foulbrood, the small hive beetle and the tracheal mite have not been reported. In Australia, small hive beetle, nosemosis (*N. apis* and *N. ceranae*), American foulbrood, European foulbrood; chalkbrood disease and honey bee viruses are present. The parasitic mites Varroa spp., *Tropilaelaps* spp., and *Acarapis woodi* are not present. Deformed wing virus has not been reported. Little is known about the pest and disease status of honey bees in Polynesia. However, V. destructor has been reported from both Tonga and Hawaii. Information on pests and diseases control strategies is provided.

Nicholls, H. M. (1934). "Diseases of adult bees." Tasmanian Journal of Agriculture 5(1): 13-pp.

The author states that the wholesale dying-off of adult bees which has recently been reported from several apiaries in Tasmania has been found to be due in part to the well-known microsporidiosis caused by *Nosema apis* (apparently its first record in Tasmania) and in part to infection by Trichoderma lignorum [R.A.M., v, p. 300]. In the great majority of the cases investigated the two organisms were found to occur in close association with one another in the chyle-stomach of the dead bees, the walls of which were riddled by the hyphae of T. lignorurm} and in many cases the outer coating of muscular fibres was detached from the underlying cells .by the mycelium. There did not appear to be any definite external symptoms of infection by either organism, apart from the rapid dwindling of the bee colonies, and no external growth developed on dead bees when incubated. T. lignorum was found to be still viable in dead bees kept dry for over a year in the laboratory. One of the main sources of infection appears to be drinking water, especially that in close proximity to infected beehives. The fungus has been found several times in the cells of combs from infected hives, and it is possible that it is introduced into the cells by foraging bees, and can thence infect the whole hive. The paper terminates with a brief consideration of possible means of control of the disease.

Norton, A. M., et al. (2015). "Quantitation of Dihydroxyacetone in Australian Leptospermum Nectar via High-Performance Liquid Chromatography." Journal of agricultural and food chemistry. 63(29): 6513-6517.

The nonperoxide antibacterial activity of New Zealand manuka honey originates from dihydroxyacetone (DHA) within Leptospermum scoparium nectar. This study determined if DHA was present within the nectar of four Australian Leptospermum species: L. laevigatum, L. polygalifolium, L. trinervium, and L. whitei. A rapid and convenient new method was developed, which quantitated DHA/sugar ratios (ppm). The DHA and sugars were derivatized with o-(2,3,4,5,6-pentafluorobenzyl) hydroxylamine hydrochloride and analyzed via RP-HPLC with diode array detection at two wavelengths (200 and 243 nm). DHA was detected in all L. whitei and L. polygalifolium samples, where DHA/sugar ratios ranged from 10169 to 24199 ppm and from 9321 to 20174 ppm, respectively. DHA was undetected in any of the L. laevigatum and L. trinervium samples, and nectar activity was <100 ppm. The results of this study have implications for the Australian beekeeping industry, as the findings indicated that not all species of Leptospermum will produce active honey.

Oldroyd, B. P. (1988). "The effectiveness of prophylactic sterilisation of beehive materials by gamma radiation." Australian journal of experimental agriculture. 28(6): 809-811.

Oldroyd, B. P. (1998). "Controlling feral honey bee, *Apis mellifera* L. (Hymenoptera: Apidae), populations in Australia: Methodologies and costs." Australian Journal of Entomology 37(2): 97-100.

The level of impact of feral honey bees on the Australian ecosystems is controversial but may include competition with native fauna for floral resources or nesting sites, inadequate pollination of native flora or undesirable pollination of exotic flora. The precautionary principle suggests that control of feral bees in areas of high conservation value would be desirable. This raises the question of the feasibility and cost of controlling or eradicating feral bees in conserved areas. Possible methods for controlling feral bees in Australia are reviewed. It is concluded that eradication is not feasible on a broad scale, but would be in small areas that are heavily used by the public.

Oldroyd, B. P. and M. Beekman (2009). "Intergenerational reproductive parasitism in a stingless bee." Molecular ecology. 18(19): 3958-3960.

Insect colonies have been traditionally regarded as closed societies comprised of completely sterile workers ruled over by a single once-mated queen. However, over the past 15 years, microsatellite studies of parentage have revealed that this perception is far from the truth (Beekman '' Oldroyd 2008). First, we learned that honey bee queens are far more promiscuous than we had previously imagined (Estoup et al. 1994), with one Apis dorsata queen clocked at over 100 mates (Wattanachaiyingcharoen et al. 2003). Then Oldroyd et al. (1994) reported a honey bee colony from Queensland, where virtually all the males were sons of a single patriline of workers - a clear case of a cheater mutant that promoted intra-colonial reproductive parasitism. Then we learned that both bumble bee colonies (Lopez-Vaamonde et al. 2004) and queenless honey bee colonies (Nanork et al. 2005, 2007) are routinely parasitized by workers from other nests that fly in and lay male-producing eggs that are then reared by the victim colony. There is even evidence that in a thelytokous honey bee population, workers lay female-destined eggs directly into queen cells, thus reincarnating themselves as a queen (Jordan et al. 2008). And let us not forget ants, where microsatellite studies have revealed equally bizarre and totally unexpected phenomena (e.g. Cahan '' Keller 2003 ; Pearcy et al. 2004 ; Fournier et al. 2005). Now, in this issue, Alves et al. (2009) use microsatellites to provide yet another shocking and completely unexpected revelation about the nefarious goings-on in insect colonies: intergenerational reproductive parasitism by stingless bee workers.

Palmer-Jones, T. (1964). "Diseases of honey bees in New Zealand." New Zealand Entomologist 3(3): 41-44.

Pharo, H. (2014). "Regulation of honey bee health in New Zealand." Bee health and veterinarians: 313-316.

This article outlines the basic requirements for the regulation of bee health, and how these are applied in the New Zealand context.

Pinnock, D. E. (1980). "Research on bee diseases at the Insect Pathology Laboratory, Department of Entomology, the University of Adelaide, Waite Agricultural Research Institute." Beekeepers' Bulletin(10): 2-3.

Purkiss, T. and L. Lach (2019). "Pathogen spillover from *Apis mellifera* to a stingless bee." Proceedings. Biological sciences 286(1908): 20191071-20191071.

Pathogen spillover from managed bees is increasingly considered as a possible cause of pollinator decline. Though spillover has been frequently documented, evidence of the pathogen's virulence in the new host or mechanism of transmission is rare. Stingless bees (Apocrita: Meliponini) are crucial pollinators pan-tropically and overlap with managed honeybees (*Apis mellifera*) in much of their range. *Nosema ceranae* is the most prevalent disease of adult *A. mellifera*. We used laboratory experiments and field surveys to investigate the susceptibility of stingless bees (Tetragonula hockingsi) to *N. ceranae*, infection prevalence and transmissibility via flowers. We found that 67% of T. hockingsi fed sucrose with *N. ceranae* had detectable spores in their ventriculus, and they died at 2.96 times the rate of sucrose-only fed bees. Five of six field hives harboured bees with *N. ceranae* present at least once during our five-month survey, with prevalence up to 20%. In our floral transmission experiment, 67% of inflorescences exposed to infected *A. mellifera* yielded *N. ceranae* spores, and all resulted in T. hockingsi with *N. ceranae* spores in their guts. We conclude that *N. ceranae* is virulent in T. hockingsi under laboratory conditions, is common in the local T. hockingsi population and is transmissible via flowers.

Rankmore, M. (2003). "Sending beehives for irradiation. Agnote DAI-35." Agnote - NSW Agriculture(DAI-35(4th Edition)): 1-2.

One of the approved control methods for American foul brood (Paenibacillus larvae) disease of honey bees in New South Wales, Australia, is the irradiation of all hive materials. This paper discusses the cost of irradiation, compensation, preparation of material, preparation of the hives, arrangements with the commercial irradiation facility (i.e. Steritech), transport, and important reminders.

Rawdon, T. (2019). "Quarterly report of investigations of suspected exotic diseases: July to September 2019." Surveillance (Wellington) 46(4): 17-21.

This paper presents the report of the Ministry for Primary Industries (MPI) Diagnostic and Surveillance Services Directorate, Wallaceville, New Zealand on the occurrence of suspected exotic disease of domestic and wild animals during the period from July to September 2019.

Rawdon, T., et al. (2011). "Iridovirus excluded in investigation of honey bee syndrome characterised by purple brood discolouration." Surveillance (Wellington) 38(4): 12-15.

An incidence of purple discolouration and mortality in larvae, pupae and emergent bees occurred in a commercial beekeeper's hives in New Zealand in February 2011. Samples were negative for iridoviruses but subsequent samples were positive for Kashmir bee virus, Sacbrood virus and Deformed wing virus. The syndrome resolved rapidly in two affected hives that were brought in for close monitoring. Ten days after the report, on a subsequent visit to the beekeeper's hive sites, no discolouration of larvae or pupae could be identified. It is suggested that there is a potential association of the brood colour change with local pollen sources.

Reid, G. M. (1990). "Feeding drugs to honey bees to control diseases - some of the issues." Feeding drugs to honey bees to control diseases - some of the issues.: 26-pp.

This review, with 30 references, covers the following topics: AFB, particularly its development and present level in New Zealand; AFB-resistant strains of honey bees (*Apis mellifera*); controlling AFB by management methods and by antibiotics; antibiotic-resistant strains of Bacillus larvae; costs, benefits and availability of antibiotics; contamination of honey with oxytetracycline residues; EFB and drug feeding.

Reid, M. (1988). "Diseases of honey bees in New Zealand." Surveillance 15(5): 15-17.

The most serious diseases or pests of honey bees present in New Zealand are American foul brood, sacbrood virus, chalkbrood and *Nosema*. Also present are amoebiasis, chronic bee paralysis, Kashmir bee virus, black queen cell virus and wax moths. The control of and regulations concerning bee diseases in New Zealand are discussed.

Rhodes, J. (1983). "Formation of a national honey bee disease liason group." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.

Rhodes, J. (1983). "State policies on disease control." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 81-88.

Rhodes, J. and R. Goebel (1986). "Diseases of honey bees: the importance of correct diagnosis." Queensland Agricultural Journal 112(2): 71-74.

Roff, C. (1970). "Animal enemies of honeybees [in Queensland, including insects and mites]." Queensland Agricultural Journal 96(10): 681-687.

Roff, C. (1974). "Honey bees and giant toads bufo-marinus in Queensland." HARNAJ, V. (ED.). APIMONDIA SCIENTIFIC BULLETIN, 1972. SYMPOSIA. 1972. 535P. ILLUS. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 416-419.

Roff, C. (1975). "Honeybees, giant toads and hive stands." Queensland Agricultural Journal 101(6): 689-691.

Collapsible stand, 60 cm high, for raising the hive out of reach of Bufo marinus.

Roper, T. (2015). "Honey bee exotic pest and disease surveillance report." Surveillance (Wellington) 42(3): 30-31.

Rowarth, J. S. (1990). "Lead concentration in some New Zealand honeys." Journal of apicultural research. 29(3): 177-180.

Schrader, M. and M. Reid (1986). "Control of honey bee disease and pests in New Zealand." American bee journal 126(11): 742-745.

New Zealand's emergence as a important exporter of quality queen bees has prompted questions from beekeepers worldwide. Their interest range from curiosity about where New Zealand is, through to a need for knowledge of our bee health status. This article is written as a response to this interest. American foulbrood is New Zealand's most serious bee disease; the average incidence over the last five years has been 0.6% of hives per year. *Nosema* is regarded by many as the next most serious bee disease.

Shanks, J. L. (2015). *Tetragonula carbonaria* and disease: Behavioural and antimicrobial defences used by colonies to limit brood pathogens. PQDT - Global. Ann Arbor, University of Western Sydney (Australia): 308-308.

The honey bee, *Apis mellifera*, is suffering heavily from the impacts from intensive management. Pests and diseases contribute to the population losses experienced globally. Brood disease is of concern for the apiculture industry because of the direct effects it has on population numbers and despite control measures; resistance to antibiotics and pesticides are common. Alternative pollinators such as stingless bees, including Tetragonula carbonaria, appear to be less impacted by brood diseases. However, there is very little information regarding why this is so. Prior to this study, there are only a few indications about a possible bacterial brood disease in Brazilian stingless bees (Kerr 1948, Nogueira-Neto 1997), with no follow up investigations, and no cases of brood disease losses in Australian stingless bees. As a result, this study presents information on the behavioural and antimicrobial defences of T. carbonaria colonies as mechanisms to limit the development of brood pathogens. In addition to these aims and objectives, this study also introduces and documents the first disease causing brood pathogen in Australian stingless bees. Therefore, the interaction of the defence mechanisms and the identified brood pathogen was also explored. Suitable nest conditions need to exist to sustain pathogen growth and development. *Apis mellifera* pathogens such as *Paenibacillus* larvae and *Ascosphaera apis* utilise nest conditions, especially in the brood area for growth. The limited number of stingless bee pathogens may be related to brood temperature. Thermoregulation behaviour has been investigated in a number of stingless bee species; however, Australian studies are limited to *Austroplebeia australis* (Halcroft et al. 2013b) and greenhouse maintained *T. carbonaria* colonies (Amano et al. 2000, Amano 2004, A. Tse, pers. comm., 2011), with outcomes applied to their pollination servicing. This study (Chapter 2) investigated T. carbonaria thermoregulation behaviours during fluctuating ambient temperatures and the influence these have on brood production. Over the 13-month study, T. carbonaria was able to maintain brood temperatures between 15–31ºC, despite ambient temperatures ranging from 0–37°C. The recorded brood temperatures resulted in colonies maintaining yearlong brood development, which would suggest that this could provide a suitable resource for pathogen development year-round. However, pathogen occurrences are rare, it is speculated that the greater brood temperature range which is tolerated by colonies, is ultimately unsuitable for brood pathogen development, especially the lower winter temperatures.

Silvester, R., et al. (2019). "Behavioural tactics used by invasive cane toads (*Rhinella marina*) to exploit apiaries in Australia." Austral Ecology 44(2): 237-244.

Behavioural flexibility plays a key role in facilitating the ability of invasive species to exploit anthropogenically-created resources. In Australia, invasive cane toads (*Rhinella marina*) often gather around commercial beehives (apiaries), whereas native frogs do not. To document how toads use this resource, we spool-tracked cane toads in areas containing beehives and in adjacent natural habitat without beehives, conducted standardized observations of toad feeding behaviour, and ran prey-manipulation trials to compare the responses of cane toads versus native frogs to honeybees as potential prey. Toads feeding around beehives travelled shorter distances per night, and hence used different microhabitats, than did toads from nearby control sites without beehives. The toads consumed live bees from the hive entrance (rather than dead bees from the ground), often climbing on top of one another to gain access to the hive entrance. Prey manipulation trials confirm that bee

movement is the critical stimulus that elicits the toads' feeding response; and in standardized trials, native frogs consumed bees less frequently than did toads. In summary, cane toads flexibly modify their movements, foraging behaviour and dietary composition to exploit the nutritional opportunities created by commercial beehives, whereas native anurans do not.

Silvester, R., et al. (2017). "The ecological impact of commercial beehives on invasive cane toads (*Rhinella marina*) in eastern Australia." Biological invasions. 19(4): 1097-1106.

Understanding the factors that affect an invasive species viability and distribution has vital implications for biocontrol. In Australia, invasive cane toads (*Rhinella marina*) are anecdotally reported to utilise commercial beehives as a prey resource, but that interaction has never been studied in detail. We investigated the impact of apiaries on cane toads in northern New South Wales via mark-recapture surveys, dissections, and camera-trap observations. Cane toads were the most frequent visitors to apiaries, followed by bandicoots and corvid birds. Cane toads at apiaries were more abundant and in better body condition (i.e., larger mass relative to snout-urostyle length) than were toads at nearby control sites. Toads at beehives contained more prey items per stomach (mostly bees, which were never recorded in the stomachs of toads from other sites), and adult female toads at beehives had larger livers and ovaries relative to body size. We conclude that commercial apiaries attract cane toads, influence their diets, and increase their feeding rates and reproductive capacity. Like other habitat modifications wrought by agricultural activities, honey bee colonies provide resources that facilitate the spread of cane toads through an otherwise harsh landscape matrix. Minor modifications to beehives could exclude toads, thereby eliminating their positive impact on the invader.

Smith, G. P. D. (1914). "Bee Diseases." Third Rept. of the Government Bureau of Microbiology, for the year 1912: 134-135.

Throughout the year specimens of bees affected with the Isle of Wight bee disease, *Nosema apis*, were received. The bees suffered from a form of paralysis or from dysentery. Examination of the faeces usually revealed the presence of large numbers of spores of *N. apis*.

Smithers, C. N. and G. A. Holloway (1978). "Establishment of Vespula germanica (Fabricius) (Hymenoptera: Vespidae) in New South Wales." Australian Entomological Magazine 5(3): 55-59.

The establishment of *Dolichovespula germanica* (F.) (*Vespula germanica*) in the Sydney area of New South Wales, where the wasp was first found in 1975, is confirmed from observations in 1978, and its distribution there is given. Notes are provided on nest sites, which included dwellings, and it is shown that as in Europe but not in New Zealand, most nests have been found in protected situations. The status of the wasp in New Zealand and its potential economic importance in Australia are discussed.

Somerville, D. (1988). "Procedures for the gamma radiation of bee materials." Australasian beekeeper 90(1): 36-37.

Irradiation of hives and other equipment infected with AFB is preferable to burning them. In New South Wales, Australia, 45 000 hive boxes have been treated in less than 3 years. Procedures to be taken by a beekeeper who has hives contaminated with AFB are listed; particular care must be taken to keep the equipment bee-proof during transport to the treatment plant. Hives can be used immediately after treatment. CENTREQUAD~ P. Walker.

Somerville, D. (1994). "Bee incursion response exercise." Bee Briefs 11(4): 3-5.

In Australia there is concern that Asian honey bees [*Apis cerana*] could reach Queensland from Papua New Guinea, and could introduce *Varroa jacobsoni*. During an exercise, personnel who might be involved in eliminating unwanted bees from an area tested and improved techniques. One approach is to get bees to feed at an artificial feeder, then follow them back to their nest which can be destroyed. In rough terrain, 'remote' poisoning of colonies would be preferable, but the method and materials need further testing.

Sopow, S. L., et al. (2017). "Potential impacts of *Tuberolachnus salignus* (giant willow aphid) in New Zealand and options for control." Agricultural & Forest Entomology 19(3): 225-234.

1 The giant willow aphid *Tuberolachnus salignus* was discovered in New Zealand in late 2013. Despite being a recent addition to the New Zealand fauna, the aphid is already widespread and abundant throughout the country.2 The giant willow aphid is expected to have negative impacts on host trees, primarily willows (Salix spp.), as has been

observed elsewhere. All willows are exotic to New Zealand and a few have formal weed status, however many species are valued for multiple purposes, including flood protection, land stabilization, shelterbelts, and as early season pollen and nectar resources for honey bees.3 *Tuberolachnus salignus* presents a unique problem for New Zealand's thriving honey and honey products industries. Bees readily forage on the vast quantities of honeydew secreted by the aphid, however the honeydew contains melezitose sugar. The low solubility of this sugar results in honey crystallizing in the comb, making it difficult to extract and thereby reducing yield. It is also considered to be poor food for bees, and has been linked to bee dysentery and low overwintering survival.4 We elaborate on the potential complications for New Zealand as a result of the arrival of this new species and present options for its control and management.

Stone, M. (2005). "Quarterly report of investigations of suspected exotic diseases." Surveillance (Wellington) 32(4): 20-23.

A summary of investigations of suspected exotic diseases of domestic and wild animals and honey bees (exotic vesicular disease, transmissible spongiform encephalopathy, rinderpest, *Mycoplasma mycoides* subsp. mycoides, *Capripoxvirus*, equine viral arteritis, equine infectious anaemia, postweaning multisystemic wasting syndrome, *Trichinella spiralis*, *Brucella canis*, *Ehrlichia canis*, exotic ticks, *Lyssavirus*, feline spongiform encephalopathy, feline babesiosis, infectious bursal disease, honey bee mites and small hive beetles) from July-September 2005 are presented. These diseases were subsequently ruled out.

Sullivan, R. (2012). "Combating bee pollinator decline." Ecos(171): 1-6.

The article focuses on the decline in the bee population around the world and the arrival of *Varroa destructor* mite in Australia. It talks about the link between colony collapse disorder (CCD) and the *Varroa destructor* mite. It also looks into ways on how to protect pollinators from the notorious mite, the success of beekeepers in managed pollination, and the potential of native bees as crop pollinators.

Taylor, B. (2010). "Honey bee exotic disease surveillance report." Surveillance (Wellington) 37(3): 17-19.

Taylor, B. and L. Peacock (2008). "Honey bee exotic disease surveillance report." Surveillance (Wellington) 35(3): 13-14.

This report summarizes the MAF Biosecurity New Zealand's honey bee exotic disease surveillance programme for the period 1 July 2007-30 June 2008. Data showed that none of the 363 high-risk apiaries and 446 export apiaries inspected, sampled and tested were positive for exotic honey bee diseases, pests and undesirable genetic strains, namely European foul brood (*Melissococcus plutonius*), small hive beetle (*Aethina tumida*), parasitic fly (Braula coeca), tracheal mite (*Acarapis woodi*), Asian mites (*Tropilaelaps clareae* and T. koenigerum), varroa mite (*Varroa destructor*), Africanized honey bee (*Apis mellifera* scutellata), Cape bee (*A. mellifera* capensis) and Apis species other than mellifera.

Taylor, M. A., et al. (2007). "Destroying managed and feral honey bee (*Apis mellifera*) colonies to eradicate honey bee pests." New Zealand Journal of Crop & Horticultural Science 35(3): 313-323.

This paper reports on trials conducted to kill managed and feral honey bee (*Apis mellifera*) colonies to eradicate unwanted honey bee pests. The effectiveness of Pestigas-P-TM (natural pyrethrum) for the destruction of managed colonies was assessed. Pestigas-P-TM was effective when applied as a single 15-s spray into an empty three-quarter-depth super and across the top of the frames. This allowed the gas to filter throughout the hive. Piperonyl butoxide (wax = 42.28 mg/kg, honey = 0.34 mg/kg, propolis = 9.2 mg/kg, floor scrapings = 270.34 mg/kg) and pyrethrum (wax = 21.3 mg/kg, honey = 0.06 mg/kg, propolis = 6.8 mg/kg, floor scrapings = 172.4 mg/kg) residues were found in the hive but after 4 weeks these had no detectable effect on newly introduced honey bee colonies. Combined analyses of attractiveness, toxicity, and lethal time trials identified Ascend((R)) 200SC (a.i. fipronil) as effective for depopulating feral honey bee colonies in New Zealand using poisoned baits. Ascend((R)) 200SC is a slow acting stomach toxin. The effect of Ascend((R)) on feral honey bee colonies was assessed in Canterbury, New Zealand in 2003. Nucleus colonies were placed between bait stations set out in a 4 km(2) grid. The stations were pre-baited with sugar syrup which was replaced with sugar syrup containing fipronil (0.05 ml/litre) once 300 bees were foraging from a single bait station. In the autumn trial all 20 colonies died within 13 days of poisoning. After 6 weeks the effect of poisoned hives on the survival of newly introduced colonies was assessed. Five colonies were placed next to

10 poisoned hives in the original eradication area, five colonies were placed with 10 poisoned hives at least 4 km from the original area, and an additional 10 colonies were placed at least 4 km from the original area and 4 km apart. Introduced colonies are likely to die if they consume the stored fipronil in poisoned colonies. This persistent poisoning action increases the likelihood of a honey bee eradication attempt being successful, as the colonies that are not killed in the first round of poisoning may be poisoned by robbing honey containing fipronil from a previously poisoned hive. Fipronil remained toxic in honey for at least 26 months when stored at 0 degrees C, 5 degrees C, and 25 degrees C.

Thomas, C. R. (1960). "The European wasp (Vespula germanica Fab.) in New Zealand." Inform. Ser. Dep. Sci. Industr. Res. N. Z.(27): 74-pp.

The following is based almost entirely on the author's summary. Vespula germanica (F.) was first recorded in New Zealand in 1922, but did not become established until 1945, when it was found breeding in the Hamilton district [cf. R.A.E., A 34 323]. Its spread was assisted by rail and road traffic until, in 1951, it was widespread over most of the North Island. Experiments in 1949-51 with various baits indicated that dilute beer was the best of the attractants tested. Workers were most abundant in late April and early May. Peak catches of drones were made in mid-May, and queens were most abundant in late October. Marked seasonal changes occurred in the diet of the wasps. Insects and other animal matter comprised the main food for workers in spring and early summer, but in mid-March a predominantly sweet diet, including honeydew, damaged fruits, jam and honey, was suddenly preferred. Drones also preferred sweet materials and, in addition, both drones and workers imbibed oral secretions of larvae in their nests. Foraging workers imbibed large quantities of water and carried it back to their nests, which were seldom more than 400-500 yards from a water supply. Queen wasps fed primarily on honeydew, but also on nectar. After mating in the autumn, queen wasps did not forage and hibernated in sheltered situations until late August or early September, when, with the onset of warm weather, they began to forage and to establish nests. By midsummer, nests were usually established. Subterranean sites were favoured, though, contrary to findings in other countries, aerial sites were not uncommon. Details of nest construction are described. When the first batch of workers reached maturity, the queen ceased to forage and engaged solely in egg-laying. The workers collected food and water and constructed and maintained the brood combs. Drones emerged from mid-February to late May or June and were also sometimes found in overwintering colonies throughout the year. They did not forage until the colony was nearing extinction, and extreme demands were first made upon the foraging workers at this time, when they became pests owing to their liking for sweet materials. It is suggested that drone-producing eggs were laid by workers and not by the queen. The change from drone-to queen-production was abrupt and appeared to be initiated, in part at least, by the first winter frosts. Pairing, which is described, usually occurred in late April or May, when queens and drones were mature. After the queens had mated, the colonies declined, until by late May or June only the hibernating queens still survived. Some unusually large nests have been found in New Zealand, where the average nest size appears to be considerably larger than in other countries. Over 11, 900 adults were counted in one large nest. Where winter frosts did not occur, many colonies overwintered. In these nests, unused combs were sealed off and many cells were sealed with paper disks. Considerably less brood was produced than in summer nests, and most of it consisted of queens. With the onset of warm spring weather, the production of the worker caste was resumed. Such nests may remain inhabited for several seasons, and these, particularly aerial ones, sometimes attain enormous proportions. The main economic importance of the wasps lies in the damage they cause to fruit in orchards and vineyards and their habit of taking honey from beehives. Losses of fruit were small, since the wasps did not reach peak abundance until April or May, when most commercial fruit crops were already picked. Losses in winter stores from beehives were sometimes serious, autumn-reared nuclei being especially liable to attack. On the other hand, wasps were beneficial in that they killed and ate many harmful insects, especially blowflies and caterpillars. In control experiments, the destruction of the queens during hibernation or in spring proved impracticable, since the population level was maintained if only a small proportion of queens survived. Chemical treatment of the nests proved the most effective co trol method. DDT, methoxy-DDT (methoxychlor), toxaphene, BHC (Gammexane), calcium cyanide, carbon bisulphide, chloropicrin and parathion, but not boric acid or lead arsenate, were effective; the most suitable for general use were a dust of 10 per cent. DDT blown into the nest entrance or chloropicrin applied as a fumigant. The use of poisonous sprays or baits on plants was complicated by their danger to foraging honey bees. No evidence of parasitism was found.

Traynor, K. (2010). "New Zealand beekeeping conference." American bee journal. 150(11): 1057-1059.

Van Eaton, C. (1992). "New developments in the control of honey bee diseases in New Zealand." Surveillance 19(1): 8-9.

In August 1991 the New Zealand government announced that it would no longer fund the endemic honey bee disease programme, which concentrated mainly on the control of AFB. The National Beekeepers' Association's funding of disease inspection has also been reduced, and it was forecast that in 1991/92 only 4% of apiaries would be inspected. An increased hive levy is being proposed to pay for more inspections. The changes in the government funding have necessitated reorganization of procedures for certification of bees for export. The government will continue to fund active surveillance for exotic bee diseases and the Emergency Disease and Pest Response (EDPR) programme. Work already carried out under these programmes is described, and possible changes are discussed.

Walton, G. M. (1980). "Honeybees, overseas diseases and pests. Features and potential damage." Farm Production & Practice, Ministry of Agriculture and Fisheries, New Zealand(FPP 428): 4-pp.

Walton, T. (1979). "Australian disease not wanted." New Zealand beekeeper. 40(3): 21-23.

Wheen, G. (1988). "The use of the Australian quarantine facility for honey bees." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 57-58.

White, B. (1988). "Disease control strategies in New South Wales - now and in the future." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 85-87.

White, B. (1993). "Exotic honey bee disease found in Queensland." Australasian beekeeper 94(8): 345-346.

Chalk brood was identified in February 1993 by the CSIRO in specimens taken from honey bee colonies [*Apis mellifera*] near Warwick, Queensland, Australia. Shortly afterwards further cases were found near Brisbane, Queensland. These are the first reported findings of chalk brood in Australia. The symptoms of the disease are discussed, and a quarantine order restricting the movement of bees, beekeeping equipment and bee products from Queensland into New South Wales is reprinted.

White, B., et al. (1981). "Four important bee diseases." Agfact, New South Wales Department of Agriculture(A8.9.1): 4-pp.

EFB and AFB (referred to as European and American brood disease), *Nosema*, sacbrood.

Woodward, D. and D. Brown (1991). "South Australian apiarists' survey on bee diseases, treatment and crop pollination." Australasian beekeeper 92(10): 417-418.

The results of a postal survey in 1990 are summarized and discussed.

Woodward, D. and W. Jones (1991). "Ant control in apiaries." Bee Briefs 8(2): 2-5.

In Australia, several species of ants [the most troublesome are referred to as the 'red meat ant' or 'road ant' and the 'black sugar ant'] can cause serious damage to honey bee colonies. Procedures for ant control, before and after introduction of hives to an apiary, are summarized, starting with spraying ant nests 3-4 weeks beforehand. Dieldrin and chlordane, which were previously used for this purpose, have now been phased out; suitable pesticides, mainly pyrethroids and organophosphates, are listed. Physical barriers to ants are usually not effective, but they can be tried as a first step and different kinds are listed.

Chalkbrood

(1989). "Potential for the introduction of chalkbrood disease into Australia in imported honey." Australasian beekeeper 91(2): 75-80.

Chalk brood is absent from Australia, although present in New Zealand, and some concern has been expressed that the disease may be introduced by means of fungal spores in imported honey, but there is little information in the literature about the likelihood of this occurring. In 1986-87, Australia imported about 100 t honey, and double this in 1987-88. Honey imports are expected to increase, especially from New Zealand. The Australian Quarantine and Inspection Service has recently started to inspect containers of bulk honey. It is considered that pre-packaged honey is probably safe to import, but "home-produced" honey from-small scale beekeepers should be prohibited.

(1997). "Chalkbrood quarantine restrictions removed for imported honey." AQIS Bulletin 10(8): 9-9.

Quarantine restrictions for chalk brood disease (Ascosphaera apis) have been removed from honey, propolis and royal jelly entering all states of Australia except Western Australia (where honey imports must still be heat treated). Comb honey, chunk honey, pollen and beeswax still require a permit.

Anderson, D., et al. (1997). "Detection and thermal destruction of the chalkbrood fungus (Ascosphaera apis) in honey." Journal of Apicultural Research 36(3/4): 163-168.

A sensitive culture technique for detecting viable spores and mycelial elements of A. apis is described. The technique involves embedding honey or distilled water containing A. apis spores or mycelial elements in 15 ml of sterile liquid nutrient agar medium (10 g yeast, 10 g glucose, 13.5 g KH2PO4, 10 g soluble starch and 20 g agar) cooled to 60 degrees C. This medium is then poured on a 7-ml layer of similar but solid agar medium in a standard 8.5-cm petri dish and allowed to solidify by cooling. The medium is incubated in an anaerobic environment at 37 degrees for 24 h, and then incubated in an aerobic environment for up to 9 days at 37 degrees . It is examined daily for A. apis growth. The technique facilitated the detection of viable A. apis in honey and was used to show that many pre-packaged retail honeys contain viable A. apis. The technique was also used to show that honey may be rendered free of viable A. apis by holding it in water baths at 65 degrees for 8 h or at 70 degrees for 2 h.

Douglas, I. C. (1993). "Epidemiology of the chalkbrood disease outbreak in Queensland." Australian bee journal 74(1): 16-23.

This is the full text of a report by a working group considering responses to the discovery, for the first time, of chalk brood (caused by Ascosphaera apis) in Australia (south-east Queensland, January 1993). After considering the economic impact of the disease and possible control procedures, the committee makes recommendations for continued surveillance and monitoring, a progressive relaxation of controls on movements of bees and bee products from areas with the disease, and the continued controls on movement of bees and bee products into the isolated states of Western Australia and Tasmania.

Fearn, J. T. (1974). "Chalk brood in imported leaf cutter bees." American bee journal 114(6): 209-209.

Gerdts, J., et al. (2018). "Hygienic behaviour selection via freeze-killed honey bee brood not associated with chalkbrood resistance in eastern Australia." PLoS One 13(11).

Hygienic behaviour is a social immune response in honey bees shown to help provide resistance to honey bee pests and diseases. A survey of hygienic behaviour and brood diseases was conducted on 649 colonies in eastern Australia to initiate a selective breeding program targeting disease resistance and provide a level of resistance to Varroa (*Varroa destructor* Anderson and Trueman and V. jacobsoni Oudemans) mites should they become established in Australia. The test population showed a remarkably high baseline level of hygienic behaviour with 17% of colonies meeting or exceeding breeding selection thresholds. Colonies belonging to a breeding program were 5.8 times more likely to be highly hygienic and colonies headed by queens raised from hygienic queen mothers were 2.2 times more likely. Nectar availability (nectar yielding flowering plants within honey bee forage range) influenced hygienic behaviour expression but was not a significant predictor of level of hygienic behaviour. Surprisingly, hygienic behaviour was not a significant predictor of the presence of infection of the honey bee brood disease chalkbrood (Ascosphaera apis) and was not influential in predicting severity of chalkbrood infection in surveyed honey bee

colonies. This study, along with reports from commercial beekeepers that chalkbrood infection is on the rise, warrants a deeper exploration of the host-pathogen relationship between *Apis mellifera* and Ascosphaera apis in Australia. © 2018 PLOS ONE.This is an open access article, free of all copyright, and may be freely reproduced, distributed, transmitted, modified, built upon, orotherwise used by anyone for any lawful purpose. The work is made available under the Creative Commons CC0 public domain dedication.

Gilliam, M. (1984). "Letter to F.C.A.A.A. - New Zealand chalk brood." Australian bee journal 65(9): 7-7.
Discusses controls on Australian imports of Megachile rotundata from New Zealand now that Ascosphaera apis has been found there in honeybees.

Heath, L. A. F. (1985). "Occurrence and distribution of chalk brood disease of honeybees." Bee World 66(1): 9-15.
This review, with 74 references, describes the distribution of Ascosphaera apis, particularly in temperate regions. Until recently chalk brood disease had been reported only from the North, but since 1980 it has also been reported from New Zealand and Argentina. Its occurrence in tropical regions seems to be limited, though it has been reported from southern Mexico, Belize, Honduras and the Phillipines. It is suggested that more accurate measures of chalk brood disease frequency and importance in various parts of the world are needed, as many reports fail to indicate whether a single colony is involved or whether the infection is widespread. Recent experiences in New Zealand, Australia and North America suggest that strains of honeybee resistant to the disease exist and could be used in selective breeding programmes. [Available as IBRA Reprint M115, price #0.60 or US$1.10]D.G. Lowe.

Hitchcock, J. D. (1972). "Chalk brood disease of honey bees: a review." American bee journal 112(8): 300-301.
The geographical distribution of Ascosphaera apis in Europe and New Zealand is reviewed, and factors thought to affect the incidence of chalk brood, e.g. temperature, humidity. Various brood treatments and comb disinfectants are described. Nomia melanderi, Chalicodoma sp., and some Megachile and Anthophora species are named as alternative hosts; the fungus having been isolated from faeces, food stores, or from various larval stages.D.G.Lowe

Khan, S., et al. (2020). "Environmental gut bacteria in European honey bees (*Apis mellifera*) from Australia and their relationship to the chalkbrood disease." PLoS One 15(8): e0238252-e0238252.
We report on aerobic "environmental" bacteria isolated from European honey bees (*Apis mellifera*). We determined the number of culturable aerobic bacteria in the gut of nurse bees sampled from locations around Australia. Bees from healthy colonies had 10(7)-10(8)aerobic bacteria per g of bee gut, while bees from colonies with chalkbrood consistently had significantly fewer bacteria (10(4)-10(5)bacteria per g). When colonies recovered from chalkbrood, bacterial numbers returned to normal levels, suggesting that counting aerobic bacteria in the gut could be used to predict an outbreak of the disease. Furthermore, Western Australian bees from the "Better Bees" program (bred to promote hygienic behaviour) had significantly higher numbers of aerobic gut bacteria compared to regular bees from healthy colonies. Bacteria with the ability to inhibit the chalkbrood pathogen were found in most bees from regular colonies (> 60%) but only in a few "Better Bees" (10%). Phylogenetic analysis of aerobic bacterial isolates that inhibited the chalkbrood pathogen revealed a close relationship (>97% sequence identity) to the generaBacillus,Klebsiella,Pantoea,Hafnia, andEnterobacter(bacteria that have previously been isolated from honey bees), but we also isolatedMaccrococcusandFrigoribacteriumspecies (bacteria that were not previously identified in bees). Finally, we investigated the ability of bacteria to inhibit the chalkbrood fungusAscosphaera apis. Mass spectroscopy analysis revealed that the bee gut isolatesFrigoribacteriumsp. andBacillus senegalensisproduce gluconic acid. We further found that this simple sugar is involved in chalkbrood fungal hyphal lysis and cytoplasmic leakage. Our findings suggest that "environmental" gut bacteria may help bees to control the chalkbrood pathogen.

Oldroyd, B. P. (1996). "Evaluation of Australian commercial honey bees for hygienic behaviour, a critical character for tolerance to chalkbrood." Australian journal of experimental agriculture. 36(5): 625-629.

Reid, G. M. (1984). "Chalkbrood and half-moon in N.Z." Australasian beekeeper 85(12): 232-234.

Reid, M. (1993). "Chalkbrood disease: the NZ experience." Australasian beekeeper 94(12): 497-508.

The discovery of chalk brood caused by Ascosphaera apis in Northland, New Zealand, in 1983 prompted an emergency response and extensive inspection of apiaries. The disease was found to be well established and was declared endemic. This review covers the development of a policy on chalk brood by the government and beekeeping industry, and the spread of the disease throughout the country. New Zealand and international studies on levels of chalk brood infection, factors affecting its spread, control measures and interactions with other diseases are reviewed. Suggestions for the Australian beekeeping industry are given.

Witte, K. d. (2000). "Chalkbrood disease of honey bees." Agnote (Darwin)(578): 3-pp.

European foulbrood

(1995). "H. B. R. & D. C. research project "Oxytetracycline in honey"." Australian bee journal 76(4): 19-21.

Oxytetracycline (OTC) was fed to honey bee colonies [to prevent European foul brood] in Victoria, Australia, in 3 different ways: 1 g a.i. OTC in 500 ml of 50% sugar syrup (A); 1 g a.i. OTC in 99 g of castor (fine granulated) sugar (B); 0.3 g a.i. OTC in 200 ml sugar syrup, repeated twice at 7-d intervals (C). Whether fed during a poor honey flow, a good honey flow or 5 wk prior to a honey flow, treatment B always resulted in lower residues of OTC in honey. Beekeepers in Victoria are recommended to discontinue feeding OTC in sugar syrup and use castor sugar only.

Bailey, L. (1977). "European foulbrood in Australia." Australasian beekeeper: 114-117.

Budge, G. E., et al. (2014). "Molecular epidemiology and population structure of the honey bee brood pathogen Melissococcus plutonius." ISME Journal 8(8): 1588-1597.

Melissococcus plutonius is the causative agent of European foulbrood (EFB), which is a serious brood disease of the European honey bee (*Apis mellifera*). EFB remains a threat because of a poor understanding of disease epidemiology. We used a recently published multi-locus sequence typing method to characterise 206 M. plutonius isolates recovered from outbreaks in England and Wales over the course of 2 years. We detected 15 different sequence types (STs), which were resolved by eBURST and phylogenetic analysis into three clonal complexes (CCs) 3, 12 and 13. Single and double locus variants within CC3 were the most abundant and widespread genotypes, accounting for 85% of the cases. In contrast, CCs 12 and 13 were rarer and predominantly found in geographical regions of high sampling intensity, consistent with a more recent introduction and localised spread. K-function analysis and interpoint distance tests revealed significant geographical clustering in five common STs, but pointed to different dispersal patterns between STs. We noted that CCs appeared to vary in pathogenicity and that infection caused by the more pathogenic variants is more likely to lead to honey bee colony destruction, as opposed to treatment. The importance of these findings for improving our understanding of disease aetiology and control are discussed.

Djordjevic, S. P., et al. (1999). "Geographically diverse Australian isolates of Melissococcus pluton exhibit minimal genotypic diversity by restriction endonuclease analysis." FEMS microbiology letters. 173(2): 311-318.

Melissococcus pluton, the causative agent of European foulbrood is an economically significant disease of honey bees (*Apis mellifera*) across most regions of the world and is prevalent throughout most states of Australia. 49 isolates of M. pluton recovered from diseased colonies or honey samples in New South Wales, Queensland, South Australia, Tasmania and Victoria were compared using SDS-PAGE, Western immunoblotting and restriction endonuclease analyses. DNA profiles of all 49 geographically diverse isolates showed remarkably similar AluI profiles although four isolates (one each from Queensland, South Australia, New South Wales and Victoria) displayed minor profile variations compared to AluI patterns of all other isolates. DNA from a subset of the 49 Australian and three isolates from the United Kingdom were digested separately with the restriction endonucleases CfoI, RsaI and DraI. Restriction endonuclease fragment patterns generated using these enzymes were also similar although minor variations were noted. SDS-PAGE of whole cell proteins from 13 of the 49 isolates from different states of Australia, including the four isolates which displayed minor profile variations (AluI) produced indistinguishable patterns. Major

immunoreactive proteins of approximate molecular masses of 21, 24, 28, 30, 36, 40, 44, 56, 60, 71, 79 and 95 kDa were observed in immunoblots of whole cell lysates of 22 of the 49 isolates and reacted with rabbit hyperimmune antibodies raised against M. pluton whole cells. Neither SDS-PAGE or immunoblotting was capable of distinguishing differences between geographically diverse isolates of M. pluton. Collectively these data confirm that Australian isolates of M. pluton are genetically homogeneous and that this species may be clonal. Plasmid DNA was not detected in whole cell DNA profiles of any isolate resolved using agarose gel electrophoresis.

Giacon, H. and L. Malone (1995). "Testing imported bee products for European foul brood." New Zealand beekeeper 2(8): 8-9.

In New Zealand, samples of imported materials containing bee products are tested for EFB by attempting to culture Melissococcus pluton. Over a year, a total of 325 kg of royal jelly in various formulations and 180 litres of various products containing honey were tested, and all results were negative. The lower limit of detection has not been determined.

Hornitzky, M., et al. (1978). "A disease of bees - European [foul] brood disease." Agricultural Gazette of New South Wales 89(5): 3-pp.

EFB was first found in S. Australia and in NSW in 1977.

Hornitzky, M. A. Z., et al. (1988). "Oxytetracycline activity in honeybee larvae following hive treatment with various oxytetracycline preparations." Journal of apicultural research. 27(4): 239-244.

Hornitzky, M. A. Z. and L. A. Smith (1999). "Sensitivity of Australian Melissococcus pluton isolates to oxytetracycline hydrochloride." Australian Journal of Experimental Agriculture 39(7): 881-883.

The effectiveness of the antibiotic oxytetracycline hydrochloride) against the bacterium Melissococcus pluton, which causes European foulbrood in honey bees (*Apis mellifera*) was investigated in this study. The minimum inhibitory concentration of oxytetracycline hydrochloride for 104 M. pluton isolates cultured from samples of brood and honey collected from *A. mellifera* colonies in New South Wales, Victoria, South Australia and Tasmania was determined. The minimum inhibitory concentration was 1 mug/mL for 51 isolates, and 2 mug/mL for 53 isolates. These results indicate that, although oxytetracycline hydrochloride has been used exclusively for the past 22 years to treat European foulbrood, Australian isolates of M. pluton are still sensitive to this antibiotic.

Kessell, A. C. (1977). "European foul brood in South Australia." Beekeepers' Bulletin(6): 5-6.

McKee, B. A., et al. (2003). "Oxytetracycline hydrochloride activity in honey bee larvae (*Apis mellifera*) following medication with various doses." Apidologie 34(3): 269-279.

Four replicated experiments were conducted to determine the concentration of oxytetracycline hydrochloride (OTC) in honey bee (*Apis mellifera*) larvae following application of the antibiotic to honey bee colonies. In the first experiment, the mean OTC concentration was significantly greater in whole larvae than in larval guts sampled from hives on the day immediately following treatment. In two further experiments, 0.3 g, 0.5 g and 1.0 g active OTC in caster sugar was administered to single- and double-storey colonies. The mean OTC concentration was above the minimum inhibitory concentration of OTC to Melissococcus pluton for 2 to 6 days post-treatment, depending upon the dose. The daily rate of change of concentration of OTC in larvae sampled from treated colonies ranged from 0.423 to 0.672. In a fourth experiment, application of 0.3 g and 0.5 g OTC in distilled water gave equal to or higher OTC levels in larvae on the first two days post-treatment when compared to the same doses applied in caster sugar.

Pinnock, D. E. and N. E. Featherstone (1984). "Detection and quantification of Melissococcus pluton infection in honeybee colonies by means of enzyme-linked immunosorbent assay." Journal of apicultural research. 23(3): 168-170.

Trend, B., et al. (2007). "European foulbrood disease of bees."

White, B. and B. Ward (1977). "European brood disease." Australasian beekeeper: 110-113.

Winn, B. (1977). "European foulbrood." Australasian beekeeper: 259-260.

Winn, R. A. (1978). "An outbreak of European foul brood in South Australia." Australasian beekeeper 79(7): 136-140.

Witte, K. d. (2003). "European foul brood disease of honey bees." Agnote - Northern Territory of Australia(K14): 3-pp.
The Australian distribution, causal organism (Melissococcus pluton [M. plutonius]), symptoms, transmission and control (chemical and cultural) of the European foul brood disease of honey bee larvae are presented.

Hive Beetle

Annand, N. (2011). Investigations on small hive beetle biology to develop better control options. PQDT - Global. Ann Arbor, University of Western Sydney (Australia): 164-164.
The small hive beetle (SHB), *Aethina tumida* Murray, was first detected in Australia in 2002. Since then it has become a major pest of bee hives, spreading rapidly throughout the eastern mainland states. When conditions are suitable, beetles lay their eggs within bee hives and honey sheds, often in the combs, either in the hive or in stored honey combs pre- or post-extraction. Hatching larvae then feed on the honey, pollen, bee eggs, bee larvae and brood. The resulting contamination of the honey renders it useless for extraction, thereby leaving beekeepers bereft of their main source of income from the hives. Beekeepers also face the cost of cleaning contaminated supers and hives and restoring colonies to full strength or even replacing colonies following heavy infestations. A number of strategies to minimise the impact of SHB are already in use in Australia, and include trapping devices, insecticide delivery mechanisms, modifications to hive designs, improved beekeeping techniques and hygienic procedures. However, SHB continues to cause large-scale economic losses within the industry. It is clear that a better understanding of the biology of the SHB is required if beekeepers are to effectively manage this pest using a sustainable, integrated approach. This project sought to elucidate a number of biological and behavioural characteristics of SHB that directly relate to damage in hives and honey houses. The research was aimed at generating data that would support and enhance the effectiveness of existing SHB control strategies as well as provide the basis for new strategies, for the commercial and amateur beekeeping industry.

Arbogast, R. T., et al. (2012). "Estimating Reproductive Success of *Aethina tumida* (Coleoptera: Nitidulidae) in Honey Bee Colonies by Trapping Emigrating Larvae." Environmental Entomology 41(1): 152-158.
The small hive beetle (*Aethina tumida* Murray) is a scavenger and facultative predator in honey bee colonies, where it feeds on pollen, honey, and bee brood. Although a minor problem in its native Africa, it is an invasive pest of honey bees in the United States and Australia. Adult beetles enter bee hives to oviposit and feed. Larval development occurs within the hive, but mature larvae leave the hive to pupate in soil. The numbers leaving, which can be estimated by trapping, measure the reproductive success of adult beetles in the hive over any given period of time. We describe a trap designed to intercept mature larvae as they reach the end of the bottom board on their way to the ground. Trap efficiency was estimated by releasing groups of 100 larvae into empty brood boxes and counting the numbers trapped. Some larvae escaped, hut mean efficiency ranged from 87.2 to 94.2%. We envision the trap as a research tool for study of beetle population dynamics, and we used it to track numbers of larvae leaving active hives for pupation in the soil. The traps detected large increases and then decreases in numbers of larvae leaving colonies that weakened and died. They also detected small numbers of larvae leaving strong European and African colonies, even when no larvae were observed in the hives.

Arbogast, R. T., et al. (2009). "Trophic Habits of *Aethina tumida* (Coleoptera: Nitidulidae): Their Adaptive Significance and Relevance to Dispersal." Environmental entomology. 38(3): 561-568.
Aethina tumida Murray is an African native that has become an important pest of honey bee colonies in North America and Australia. Adults and larvae feed on pollen, honey, and brood in bee hives. The beetle is also able to feed and reproduce on fresh or rotting fruit, but natural occurrence on this diet has rarely been observed. We compared the reproductive success--as measured by progeny production, weight of progeny, developmental rate, and survival of immature stages--of beetles reared on various diets of fruit and bee products. Reproduction on all of

the diets was sufficient for population growth. Using baited flight traps to monitor the presence of A. tumida, we found persistent although tenuous populations in wooded habitats lacking managed bee colonies. On the basis of these findings and the habits of other nitidulid beetles, we propose that A. tumida is an ecological generalist able to maintain adequate levels of reproduction in marginal environments but able to reach high levels in favorable, resource rich environments, such as honey bee colonies. This hypothesis has significance for active dispersal and range expansion, because reproduction in the absence of bees would facilitate long range dispersal by flight through successive generations. Although our findings support the hypothesis, definitive proof would require association of beetles with hosts, trapping adults as they emerge from the soil, or other methods that would confirm feeding and reproduction at a given site, rather than immigration from bee colonies.

Atkinson, E. B. (2011). Investigating the integration of small hive beetles (*Aethina tumida*) Murray, Coleoptera: Nitidulidae) into western honey bee (*Apis mellifera* L., Hymenoptera: Apidae) colonies.

The small hive beetle (*Aethina tumida* Murray; Coleoptera: Nitidulidae) is native to sub-Saharan Africa, where it is considered an occasional nuisance in honey bee (*Apis mellifera* L.; Hymenoptera: Apidae) colonies. However, the species is considered a significant pest of honey bees in its introduced range of North America and Australia, where the beetle has been established since 1996 and 2002, respectively. The small hive beetle damages colonies through feeding and reproductive behaviors, and can cause absconding or complete colony collapse. Small hive beetles integrate into honey bee colonies via several adaptations, including: retraction of appendages beneath the body when encountering defensive honey bees, finding hiding areas (confinement sites) within the bee nest that are inaccessible to honey bees, and coercing host honey bees to feed them while confined. Other nitidulids have been found in honey bee colonies and they appear to have lower degrees of integration into honey bee nests than do small hive beetles. A series of experiments was conducted to investigate potential morphological (Chapter 3), behavioral (Chapters 2, 4-7), and chemical (Chapter 5) adaptations that enable small hive beetles to integrate successfully into honey bee nests. The results of the research suggest that small hive beetles are attracted to odors present in honey bee colonies (Chapter 2). Also, they possess leg modifications that allow them to retract their appendages beneath their bodies more fully (Chapter 3), thus resisting attack from honey bee hosts who treat them more defensively than they treat other beetles at the nest entrance (Chapter 4). Furthermore, small hive beetles have an altered chemical profile that is dependent upon their post-eclosion diet (Chapter 5), though the significance of the altered profile is unclear. Finally, small hive beetles are unique among other beetle species in their ability to find hiding places within the colony where they are confined by honey bee hosts (Chapter 6) until the ambient temperature decreases, whereafter the beetles enter the thermoregulatory cluster of honey bees (Chapter 7). The research presented herein contributes to a greater understanding of attributes of small hive beetles that enable them to integrate successfully into honey bee nests. (Full text of this dissertation may be available via the University of Florida Libraries web site. Please check http://www.uflib.ufl.edu/etd.html)

Atkinson, E. B. and J. D. Ellis (2012). "Temperature-Dependent Clustering Behavior of *Aethina Tumida* Murray in *Apis Mellifera* L. Colonies." Journal of insect behavior. 25(6): 604-611.

Temperate races of honey bees (*Apis mellifera*) are able to survive cold temperatures by forming thermoregulatory clusters. Small hive beetles (*Aethina tumida*), which inhabit honey bee colonies in their native range of sub-Saharan Africa and in their introduced ranges of the United States and Australia, are able to endure temperate climates by entering the bee cluster when cold temperatures persist. We conducted an experiment to address the temporal aspects of the cluster-entering behavior of small hive beetles. We did this by exposing beetle-infested observation bee hives to different ambient temperatures and counting the number of beetles remaining in confinement sites on the hives periphery at each temperature. The resulting regression analyses suggest that the beetles enter the cluster more rapidly than they exit it, a behavior possibly linked to a colonys decision to form and dismantle a cluster.

Buchholz, S., et al. (2008). "Alternative food sources of *Aethina tumida* (Coleoptera: Nitidulidae)." Special Issue: The small hive beetle. 47(3): 202-209.

The small hive beetle (SHB) is a parasite and scavenger of honey bee colonies, but may also be able to exploit alternative food sources. We conducted experiments to shed further light on the role of alternative foods for SHB. (1) Laboratory choice experiments showed that adult SHB oviposit on fruit and even on decaying meat and that SHB larvae feed on it despite the presence of bee products. (2) In the laboratory, SHB reproduced on mango, banana

and grapes at lower rates than on a pollen and honey mixture. (3) Adult SHB were rarely observed on fruit buckets in the field. They reproduced only when caged and in much smaller numbers than Drosophilidae and other Nitidulidae. (4) While Aethina concolor was repeatedly observed during a field survey, no adult SHB were found on any flowers. (5) Less than 2% of adult SHB survived on blooming pot plants and no reproduction was recorded, suggesting that flowers are unlikely to serve as an alternative food and breeding substrate. Nevertheless, the high degree of opportunism displayed, supports the view that honey bee nests are not essential for SHB survival and reproduction. Despite the observed high degree of SHB opportunism, it appears as if alternative food sources play a minor role only for reproduction in the field when host colonies are available. Even though SHB may use alternative food sources in the absence of bee hives (e.g. after migratory beekeeping), it is unclear whether this is likely to contribute to SHB population build up.

Downey, D., et al. (2015). "Radiobiology of Small Hive Beetle (Coleoptera: Nitidulidae) and Prospects for Management Using Sterile Insect Releases." Journal of economic entomology. 108(3): 868-872.

Small hive beetle, *Aethina tumida* Murray (Coleoptera: Nitidulidae), is considered a serious threat to beekeeping in theWestern Hemisphere, Australia, and Europe mainly due to larval feeding on honey, pollen, and brood of the European honeybee, *Apis mellifera* L. Control methods are limited for this pest. Studies were conducted to provide information on the radiobiology of small hive beetle and determine the potential for sterile insect releases as a control strategy. Adult males and females were equally sensitive to a radiation dose of 80 Gy and died within 57 d after treatment. In reciprocal crossing studies, irradiation of females only lowered reproduction to a greater extent than irradiation of males only. For matings between unirradiated males and irradiated females, mean reproduction was reduced by >99% at 45 and 60 Gy compared with controls, and no larvae were produced at 75 Gy. Irradiation of prereproductive adults of both sexes at 45 Gy under low oxygen (14%) caused a high level of sterility (>99%) while maintaining moderate survivorship for several weeks, and should suffice for sterile insect releases. Sterile insect technique holds potential for suppressing small hive beetle populations in newly invaded areas and limiting its spread.

Hayes, R. A., et al. (2019). "Behavioural responses of the small hive beetle to volatile components of fermenting honeybee hive products." Entomologia experimentalis et applicata. 167(9): 784-793.

The small hive beetle, *Aethina tumida* Murray (Coleoptera: Nitidulidae), is a significant pest of managed honeybees in the USA and eastern Australia. The beetle damages hives by feeding on hive products and leaving behind fermented wastes. The beetle is consistently associated with the yeast Kodamaea ohmeri (Etchells & Bell) Yamada et al. (Saccharomycetales: Metschnikowiaceae), and this yeast is the presumed agent of the fermentation. Previous work has noted that the small hive beetle is attracted to volatiles from hive products and those of the yeast K. ohmeri. In this study, we investigated how the volatile compounds from the fermenting hive products change depending upon the source of the hive material and also how these volatiles change through time. We used gas chromatography-mass spectrometry and choice-test behavioural assays to investigate these changes using products sampled from apiaries across the established range of the beetle in eastern Australia. The starting hive products significantly affected the volatile composition of fermenting hive products, and this composition varied throughout time. We found 61.7% dissimilarity between attractive and non-attractive fermenting hive products, and identified individual compounds that characterise each of these groups. Eleven of these individual compounds were then assessed for attractiveness, as well as testing a synthetic blend in the laboratory. In the laboratory bioassay, 82.1 A+/- 0.02% of beetles were trapped in blend traps. These results have strong implications for the development of an out-of-hive attractant trap to assist in the management of this invasive pest.

Hayes, R. A., et al. (2015). "Increased attractiveness of honeybee hive product volatiles to adult small hive beetle, *Aethina tumida*, resulting from small hive beetle larval infestation." Entomologia experimentalis et applicata. 155(3): 240-248.

The small hive beetle, *Aethina tumida* Murray (Coleoptera: Nitidulidae), is a recent but significant pest of honeybee [*Apis mellifera* L. (Hymenoptera: Apidae)] hives in various regions throughout the world, including Eastern Australia. The larval stage of this beetle damages hives when they feed on brood, pollen, and honeycomb, leaving behind fermented wastes. In cases of extreme damage, hives collapse and are turned to an odorous mass of larvae in fermenting hive products. The yeast Kodamaea ohmeri (Etchells & Bell) Yamada et al. (Ascomycota) has been consistently isolated from the fermenting material as well as each life stage of this beetle. Various studies have noted

that the small hive beetle is attracted to volatiles from hive products and those of the yeast K. ohmeri, although earlier studies have not used naturally occurring hive products as their source of fermentation. This study investigated changes through time in the attractiveness of natural honeybee hive products to the small hive beetle as the hive products were altered by the action of beetle larvae and fermentation by K. ohmeri. We used gas chromatography-mass spectrometry and choice-test behavioural assays to investigate these changes using products sampled from three apiaries. Attractiveness of the fermenting hive products (-slime-) increased as fermentation progressed, and volatile profiles became more complex. Fermenting hive products remained extremely attractive for more than 30 days, significantly longer than previous reports. These results have strong implications for the development of an external attractant trap to assist in the management of this invasive pest.

Levot, G. W. and D. Somerville (2012). "Efficacy and safety of the insecticidal small hive beetle refuge trap APITHORTM in bee hives." Australian Journal of Entomology 51(3): 198-204.

Research into the insecticidal control of adult small hive beetle culminated in the development of an insecticidal refuge trap for deployment inside commercial bee colonies. The device (APITHORTM) is comprised of a two-piece rigid plastic shell encasing a fipronil-treated corrugated cardboard insert. Comparison of key hive health parameters (frames of bees, area of brood and weight of honey produced) between 'control' and APITHORTM-treated hives demonstrated no significant differences over a 6-week trial conducted during a spring honey flow. Mean fiprole (fipronil plus its toxic metabolites) residues in honey ripened while the devices were in place did not exceed the limit of quantification (1 micro g/kg). In a 36-day field trial conducted in a beetle-infested apiary, all live adult beetles were eliminated from hives containing APITHORTM, while beetle numbers increased by approximately 20% in co-located control hives.

Li, D., et al. (2018). "Molecular detection of small hive beetle *Aethina tumida* Murray (Coleoptera: Nitidulidae): DNA barcoding and development of a real-time PCR assay." Scientific Reports (Nature Publisher Group) 8: 1-13.

Small hive beetle (SHB), *Aethina tumida* can feed on honey, pollen and brood in honey bee colonies. It was endemic to Africa, but since 1996 has been detected in a number of countries worldwide, including Australia, Brazil, Canada, Italy, Mexico, South Korea, Philippines and the USA where it has had economic effects on local apiculture. To improve SHB identification, we obtained the first reference sequences from the DNA barcoding 5′ COI gene region for SHB and some species of the family Nitidulidae associated with beehives. Phylogenetic analysis of SHB COI sequences (3′ COI) revealed two divergent lineages, with those from Australia and USA being genetically different from the recent detection in Italy. Many countries, including New Zealand, are currently free from SHB, and require a rapid detection method for biosecurity. Here we present the development and validation of a real-time PCR assay for detection of SHB. The assay showed high specificity and sensitivity for detecting SHB, with no cross-reaction observed with closely related species, such as A. concolor. The real-time PCR is sensitive, detecting the target sequences up to 100 copies/µL. This assay should prove a useful biosecurity tool for rapid detection of SHB worldwide.

Neumann, P., et al. (2010). "High and rapid infestation of isolated commercial honey bee colonies with small hive beetles in Australia." Journal of Apicultural Research 49(4): 343-344.

Willcox, B. K., et al. (2017). "Absence of small hive beetles from flowering plants." Journal of Apicultural Research 56(5): 643-645.

Small hive beetles (SHBs), *Aethina tumida* (Coleoptera: Nitidulidae), are parasites and scavengers of honey bee colonies in their endemic range in sub-Saharan Africa as well as in their new distribution range. Even though flowering plants may in principle also serve as a food for SHBs, evidence so far suggest that this beetle is unlikely to visit flowers. However, field data remain scarce calling for more efforts to investigate the potential of flowers as reservoirs for this pest of social bees. Here, we conducted extensive field surveys of flowering plants in Australia. Despite the very large sample size, not a single adult SHB was found on any of the flowers. This is in line with an earlier field survey. Since SHBs were also absent from fruits in another surveys, it appears as if alternative food sources outside of bee colonies are of minor importance only for SHBs.

Mites and Viruses

(1985). "A new mite." Canadian Beekeeping 12(4): 78-78.

Mellitiphis alvearius was found on attendant workers accompanying a queen, and in 14 of 16 package colonies, all imported from New Zealand.

(1991). "The threat to Australia from exotic bee mites." AQIS Bulletin 4(2, Supplement): 1-4.

The threat to Australian bees (*Apis mellifera*) by the parasitic mites *Varroa jacobsoni* and *Tropilaelaps clareae* (expected to reach the southern coast of Papua New Guinea by 1995) is described. Mite biology, potential cost to the industry, their current proximity to Australia, likely methods of spread across the Torres Strait, current surveillance, monitoring for swarms on the islands of Boigu, Saibai and Dauan, a quarantine zone across the Strait, an awareness programme, contingency planning and trade implications are discussed.

(1995). "Might be bee mites." AQIS Bulletin 8(1): 9-9.

Varroa (*Varroa jacobsoni*) has been detected in feral colonies of the Asian honey bee *Apis cerana* on Dauan Island, in the far north of the Torres Strait adjacent to Papua New Guinea. This island and the neighbouring Saibai and Boigu Islands, all Australian territory, have been declared an infected zone. The remaining Australian islands in the Torres Strait (which is c. 150 km across) have been declared a surveillance zone, monitored by the Australian Quarantine and Inspection Service. The Australian mainland remains free of both V. jacobsoni ad *A. cerana*.

(2000). "Varroa found in New Zealand." American bee journal. 140(6): 438-438.

(2012). "Australian honeybees lack immunity to Varroa mite." Ecos(173): 1-2.

The article reports that according to a research by University of Sydney's School of Biological Sciences and the Agricultural Research Service of the United States Department of Agriculture, honeybees in Australia are highly susceptible to Varroa mite, a pest that hasn't yet reached our shores. After only four months of exposure to the Varroa mite, 44 per cent of all the Australian honeybee lines had died.

Abbo, P. M., et al. (2017). "Effects of Imidacloprid and *Varroa destructor* on survival and health of European honey bees, *Apis mellifera*." Insect science 24(3): 467-477.

There has been growing concern over declines in populations of honey bees and other pollinators which are a vital part to our food security. It is imperative to identify factors responsible for accelerated declines in bee populations and develop solutions for reversing bee losses. While exact causes of colony losses remain elusive, risk factors thought to play key roles are ectoparasitic mites *Varroa destructor* and neonicotinoid pesticides. The present study aims to investigate effects of a neonicotinoid pesticide Imidacloprid and Varroa mites individually on survivorship, growth, physiology, virus dynamics and immunity of honey bee workers. Our study provides clear evidence that the exposure to sublethal doses of Imidacloprid could exert a significantly negative effect on health and survival of honey bees. We observed a significant reduction in the titer of vitellogenin (Vg), an egg yolk precursor that regulates the honey bees development and behavior and often are linked to energy homeostasis, in bees exposed to Imidacloprid. This result indicates that sublethal exposure to neonicotinoid could lead to increased energy usage in honey bees as detoxification is a energy-consuming metabolic process and suggests that Vg could be a useful biomarker for measuring levels of energy stress and sublethal effects of pesticides on honey bees. Measurement of the quantitative effects of different levels of Varroa mite infestation on the replication dynamic of Deformed wing virus (DWV), an RNA virus associated with Varroa infestation, and expression level of immune genes yields unique insights into how honey bees respond to stressors under laboratory conditions. Copyright © 2016 Institute of Zoology, Chinese Academy of Sciences.

Allen, M. F. and B. V. Ball (1995). "Characterisation and serological relationships of strains of Kashmir bee virus." Annals of applied biology. 126(3): 471-484.

Anderson, D. (1983). "Viruses of honeybees." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 52-60.

Anderson, D. (1985). "Viruses of New Zealand honey bees." New Zealand beekeeper(188): 8-10.

Anderson, D. and A. Gibbs (1984). "Picornaviruses in Australian honeybees." Abstracts of the Sixth International Congress of Virology, 1-7 September 1984.: 340-340.

Anderson, D. L. (1983). "Viruses of honeybees in North Eastern Australia." Australasian beekeeper 84(11): 219-223.
The occurrence and distribution of viruses was surveyed in October 1981 in 52 colonies (NE New South Wales and SE Queensland) and in October 1982 in 30 colonies (S, central and far north coastal regions of Queensland). Sac brood virus (SBV) was found in 85% and 95% of the colonies in the 2 surveys. Black queen cell virus (BQCV) and cloudy wing virus, the only other viruses found, were less common. BQCV was found only in colonies infected with SBV; up to 3 viruses were isolated from an individual colony.Author.

Anderson, D. L. (1991). "Kashmir bee virus--a relatively harmless virus of honey bee colonies." American bee journal. 131(12): 767-767.

Anderson, D. L. and A. J. Gibbs (1988). "Inapparent virus infections and their interactions in pupae of the honey bee (*Apis mellifera* Linnaeus) in Australia." Journal of general virology. 69(7): 1617-1625.

Bailey, L. (1967). "The incidence of virus diseases in the honey bee." Annals of Applied Biology 60(1): 43-48.
Chronic bee-paralysis virus and sacbrood virus occur commonly in apparently normal honey-bee colonies in Britain. Most sick adult bees not affected by *Nosema apis*, *Malpighamoeba mellificae* or *Acarapis woodi* have chronic paralysis and most dead larvae not affected by micro-organisms have sacbrood. Both virus diseases are probably limited by hereditary factors, but unknown environmental factors also seem to influence disease. Paralysed bees from Australia, Canada, Eire, Germany and Mexico were found to be infected with chronic paralysis virus. Copyright © 1967, Wiley Blackwell. All rights reserved

Bailey, L., et al. (1980). "Bee virus Y." Journal of general virology 51: 405-407.
During surveys of honeybees in England and Wales, virus Y, not previously reported, was found in dead adult bees. The virus was also found in samples of bees from Canada and Australia. Bee virus Y is a serotype of bee virus X [see AA 1129/76], and is physically similar to it, but virus Y aggregates in low salt concentrations, and its single protein has a slightly lower mol wt than bee virus X. The viruses formed separate bands when centrifuged to equilibrium in caesium chloride. P. Walker

Bailey, L., et al. (1979). "Egypt bee virus and Australian isolates of Kashmir bee virus." Journal of general virology 43(3): 641-647.

Bailey, L., et al. (1981). "Properties of a filamentous virus of the honey bee (*Apis mellifera*)." Virology 114(1): 1-7.
An ellipsoidal particle, 450 X 150 nm, was obtained from dead honeybees from an infected colony in England. The particle comprises a nucleocapsid 3000 X 40 nm, containing double-stranded DNA with a mol wt of approximately 12 X 106, which is coiled within a membrane. The buoyant densities in caesium chloride of the whole particle, nucleocapsid, DNA, and DNA with ethidium bromide, are 1.28, 1.36, 1.71 and 1.61 g/ml, respectively. The particle contains about 12 proteins, with mol wts ranging from 13 000 to 70 000, which are distributed approximately equally between the membrane and the nucleocapsid. The virus does not appear to belong to any currently described group of insect viruses. Particles of exactly the same morphology have been found in bees from Japan and New Zealand, and a similar virus was reported in the USA [AA 619/81]. P. Walker

Banks, A. W. and A. Koethals (1961). "Mites of the genus *Acarapis* on bees in South Australia." Australian Veterinary Journal 37(10): 397-pp.

Following the discovery in Australia in June 1959 of mites of the genus *Acarapis* on worker honey bees accompanying three queen bees imported from the United States [cf. R.A.E., A 50 295], the queens with accompanying Australian worker bees were examined at the Commonwealth Institute of Entomology, where small numbers of external mites were found on the former and larger numbers on the latter; no mites were discovered in the tracheae. Subsequent surveys in the United States and Canada showed that external mites were widely distributed in 12 States and three Provinces [cf. 50 342]. In a survey carried out between October 1960 and January 1961 in South Australia, mainly in a district where there were hives from a wide area, six mites, identified as close to A. dorsalis Morgenthaler, but certainly not A. woodi (Eennie), were found on young bees from four of 20 properties by a method involving washing and centrifuging. No external mites were found by direct examination, and no mite excreta or damage could be seen in the tracheae of any bees.

Benard, H., et al. (2001). "The outbreak of *Varroa destructor* in New Zealand bees: delimiting survey results and management options." Surveillance (Wellington) 28(3): 3-5.

A delimiting survey was conducted from April 12 to early June 2000 to determine the geographical distribution of *Varroa destructor* infestations and to obtain information regarding the timing and means of introduction of these honey bee ectoparasites into New Zealand. The survey design, as well as associated technical and epidemiological projects that were simultaneously conducted, is presented. Results of the survey and proposed management options are discussed.

Bolger, P. (2001). "Varroa update: South Island remains varroa free." Biosecurity(32): 5-6.

An extensive surveillance programme using GIS (Geographical Information Systems) was conducted in the South Island of New Zealand [date not given] to: (1) detect any incursion of varroa mites (*Varroa destructor*) early, and (2) demonstrate that the South Island is free of varroa. Individual apiaries were tracked. Recognizing that swarms travelling on ships are a potential means of spreading varroa, a swarm trapping programme was also trialled at three South Island seaports to check for the presence of varroa. Results showed that all 1737 apiaries and 24 737 hives checked were negative for varroa. Also, 2 swarms found at ports tested negative for varroa. It is concluded that the South Island was free from varroa at the levels the survey could detect. Another round of surveillance in 2002 is recommended to confirm this state.

Boudagga, H., et al. (2003). "Morphological identification of the Varroa species (Acari: Varroidae) colonizing Tunisian apiaries." Systematic and applied acarology. 8(1): 97-100.

The mite that attacks Tunisian honeybees (*Apis mellifera* intermissa L.), previously known as *Varroa jacobsoni* Oudemans 1904 (Acari: Varroidae), is identified as *Varroa destructor* Anderson & Trueman 2000, by a morphological study of many females collected throughout the country. This is the species present in Europe, Middle East, South Africa, Asia, North and South America and in New Zealand.

Bowman, C. E. and C. A. Ferguson (1985). "Forcellinia galleriella, a mite new to British beehives." Bee World 66(2): 51-53.

Forcellinia galleriella, a mite known previously only in Perth, Australia, is recorded for the first time from a hive of honeybees (*Apis mellifera*) in Slough, England. Since in Australia it was found in hives heavily infested by Galleria mellonella, it was thought to prey on the larvae of this species, but examination of the mouthparts of the English population suggests that it is saprophagous, feeding on detritus and fungi. It is thus unlikely to be directly harmful to *A. mellifera*. Most species of Forcellinia inhabit the nests of ants and are regarded as commensals.

Brettell, L. E., et al. (2020). "Occurrence of honey bee-associated pathogens in Varroa-free pollinator communities." Journal of Invertebrate Pathology 171: 107344-107344.

Australia remains the last significant land mass free of Varroa, a parasitic mite which has caused dramatic honey bee (*Apis mellifera*) colony losses across the globe, due to its association with the pathogenic deformed wing virus (DWV). As such, Australia continues to maintain relatively healthy honey bee populations, despite recent work showing apiaries harbor a surprisingly high prevalence of microbial pathogens. We sought to determine the prevalence of these microbial pathogens in honey bees and native pollinators actively co-foraging on mass flowering crops and to understand the extent to which they may be shared between taxa. We found high pre-valences of black queen cell virus (BQCV) and sacbrood virus (SBV) in the honey bees (88% and 41% respectively), and

correspondingly, these were the most common honey bee pathogens detected in native pollinator taxa, albeit at much lower prevalence; the maximum prevalence for any pathogen in a native pollinator group was 24% (BQCV in Halictidae spp.). The viral pathogens Israeli acute paralysis virus and Lake Sinai viruses 1 and 2, and the fungal parasites *Nosema apis* and *Nosema ceranae*, were only rarely detected. Phylogenetic analyses of the most common pathogens revealed similar genotypes circulating between species. Our data suggest that, in Australian orchards, pathogen prevalence in honey bees is a good predictor of pathogen prevalence in native pollinators, which raises concerns about how the viral landscape may change in native taxa if, or when, Varroa arrives.

Brimblecombe, A. E. and C. Roff (1960). "Mites associated with honeybees in Queensland." Queensland Journal of Agricultural Science 17(4): 447-pp.

Mites determined as *Acarapis woodi* (Rennie) were recently found in Queensland on a worker honey bee in a consignment of queen bees from California, and similar mites, thought to be -4. dorsalis Morgenthaler or A. externus Morgenthaler [cf. R.A.E., A 23 185; 26 343], were subsequently found in California, Massachusetts, British Columbia and Alberta and were indirectly reported from Utah and Louisiana. A. externus was recorded from Toronto and Quebec in 1926. *Acarapis* mites were found on the thorax of bees introduced into Queensland from Italy, New Zealand, Louisiana, Mississippi and Tennessee in 1960 and a rapid survey in Queensland showed that they were present on the thorax of worker bees at Brisbane and at widely separated places in eastern Queensland, so that they seem to be generally distributed in the State. The mites were nowhere found in or near the tracheae, in which A. woodi causes Acarine (Isle of Wight) disease. It has been suggested that A. woodi occurs undetected in many countries, that it can exist as a harmless parasite and that it becomes pathogenic only under certain circumstances. In addition to Europe and North America, it is known to occur in Argentina, Chile, Uruguay. India, the Soviet Union and the Canary Islands [see also 28 655]. It has further been suggested that external mites on honey bees may represent a variety of A. woodi [cf. 23 66, etc.] or a distinct species [cf. 23 185, etc.]. Casual infestations of honey bees by Pyemotes ventricosus (Newp.) and Neocypholaelaps sp. have also been recorded in Queensland.

Chaneet, G. d., et al. (1984). "*Acarapis* mites on honeybees." Australian Veterinary Journal 61(10): 322-323.

In 1975 A. woodi was identified in 2 separate imports of queens with attendant workers from Italy. One queen, later found to be infested, was present in a colony for 5 days, but A. woodi was not found in any of the 3406 bees examined from this and other colonies in the apiary. In an examination of samples of bees (total 400 bees) from 21 apiaries in south-west Western Australia in 1979, *Acarapis* mites were found on 37 bees from 13 apiaries; they were identified as A. dorsalis and A. externus.P. Walker. ADDITIONAL ABSTRACT: In 1979 examination of 400 bees in 21 apiaries in southwest Western Australia revealed A. dorsalis and A. externus on 37 bees in 13 apiaries. As no mites were found on 50 bees from 90 apiaries in 1961/62, it is concluded that these mites have been introduced recently or are increasing in prevalence. A. woodi was not found.

Clifford, D., et al. (2011). "Using Simulation to Evaluate Time to Detect Incursions in Honeybee Biosecurity in Australia." Risk Analysis: An International Journal 31(12): 1961-1968.

A key determinant of the efficiency of a surveillance system for exotic mites is whether an incursion might be detected sufficiently quickly to allow successful management actions to occur. To assess this possibility we have developed a spatial modeling system and synthesized knowledge of honeybee and mite behavior to explore the potential spread of exotic mites and the likelihood of their detection in sentinel hives. We find that increasing the number of hives and the efficiency of the detection method are the most effective means of improving the time to detection. [ABSTRACT FROM AUTHOR]

Clinch, P. G. and J. Faulke (1977). "Toxicity to the external mite *Acarapis* externus Morgenthaler of pesticides fed in sugar syrup to infested honey bees." New Zealand journal of experimental agriculture 5(2): 185-187.

In tests in the laboratory and field in New Zealand in 1975-76, 23 acaricides and insecticides were supplied in a sugar solution to infested honey bees for the control of *Acarapis* externus Morgenthaler. Endosulfan was the most effective in the laboratory, and its activity was confirmed in field tests. A single dose of 40 mg endosulfan in 2

litres sugar syrup fed to infested colonies reduced the numbers of infested bees by 85%. A second dose 19 days later resulted in a 98% reduction. Few bees died. The effect of the acaricide on the mites appeared to be achieved systemically through the bee, and it is suggested that it could probably be used to control the internal mite A. woodi (Rennie.).

Clinch, P. G. and J. G. M. Ross (1970). "External acarine mites, *Acarapis* spp. (Acarina: Trombidiformes) on honey bees in New Zealand." New Zealand Entomologist 4(3): 136-137.

Routine examination of honey bees from areas throughout New Zealand revealed the presence of *Acarapis vagans* Schneider. All three species of acarine mites known as external parasites of honey bees (A. externus Morgenthaler, A. dorsalis Morgenthaler and A. vagans) have now been found in both islands. They are generally regarded as harmless [cf. RAE/A 50, p. 342, etc.].

Colin, T., et al. (2019). "Effects of thymol on European honey bee hygienic behaviour." Apidologie 50(2): 141-152.

The parasitic mite *Varroa destructor* is a major threat to the European honey bee *Apis mellifera*. Beekeepers apply the miticide thymol directly within the hives to kill this parasitic mite. Thymol is repellent to bees and causes them to ventilate the hive, yet its impact on bee hygienic behaviours that prevent the spread of diseases has never been studied. We measured the efficiency of colonies at removing dead adult bees, uncapping dead pupal cells and removing dead brood in two miticide-free Australian environments where the mite is absent. Thymol increased the uncapping and removal of dead brood by 24 to 36% after 48h at both locations but had no effect on the removal of dead adult bees. The increased removal of brood could enhance the effect of thymol on V. destructor, especially if bees preferentially remove cells infected with the mite.

Cook, V. A. and C. E. Bowman (1983). "Mellitiphis alvearius, a little-known mite of the honeybee colony, found on New Zealand bees imported into England." Bee World 64(2): 62-64.

On attendant workers accompanying queens imported in April and May, 1982.

Dall, D. J. (1985). "Inapparent infection of honey bee pupae by Kashmir and sacbrood bee viruses in Australia." Annals of applied biology. 106(3): 461-468.

Dall, D. J. (1987). "Intracellular structures associated with the multiplication of sacbrood virus." Journal of invertebrate pathology. 50(3): 261-268.

Davis, A. and D. McRory (1987). "Various mites from Ontario bee hives." Canadian Beekeeping 13(9): 209-209.

In 1986, 22 honeybee colonies in 6 apiaries in Ontario, Canada, were examined for external or free-living mites. Most of the colonies had been established from New Zealand package bees. Of the 4 mites found, 1 was an adult female Melittiphis alvearius, and the other 3 were nymphs of Parasitus sp., Bryobia sp. and Cheyletus sp., respectively.D.G. Lowe.

De Chaneet, G., et al. (1984). "Acarapis mites on honeybees." Australian veterinary journal. 61(10): 322-323.

Delfinado, M. D. and E. W. Baker (1974). "A new record for the bee mite Mellitiphis in New Zealand." Bee World 55(4): 148-149.

Melittiphis alvearius (Berl.), which is known in beehives in Europe (including Britain) and is believed to be a parasite of honey bees (*Apis mellifera* L.) [cf. RAE/A 18, p. 366], was found for the first time in New Zealand in 1974, in wax scrapings from a hive of honey bees in Levin. Aspects of the adult morphology of this Eviphiid mite are illustrated.

Delfinadobaker, M. (1994). "A harmless mite found on honeybees – Melittiphis alvearius - from Italy to New-Zealand." American bee journal 134(3): 199-199.

Djordjevic, S. P., et al. (1999). "Geographically diverse Australian isolates of Melissococcus pluton exhibit minimal genotypic diversity by restriction endonuclease analysis." FEMS microbiology letters. 173(2): 311-318.

Melissococcus pluton, the causative agent of European foulbrood is an economically significant disease of honey bees (*Apis mellifera*) across most regions of the world and is prevalent throughout most states of Australia. 49 isolates of M. pluton recovered from diseased colonies or honey samples in New South Wales, Queensland, South Australia, Tasmania and Victoria were compared using SDS-PAGE, Western immunoblotting and restriction endonuclease analyses. DNA profiles of all 49 geographically diverse isolates showed remarkably similar AluI profiles although four isolates (one each from Queensland, South Australia, New South Wales and Victoria) displayed minor profile variations compared to AluI patterns of all other isolates. DNA from a subset of the 49 Australian and three isolates from the United Kingdom were digested separately with the restriction endonucleases CfoI, RsaI and DraI. Restriction endonuclease fragment patterns generated using these enzymes were also similar although minor variations were noted. SDS-PAGE of whole cell proteins from 13 of the 49 isolates from different states of Australia, including the four isolates which displayed minor profile variations (AluI) produced indistinguishable patterns. Major immunoreactive proteins of approximate molecular masses of 21, 24, 28, 30, 36, 40, 44, 56, 60, 71, 79 and 95 kDa were observed in immunoblots of whole cell lysates of 22 of the 49 isolates and reacted with rabbit hyperimmune antibodies raised against M. pluton whole cells. Neither SDS-PAGE or immunoblotting was capable of distinguishing differences between geographically diverse isolates of M. pluton. Collectively these data confirm that Australian isolates of M. pluton are genetically homogeneous and that this species may be clonal. Plasmid DNA was not detected in whole cell DNA profiles of any isolate resolved using agarose gel electrophoresis.

Dobelmann, J., et al. (2020). "Genetic strain diversity of multi-host RNA viruses that infect a wide range of pollinators and associates is shaped by geographic origins." Viruses 12(3).

Emerging viruses have caused concerns about pollinator population declines, as multi-host RNA viruses may pose a health threat to pollinators and associated arthropods. In order to understand the ecology and impact these viruses have, we studied their host range and determined to what extent host and spatial variation affect strain diversity. Firstly, we used RT-PCR to screen pollinators and associates, including honey bees (*Apis mellifera*) and invasive Argentine ants (Linepithema humile), for virus presence and replication. We tested for the black queen cell virus (BQCV), deformed wing virus (DWV), and Kashmir bee virus (KBV) that were initially detected in bees, and the two recently discovered Linepithema humile bunya-like virus 1 (LhuBLV1) and Moku virus (MKV). DWV, KBV, and MKV were detected and replicated in a wide range of hosts and commonly co-infected hymenopterans. Secondly, we placed KBV and DWV in a global phylogeny with sequences from various countries and hosts to determine the association of geographic origin and host with shared ancestry. Both phylogenies showed strong geographic rather than host-specific clustering, suggesting frequent inter-species virus transmission. Transmission routes between hosts are largely unknown. Nonetheless, avoiding the introduction of non-native species and diseased pollinators appears important to limit spill overs and disease emergence.

Fagan, L. L., et al. (2012). "Varroa management in small bites." Journal of applied entomology Zeitschrift fcor angewandte Entomologie. 136(6): 473-475.

Chelifers (Arachnida: Pseudoscorpionida), also known as pseudoscorpions, have been reported to be beneficial honeybee hive generalist pest predators for over 100years and are occasionally noted by beekeepers in their hives. We collected chelifers within or closely associated with beehives in New Zealand. Under video observation conditions, they predated upon varroa mites while studiously ignoring bee larvae. Varroa mites reproduce at exponential rates during the spring season, and current chemical miticides rely on single treatments aiming for at least 90% control. An alternate strategy, removal of mites at a rate matching their reproductive capacity, although mathematically obvious, fails unless a suitable biological control agent is available. Our observations build on over 100years of sporadic work to provide further evidence that chelifers show clear potential to be a suitable predator for varroa management in beehives. Approximately 25 chelifers can be expected to manage varroa populations in a single hive.

Fung, E., et al. (2018). "Co-occurrence of RNA viruses in Tasmanian-introduced bumble bees (*Bombus terrestris*) and honey bees (*Apis mellifera*)." Apidologie. 49(2): 243-251.

A number of bee RNA viruses, including Deformed wing virus (DWV), are so far unreported from Australia. These viruses can be introduced together with imported live honey bees (*Apis mellifera*) and their products, with other bee species, and bee parasites. Given that bee viruses have a profound impact on bee health, it is surprising that since the introduction of bumble bees (*Bombus terrestris*) onto Tasmania in 1992 from New Zealand, no work

has been done to investigate which RNA viruses are associated with these bees. Consequently, we investigate the current prevalence of RNA viruses in *B. terrestris* and *A. mellifera* collected in south-eastern Tasmania. We did not find DWV in either *A. mellifera* and *B. terrestris*. However, both bee species shared Kashmir bee virus (KBV) and Sacbrood virus (SBV), but Black queen cell virus (BQCV) was detected only in *A. mellifera*. This reinforces the importance of ongoing strong regulation of the anthropogenic movement of live bees and their products.

Gibbins, B. L. and R. F. v. Toor (1990). "Investigation of the parasitic status of melittiphis alvearius (Berlese) on Honeybees, *Apis mellifera* L., by immunoassay." Journal of apicultural research. 29(1): 46-52.

Giersch, T., et al. (2009). "*Nosema ceranae* infects honey bees (*Apis mellifera*) and contaminates honey in Australia." Apidologie 40(2): 117-123.

Polymerase chain reaction (PCR), restriction fragment length polymorphism (RFLP) analysis and microscopy were used to test 307 adult bee and 37 honey samples collected in Australia for the presence of two microsporidia, *Nosema ceranae* and *Nosema apis*. *N. ceranae* was detected in samples from 4 states (Queensland, New South Wales, Victoria and South Australia) and was most commonly found in samples from Queensland where 28 (33.7%) of 83 samples were positive. New South Wales had the second highest prevalence with 15 (15.8%) of 95 samples positive. South Australia and Victoria had 4 (16%) of 25 and 2 (4.5%) of 44 samples positive respectively. *N. ceranae* was not detected in samples from Western Australia and Tasmania. *N. apis* was detected in samples from all states. Three honey samples (8.1%) were PCR positive for *N. ceranae*. These positive honey samples originated from beekeepers in Queensland. Six imported honey samples tested were negative for both *Nosema* spp.

Goodwin, M. (2004). "Introduction and spread of Varroa in New Zealand." Bee world. 85(2): 26-28.

Goodwin, R. M., et al. (2005). "Base levels of resistance to common control compounds by a New Zealand population of *Varroa destructor*." New Zealand Journal of Crop & Horticultural Science 33(4): 347-352.

Base levels of *Varroa destructor* resistance to four synthetic chemicals were established in New Zealand during May through August 2003. The four chemicals-amitraz, coumaphos, flumethrin, and fluvalinate are currently used, or may in the future be registered for use, in New Zealand. Resistance was measured by placing mites on paraffin wax impregnated with the chemicals. The LC50 estimate, adjusted for natural mite mortality, for amitraz was 110 mu g/g, and > 200 mu g/g for coumaphos, 12 mu g/g for flumethrin, and 1269 mu g/g for fluvalinate. A comparison with international data indicates that New Zealand populations are not currently resistant to flumethrin. The LC50 for two Italian locations with mites resistant to fluvalinate was 385 and 857 mu g/g, and 16-17 mu g/g for non-resistant varroa (Milani 1995). Whether the adjusted LC50 for fluvalinate in this trial (1269 mu g/g) would be observed as resistance in the field in New Zealand is unknown. Because this is the first time these tests have been conducted in New Zealand it is not known whether this level of resistance was present when varroa arrived in New Zealand or whether it has since developed.

Goodwin, R. M., et al. (2006). "Drift of *Varroa destructor*-infested worker honey bees to neighbouring colonies." Journal of Apicultural Research 45(3): 155-156.

Varroa destructor-infested honey bee (*Apis mellifera*) colonies usually die if left untreated. However, colonies that have been treated with miticides are usually reinfested soon after treatment. This study investigated whether the reinfestation of colonies is due to varroa increasing the rate with which workers drift from infested colonies into neighbouring colonies. On 7 December 2004, sixteen honey bee colonies from the same apiary were randomly allocated among 4 apiary sites (4 colonies per apiary), located at least 5 km apart, in the Waikato region of New Zealand. The average percentage of bees drifting from untreated hives infested with varroa into neighbouring Bayvarol [flumethrin]-treated hives did not exceed 3%. There were no significant differences between the percentage of drifting bees from the varroa-infested colonies and the treated colonies at any stage throughout the trial. This suggests that the reinfestation of treated colonies does not predominantly result from heavy varroa infestations causing worker bees to drift to other colonies. The presence of the queen and a small number of workers in the dying colonies suggests that the reinfestation was not due to colonies absconding and flying into colonies in the apiary. The alternative cause of reinfestation of treated colonies may be that the bees from treated colonies rob dying colonies and transport varroa back to their colonies.

Hafi, A., et al. (2012). "A benefit-cost framework for responding to an incursion of *Varroa destructor*." ABARES Research Report(12.05): v-pp.

Australia remains the only continent free of *Varroa destructor*, a devastating mite pest of European honey bees. This research report outlines a benefit-cost analysis framework that can be used in the future to assess the economic feasibility of response plans in the event of an incursion of Varroa in Australia. The framework is based on a bio-economic model that links a spatially explicit Varroa spread module with partial equilibrium market modules for pollination services and commodities produced from pollination dependent crops. The pollination services market module allows for substitution of managed pollination for any lost feral honey bee pollination, as has been observed overseas following the establishment of Varroa. The report presents illustrative estimates of economic losses and demonstrates that slowing the spread can significantly reduce these losses. It also highlights the critical role that an expanded managed pollination industry could potentially play in helping to reduce economic losses from a Varroa incursion.

Hornitsky, M. A. Z. (1987). "Prevalence of virus infections of honeybees in eastern Australia." Journal of apicultural research. 26(3): 181-185.

Hornitzky, M. (1979). "Viral infections of the honeybee." Australasian beekeeper. 81(3): 54-55.

Hornitzky, M. (1981). "The examination of honeybee virus in New South Wales." Australasian beekeeper. 82(11): 261-262.

Hornitzky, M. A. Z. (1985). "Honey bee virus in Australia." Veterinary viral diseases, their significance in South-East Asia and the Western Pacific: 535-538.

Iwasaki, J. M., et al. (2015). "The New Zealand experience of varroa invasion highlights research opportunities for Australia." Ambio 44(7): 694-704.

The Varroa mite (*Varroa destructor*) is implicated as a major disease factor in honey bee (*Apis mellifera*) populations worldwide. Honey bees are extensively relied upon for pollination services, and in countries such as New Zealand and Australia where honey bees have been introduced specifically for commercial pollinator services, the economic effects of any decline in honey bee numbers are predicted to be profound. V. destructor established in New Zealand in 2000 but as yet, Australia remains Varroa-free. Here we analyze the history of V. destructor invasion and spread in New Zealand and discuss the likely long-term impacts. When the mite was discovered in New Zealand, it was considered too well established for eradication to be feasible. Despite control efforts, V. destructor has since spread throughout the country. Today, assessing the impacts of the arrival of V. destructor in this country is compromised by a paucity of data on pollinator communities as they existed prior to invasion. Australia's Varroa-free status provides a rare and likely brief window of opportunity for the global bee research community to gain understanding of honey bee-native pollinator community dynamics prior to Varroa invasion.

Jacqui, T., et al. (2007). "Incidence and molecular characterization of viruses found in dying New Zealand honey bee (*Apis mellifera*) colonies infested with *Varroa destructor*." Apidologie 38(4): 354-367.

The virus status of New Zealand honey bee colonies infested with *Varroa destructor* was studied from 2001 to 2003. The viruses CBPV, BQCV, SBV, CWV, and KBV were all found during the study, with CWV and KBV the most common, as inferred from serological and protein profile analyses. DWV, SPV and ABPV were not detected in these colonies. CWV was present in the colonies throughout the season, while the appearance of KBV generally coincided with autumn colony collapse when V. destructor populations were large. Inconsistencies between serological analyses and viral capsid protein profiles of the extracts containing CWV and KBV were probably a result of strain differences between the viruses found in New Zealand and those used to generate the diagnostic antisera. The genome of the New Zealand KBV strain was partially sequenced. Phylogenetic and serological analyses showed this strain to be unique and most closely related to Canadian KBV isolates. [ABSTRACT FROM AUTHOR]

copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Knihinicki, D. K. and R. B. Halliday (1995). "The pollen mite, Melittiphis alvearius (Berlese) (Acarina: Laelapidae) newly recorded from beehives in Australia." Journal of the Australian Entomological Society 34(4): 323-325.

The pollen mite, Melittiphis alvearius, also known as the bee mite, is reported from Australia for the first time. It was previously known from continental Europe, Russia, Great Britain, New Zealand, Canada, United States of America and Chile. A survey of mites in honey bee (*Apis mellifera* L.) colonies in three apiaries in New South Wales showed that M. alvearius was locally abundant. This mite species is not parasitic on honey bees. No parasitic bee mites, Varroa spp., were found in any of the beehives examined.

Liu, T. P. (1991). "Australian strains of Kashmir bee virus." American bee journal. 131(5): 334-334.

Martin, S. J., et al. (2020). "*Varroa destructor* reproduction and cell re-capping in mite-resistant *Apis mellifera* populations." Apidologie 51(3): 369-381.

Globalization has facilitated the spread of emerging pests such as the *Varroa destructor* mite, resulting in the near global distribution of the pest. In South African and Brazilian honey bees, mite-resistant colonies appeared within a decade; in Europe, mite-resistant colonies are rare, but several of these exhibited high levels of “re-capping” behavior. We studied re-capping in Varroa-naïve (UK/Australia) and Varroa-resistant (South Africa and Brazil) populations and found very low and very high levels, respectively, with the resistant populations targeting mite-infested cells. Furthermore, 54% of artificially infested A. m. capensis worker cells were removed after 10 days and 83% of the remaining infested cells were re-capped. Such targeted re-capping of drone cells did not occur. We propose that cell opening is a fundamental trait in mite-resistant populations and that re-capping is an accurate proxy for this behavior.

McFadden, A. M., et al. (2014). "Israeli acute paralysis virus not detected in *Apis mellifera* in New Zealand in a national survey." Journal of Apicultural Research 53(5): 520-527.

A survey was carried out aimed at determining whether Israeli acute paralysis virus (IAPV) was present in honey bees (*Apis mellifera*) in New Zealand. There were two parts to the survey. The first, carried out during autumn 2010, comprised sampling of bees from a risk-based purposive selection of apiaries in areas from the North Island where an incursion of IAPV was considered most likely. From each selected apiary, pooled samples of approximately ten bees were tested. The bee sample was a composite sample made up of bees from all or a proportion of colonies present at the site. The second part of the survey was carried out approximately one year later during autumn 2011. It involved selecting apiaries to be sampled using generalised random tessellation, a selection technique designed to maximise spatial coverage over areas of New Zealand where beekeeping occurs. For each selected apiary a pooled sample of approximately twenty bees from each of three colonies were tested. In total, 1050 tests were carried out on honey bee samples from 499 apiaries. Israeli acture paralysis virus was not detected in any of the bee samples. The probability of absence of IAPV in the North Island of New Zealand was determined to be 96% from those colonies in the North Island associated with risk pathways and 92% for New Zealand as a whole from the subsequent spatially balanced survey. The survey assumed that IAPV if present occurred in 1% of apiaries and 65% of colonies within an affected apiary. This is the first published study estimating the probability of country absence from a bee virus.

Milne, J. R. and G. H. Walter (1997). "The potential for pollen-borne virus transfer in a plum orchard infected with Prunus necrotic ringspot virus." Phytopathologische Zeitschrift. 145(2-3): 105-111.

Norton, A. M., et al. (2020). "Accumulation and Competition Amongst Deformed Wing Virus Genotypes in Naive Australian Honeybees Provides Insight Into the Increasing Global Prevalence of Genotype B." Frontiers in Microbiology 11: 620-620.

Honeybee colony deaths are often attributed to the ectoparasitic mite *Varroa destructor* and deformed wing virus (DWV), vectored by the mite. In the presence of V. destructor both main genotypes (DWV-A and DWV-B) have been correlated with colony loss. Studies show that DWV-B is the most prevalent genotype in the United Kingdom and Europe. More recently DWV-B has increased in prevalence in the United States. The increasing

prevalence of DWV-B at the expense of DWV-A suggests that competition exists between the genotypes. Competition may be due to disparities in virulence between genotypes, differences in fitness, such as rate of replication, or a combination of factors. In this study we investigated if DWV genotypes differ in their rate of accumulation in Australian honeybees naive to both V. destructor and DWV, and if viral load was associated with mortality in honeybee pupae. We singly and co-infected pupae with DWV-A, DWV-B, and a recombinant strain isolated from a V. destructor tolerant bee population. We monitored viral accumulation throughout pupation, up to 192 h post-injection. We found significant differences in accumulation, where DWV-A accumulated to significantly lower loads than DWV-B and the DWV-recombinant. We also found evidence of competition, where DWV-B loads were significantly reduced in the presence of DWV-A, but still accumulated to the highest loads overall. In contrast to previous studies, we found significant differences in virulence between pupae injected with DWV-A and DWV-B. The average mortality associated with DWV-B (0.4% +/- 0.33 SE) and DWV-recombinant (2.2% +/- 0.83 SE) injection were significantly less than observed for DWV-A (11% +/- 1.2 SE). Our results suggest that a higher proportion of DWV-B infected pupae will emerge into adults, compared to DWV-A. Overall, our data suggest that low mortality in pupae and the ability of DWV-B to accumulate to higher loads relative to DWV-A even during co-infection may favor vector transmission by V. destructor, and may thus be contributing factors to the increasing prevalence of DWV-B globally.

Perrone, S. T. and S. Malfroy (2014). "BeeForce Australia. Part I: Involving urban beekeepers in surveillance initiatives for the early detection of varroa mites." Bee World 91(2): 36-37.

BeeForce is the first coordinated community engagement project run in Australia to complement current State and Federal Biosecurity surveillance initiatives, which are aimed at protecting Australian honeybees from exotic pests. This pilot examined the potential of urban hobby beekeepers in a post-border surveillance programme for the early detection of Varroa mites around high risk entry points in two locations in the State of Victoria.

Phillips, C. (2020). "The force of Varroa: anticipatory experiences in beekeeping biosecurity." Journal of Rural Studies 76: 58-66.

In the last decade, in light of unexpected death and disappearance rates, pollinators (especially honey bees) have received increasing attention. This attention includes what Anderson (2010) refers to as anticipatory actions: efforts to predict, prepare for, and even preempt future threats. Research on anticipatory actions has tended to focus on regulatory and macro-political concerns; however, in this paper, how anticipatory actions are experienced by those involved provides orientation. Drawing on ethnographic and policy work on beekeeping biosecurity in Australia, the paper explores how beekeeping is being reconfigured in anticipation of the arrival of a particular agricultural pest: *Varroa destructor*. Australia is one of the few places that remains free of this parasite. Its impacts are expected to be catastrophic, and the anticipatory actions undertaken are extensive. Exploring how beekeepers are participating in and responding to Varroa's influence (even in its absence) adds depth to consideration of anticipatory action, as well as offering insights into how honey bee biosecurity efforts are not simply technical matters but world-making.

Read, S., et al. (2014). "Culturing chelifers (Pseudoscorpions) that consume Varroa mites." Journal of Applied Entomology 138(4): 260-266.

Chelifers (Pseudoscorpions) are generalist predators of small prey such as mites. Their occasional presence in honeybee hives suggests potential to exploit them as part of a management programme against Varroa mites (*Varroa destructor*), a significant pest of honeybees. Two species of native New Zealand chelifers Nesochernes gracilis and Heterochernes novaezealandiae, shown to consume Varroa mites, were collected from commercial nucleus hives or in litter surrounding the hives. Methods for mass-rearing the chelifers were developed to provide specimens for research and introduction into beehives for biological control of Varroa. Cultures were fed aphids and fruit fly larvae in vented containers containing sand and bark. N.gracilis was maintained at 14 degrees C, 18 degrees C, and 22 degrees C. At 18 degrees C, 1423 nymphs were reared from 140N.gracilis adults, with 84.8% of all nymphs produced at this temperature. H.novaezealandiae was maintained at 18 degrees C and 22 degrees C, with 5 nymphs raised from 12 adults at 18 degrees C and none at the higher temperature.

Read, S., et al. (2012). "Rearing of chelifers for potential biocontrol of varroa mites." New Zealand Plant Protection 65: 290-290.

Honeybee colonies infested with the varroa mite (*Varroa destructor*) usually collapse unless they have been treated with acaracides. Resistance to the most commonly used acaracides is increasing and no biological control options are yet available. Chelifers (pseudoscorpions) are generalist predators and may have potential as a biological control agent. This poster describes an attempt to establish breeding populations of native chelifers, which have been shown to actively feed on varroa, with the ultimate aim of testing their ability as a biological control of varroa. Two species of chelifers (Nesochcrnes gracilis and Heterochernes novaezealandiae) collected from honeybee hives and in leaf litter near apiaries at Katikati (Bay of Plenty) are being maintained in the laboratory. They are surviving on a variety of different food sources such as Drosophila sp. larvae (fruit fly), aphids (Acyrthosiphon pisum) and moth larvae (Helicoverpa armigera, Spodoptcra litura and Plodia interpunctella). With little known about raising these chelifers in captivity, their diet preferences and feeding periods are being obtained as a first step to obtaining the basic information necessary for potential commercial propagation of chelifers for varroa control in honeybee hives.

Rhodes, J. and R. Goebel (1986). "Diseases of honey bees: the importance of correct diagnosis." Queensland Agricultural Journal 112(2): 71-74.

Rhodes, J. and R. Teakle (1978). "Kashmir bee virus in Queensland." Australasian beekeeper 80(2): 30-32.

Roberts, J. M. K. and D. L. Anderson (2014). "A novel strain of sacbrood virus of interest to world apiculture." Journal of Invertebrate Pathology 118: 71-74.

This study has characterised a novel serotype of Sacbrood virus (SBV) infecting *Apis mellifera* in New Guinea that has emerged in the presence of the introduced European and Asian serotypes, which infect *A. mellifera* and *Apis cerana*, respectively. The New Guinea serotype appears to have evolved through mutation of the European serotype with no evidence of recombination between known strains, although recombination was detected in other SBV isolates from Asia. SBV was also confirmed for the first time causing disease in Apis dorsata (giant Asian honeybee) in Indonesia and found to be infected by the Asian serotype.

Roberts, J. M. K., et al. (2017). "Absence of deformed wing virus and *Varroa destructor* in Australia provides unique perspectives on honeybee viral landscapes and colony losses." Scientific Reports 7: 6925-6925.

Honeybee (*Apis mellifera*) health is threatened globally by the complex interaction of multiple stressors, including the parasitic mite *Varroa destructor* and a number of pathogenic viruses. Australia provides a unique opportunity to study this pathogenic viral landscape in the absence of V. destructor. We analysed 1,240 *A. mellifera* colonies across Australia by reverse transcription-polymerase chain reaction (RT-PCR) and next-generation sequencing (NGS). Five viruses were prevalent: black queen cell virus (BQCV), sacbrood virus (SBV), Israeli acute paralysis virus (IAPV) and the Lake Sinai viruses (LSV1 and LSV2), of which the latter three were detected for the first time in Australia. We also showed several viruses were absent in our sampling, including deformed wing virus (DWV) and slow bee paralysis virus (SBPV). Our findings highlight that viruses can be highly prevalent in *A. mellifera* populations independently of V. destructor. Placing these results in an international context, our results support the hypothesis that the co-pathogenic interaction of V. destructor and DWV is a key driver of increased colony losses, but additional stressors such as pesticides, poor nutrition, etc. may enable more severe and frequent colony losses to occur.

Roberts, J. M. K., et al. (2018). "Metagenomic analysis of Varroa-free Australian honey bees (*Apis mellifera*) shows a diverse Picornavirales virome." Journal of general virology 99(6): 818-826.

The viral landscape of the honey bee (*Apis mellifera*) has changed as a consequence of the global spread of the parasitic mite *Varroa destructor* and accompanying virulent strains of the iflavirus deformed wing virus (DWV), which the mite vectors. The presence of DWV in honey bee populations is known to influence the occurrence of other viruses, suggesting that the current known virome of *A. mellifera* may be under characterized. Here we tested this hypothesis by examining the honey bee virome in Australia, which is uniquely free of parasitic mites or DWV. Using a high-throughput sequencing (HTS) approach, we examined the RNA virome from nine pools of *A. mellifera* across Australia. In addition to previously reported honey bee viruses, several other insect viruses were detected, including strains related to aphid lethal paralysis virus (ALPV) and *Rhopalosiphum padi* virus (RhPV), which have recently been identified as infecting honey bees in the USA, as well as several other viruses recently found in Drosophila spp. A further 42 putative novel insect virus genomes spanning the order Picornavirales were assembled,

which significantly increases the known viral diversity in *A. mellifera*. Among these novel genomes, we identified several that were similar (but different) to key *A. mellifera* viruses, such as DWV, that warrant further investigation. We propose that *A. mellifera* may be preferentially infected with viruses of the order Picornavirales and that a diverse population of these viruses may be representative of a Varroa-free landscape.

Roberts, J. M. K., et al. (2020). "Tolerance of Honey Bees to Varroa Mite in the Absence of Deformed Wing Virus." Viruses 12(5): 575-575.

The global spread of the parasitic mite *Varroa destructor* has emphasized the significance of viruses as pathogens of honey bee (*Apis mellifera*) populations. In particular, the association of deformed wing virus (DWV) with V. destructor and its devastating effect on honey bee colonies has led to that virus now becoming one of the most well-studied insect viruses. However, there has been no opportunity to examine the effects of Varroa mites without the influence of DWV. In Papua New Guinea (PNG), the sister species, V. jacobsoni, has emerged through a host-shift to reproduce on the local *A. mellifera* population. After initial colony losses, beekeepers have maintained colonies without chemicals for more than a decade, suggesting that this bee population has an unknown mite tolerance mechanism. Using high throughput sequencing (HTS) and target PCR detection, we investigated whether the viral landscape of the PNG honey bee population is the underlying factor responsible for mite tolerance. We found *A. mellifera* and *A. cerana* from PNG and nearby Solomon Islands were predominantly infected by sacbrood virus (SBV), black queen cell virus (BQCV) and Lake Sinai viruses (LSV), with no evidence for any DWV strains. V. jacobsoni was infected by several viral homologs to recently discovered V. destructor viruses, but *Varroa jacobsoni* rhabdovirus-1 (ARV-1 homolog) was the only virus detected in both mites and honey bees. We conclude from these findings that *A. mellifera* in PNG may tolerate V. jacobsoni because the damage from parasitism is significantly reduced without DWV. This study also provides further evidence that DWV does not exist as a covert infection in all honey bee populations, and remaining free of this serious viral pathogen can have important implications for bee health outcomes in the face of Varroa.

Rossel, J. B. (2008). "Countries unite against the mite." AQIS Bulletin (Australian Quarantine and Inspection Service)(September/OctoberJuly/August): 4-4.

This article discusses the discovery of a new strain of *Varroa jacobsoni* in the Eastern Highlands Province of Papua New Guinea, following an AQIS Northern Australia Quarantine Strategy survey carried out by CSIRO in May 2008. It documents the efforts of AQIS, AusAID and the PNG National Agriculture Quarantine and Inspection Authority (NAQIA) to manage detection of this honeybee pest, which has now been detected in other mainland PNG provinces. AQIS held a training course for quarantine and agricultural authorities and beekeepers in PNG on the detection and treatment of Varroa mite. The spread of the mite in PNG continues to be monitored under an AusAID-funded programme.

Sanson, R. L. (2007). "Simulation modelling as a tool for evaluating surveillance programmes for detection of the Asian honeybee mite (*Varroa destructor*) in the South Island of New Zealand." New Zealand Veterinary Journal 55(6): 273-279.

AIM: To use a simulation model of the spread of the Asian honeybee mite (*Varroa destructor*) amongst apiaries, to evaluate a series of detection surveillance programmes for the South Island of New Zealand. METHODS: Five potential incursion sites into the South Island were selected. A stochastic spatial simulation model, Varroa_sim, was adapted to simulate spread of the mite from these sites as a series of silent-phase propagating epidemics. The study population comprised all apiaries in the South Island registered in the Ministry of Agriculture and Forestry's (MAF's) apiary database in 2003. Six different surveillance programmes were simulated to try and detect the mite. Three of these were the actual multi-stage sampling plans conducted during the autumn (March-May) of 2001, 2002 and 2003, and the other three involved simple random sampling with sampling fractions equivalent to the actual numbers of apiaries tested in each of those years. The relative performances of the different surveillance plans were evaluated in terms of their ability to detect the mite early before it had spread too far and whilst there might still be a chance of eradication. RESULTS: There were 13 798 registered apiaries in the South Island with valid map coordinates in the apiary database at the time of the study. The model generated 50 epidemics against which the various surveillance programmes were evaluated. The actual surveillance programmes conducted during the autumn of 2001 and 2002 generally performed fairly well in detecting the mite. The programme conducted in autumn 2003 detected the mite reasonably well in high-risk areas, but was very poor in low-risk areas. The simple random

sampling strategies performed surprisingly well, and their relative rankings were proportional to the sampling fractions employed. CONCLUSIONS: This study showed the value in using a spatial simulation model to generate plausible silent-phase epidemics, against which detection surveillance programmes could be evaluated, in ways that would otherwise not be possible.

Seeman, O. D. and D. E. Walter (1995). "Life History of Afrocypholaelaps africana (Evans) (Acari: Ameroseidae), a mite inhabiting mangrove flowers and phoretic on honeybees." Journal of the Australian Entomological Society 34(1): 45-50.

In October 1993, umbels of the river mangrove Aegiceras corniculatum were infested by the ameroseiid mite Afrocypholaelaps africana (up to 32,000 m-2 of mangrove canopy) at each of 11 sites sampled in southeastern Queensland. Mite populations declined as flowering decreased and were locally extinct by 20 January. Individual mangrove florets lasted about 6 d; umbels were in flower for about 10 d. Unopened buds were mite-free, but newly opened florets were colonized by all post-embryonic stages of the mite. In the laboratory, the mites fed on pollen and sugar water. Mites dispersed on honeybees (*Apis mellifera*) primarily as egg-bearing adult females; however, a relatively small proportion of males and immature stages also occurred on bees. Only adult females have sucker-like ambulacral pads lacking claws, an apparent adaptation for phoresy. Most mites boarded and departed the bee via the tongue and were found on the venter of the head and thorax of the bee. Additionally, bees collected mites with pollen, and crushed many immature mites into their pollen baskets. Large populations of mites occurred on honeybees at beehives during late April.

Stevenson, M. A., et al. (2005). "Spatial epidemiology of the Asian honey bee mite (*Varroa destructor*) in the North Island of New Zealand." Preventive veterinary medicine. 71(3-4): 241-252.

We describe the spatial epidemiology of *Varroa destructor* infestation among honey bee apiaries in the greater Auckland area of the North Island of New Zealand. The study population was comprised of 641 apiaries located within the boundaries of the study area on 11 April 2000. Cases were those members of the study population declared Varroa-infested on the basis of testing conducted between April and June 2000. The odds of Varroa was highest in apiaries in the area surrounding transport and storage facilities in the vicinity of Auckland International Airport. A mixed-effects geostatistical model, accounting for spatial extra-binomial variation in Varroa prevalence, showed a 17% reduction in the odds of an apiary being Varroa infested for each kilometre increase in the squared distance from the likely site of incursion (95% Bayesian credible interval 7-28%). The pattern of spatially autocorrelated risk that remained after controlling for the effect of distance from the likely incursion site identified areas thought to be 'secondary' foci of Varroa infestation initiated by beekeeper-assisted movement of infested bees. Targeted investigations within these identified areas indicated that the maximum rate of local spread of Varroa was in the order of 12 km/year (interquartile range 10-15 km/year).

Taylor, M. A., et al. (2008). "The effect of honey bee worker brood cell size on *Varroa destructor* infestation and reproduction." Journal of apicultural research. 47(4): 239-242.

The effect of honey bee (*Apis mellifera*) worker brood cell size on cell infestation and reproductive success of *Varroa destructor* in New Zealand was determined by establishing ten nucleus colonies with mosaic frames, each consisting of cells drawn from five different foundation sizes. When the brood were 18-20 days old, 1636 cells were individually uncapped and the number of adult and deutonymph female mites were recorded. The internal width of each brood cell was also measured. The data were analysed according to the imprint size of the "foundation" specified by the supplier, and the "measured" internal width of each individual drawn brood cell. The "foundation" cell size had no significant effect on the reproductive success of V. destructor, but the proportion of cells that were infested by adult female mites was significantly different. A significantly higher proportion of the cells drawn from the 4.8 mm imprint "foundation" were infested compared to those of the other sizes. "Measured" brood cell size had no significant effect on mite reproduction or infestation.

Todd, J., et al. (2004). "Identifying the viruses causing mortality of honey bees in colonies infested with *Varroa destructor*." Surveillance (Wellington) 31(4): 22-25.

The death of honey bee colonies that are infested with varroa has been linked to the spread of honey bee viruses by the mites to adult bees and pupae that they feed upon. Our studies with mite-infested New Zealand colonies have suggested that Kashmir bee virus is contributing to colony losses here.

Todd, J. H., et al. (2007). "Incidence and molecular characterization of viruses found in dying New Zealand honey bee (*Apis mellifera*) colonies infested with *Varroa destructor*." Apidologie 38(4): 354-367.

The virus status of New Zealand honey bee colonies infested with *Varroa destructor* was studied from 2001 to 2003. The viruses CBPV, BQCV, SBV, CWV, and KBV were all found during the study, with CWV and KBV the most common, as inferred from serological and protein profile analyses. DWV, SPV and ABPV were not detected in these colonies. CWV was present in the colonies throughout the season, while the appearance of KBV generally coincided with autumn colony collapse when V. destructor populations were large. Inconsistencies between serological analyses and viral capsid protein profiles of the extracts containing CWV and KBV were probably a result of strain differences between the viruses found in New Zealand and those used to generate the diagnostic antisera. The genome of the New Zealand KBV strain was partially sequenced. Phylogenetic and serological analyses showed this strain to be unique and most closely related to Canadian KBV isolates.

Toor, R. F. v. (1989). "Evaluation of acaricides for control of Melittiphis alvearius mite in export bee packages." Proceedings of the Forty Second New Zealand Weed and Pest Control Conference, Taranki Country Lodge, New Plymouth, 8-10 August, 1989.: 269-273.

In a series of bioassays, 3 concn each of 3 acaricides were evaluated for the control of Melittiphis alvearius, a mite commensal with *Apis mellifera*, which may have to be dead before *A. mellifera* from New Zealand are accepted for import into other countries. Bromopropylate was harmless to *A. mellifera* but ineffective against M. alvearius. Cyhexatin was toxic to *A. mellifera*. Fluvalinate at 0.1 g/msuperscript 2 caused 99% mortality of M. alvearius within 30 h and had no toxic effects on *A. mellifera* that were exposed to it for 9 days. *A. mellifera* tolerance of low RH (40%) was improved by some acaricidal treatments.

Van Toor, R. F. (1989). "Evaluation of acaricides for control of Melittiphis alvearius mite in export bee packages." Proceedings of the Forty-second New Zealand Weed and Pest Control Conference, Taranki Country Lodge, New Plymouth, August 8-10, 1989.: 143-145.

In a set of bioassays, 3 rates of each of 3 acaricides were evaluated for the control of M. alvearius, a mite with potential to threaten New Zealand's bee export industry. Although bromopropylate had no harmful effect on bees, mortality of mites was low. Cyhexatin was highly toxic to bees and cannot be recommended for use. Fluvalinate at 0.1 g/msuperscript 2 caused 99% mortality of the mite within 30 h and showed no toxic effects on bees held in the containers for 9 days. Bee tolerance of low relative humidity (40%) was improved by some acaricide treatments.

Vetharaniam, I. and N. D. Barlow (2006). "Modelling biocontrol of *Varroa destructor* using a benign haplotype as a competitive antagonist." New Zealand Journal of Ecology 30(1): 87-102.

The two haplotypes of *Varroa destructor* that have been identified as parasites of the Western honeybee (*Apis mellifera* L.) show disparate levels of virulence towards honeybee colonies. The Korea haplotype has been associated with severe colony mortality, whereas untreated colonies of European *A. mellifera* have survived long-term infestation by the Japan haplotype. The possible existence of a benign haplotype of V. destructor raises the prospect that it be used to "inoculate" colonies to provide biocontrol of the virulent haplotype. The feasibility of such a strategy was investigated using a mathematical model. Competition for resources during reproduction is known to reduce varroa mites' reproduction rates as their infestation levels increase. Results from modelling suggested this density-dependent effect is sufficient for an established benign population to prevent the virulent population reaching destructive levels if a colony is subject to sporadic influxes of virulent mites. A colony faced with a continuous influx of mites could be protected if the proportion of virulent mites in the influx were below a threshold level (dependent on length of breeding season and intensity of influx). This condition might be achieved by "inoculating" neighbouring apiaries and controlling feral colonies in the vicinity. Decreased brood cell invasion rate by the benign haplotype decreased the threshold level. Any reproductive isolation between the benign and virulent haplotypes would cause further reproductive suppression, driving sporadic influxes of the virulent haplotype to extinction and conferring greater tolerance to a colony faced with a virulent influx. Increased colony resistance to varroa in the model was synergistic with the inoculation of colonies in the absence of reproductive isolation, but potentially antagonistic in its presence--although not to an extent that would preclude their joint use.

Waite, G. K. (1999). "New evidence further incriminates honey-bees as vectors of lychee erinose mite Aceria litchii (Acari: Eriophyiidae)." Experimental & applied acarology. 23(2): 145-147.

Waite, G. K. and J. D. McAlpine (1992). "Honey bees as carriers of lychee erinose mite Eriophyes litchii (Acari: Eriophyiidae)." Experimental & Applied Acarology 15(4): 299-302.

In an orchard in Queensland, Australia, up to 23% of honey bees (*Apis mellifera*) collected from flowering lychee trees severely infested with the lychee erinose mite (Eriophyes litchii) [Aceria litchii] were found to be carrying live mites which were picked up as the bees foraged. This method of lychee erinose mite dispersal is discussed in the context of periodic records of 'spontaneous infestation' of lychee flower panicles from previously uninfested orchards. ADDITIONAL ABSTRACT: Up to 23% of honey bees (*Apis mellifera*) collected in Australia in September and October 1989 from flowering lychee [Litchi chinensis] trees severely infested with Eriophyes litchii [Aceria litchii], were found to be carrying live mites which were picked up as the bees foraged. This method of A. litchii dispersal is discussed in the context of periodic records of 'spontaneous infestation' of flower panicles from previously uninfested orchards.

Walter, D. E., et al. (2002). "Of mites and bees: A review of mite-bee associations in Australia and a revision of Raymentia Womersley (Acari: Mesostigmata: Laelapidae), with the description of two new species of mites from Lasioglossum (Parasphecodes) spp. (Hymenoptera: Halictidae)." Australian Journal of Entomology 41(2): 128-148.

Social bees have a diverse fauna of symbiotic mesostigmatic mites, including highly pathogenic parasites of the honeybee, but there are few reports of Mesostigmata phoretic on or inhabiting the nests of solitary or communal, ground-nesting bees. In south-eastern Australia, however, native bees in the family Halictidae carry what appears to be a substantial radiation of host-specific mesostigmatans in the family Laelapidae. Herein, we redescribe the obscure genus Raymentia , associated with Lasioglossum (Parasphecodes) spp. bees (Halictidae) and describe two new species, R. eickwortiana from L. lacthium (Smith) and R. walkeriana from L. atronitens (Cockerell). The type species, R. anomala Womersley, is associated with L. altichum (Smith). In addition, we review the mites known to be associated with Australian bees, provide a key to differentiate them, and describe and illustrate acarinaria of the Halictinae. We also report on the first occurrences in Australia of the genera Trochometridium Cross (Heterostigmata: Trochometridiidae), from L. eremaean Walker (Halictidae), and Cheletophyes Oudemans (Prostigmata: Cheyletidae) from Xylocopa Latreille (Xylocopinae), and on the previously unknown association between a Neocypholaelaps Vitzthum (Mesostigmata: Ameroseiidae) and Lipotriches tomentifera (Friese) (Halictidae).

Womersley, H. (1963). "A new species of Forcellinia (Acarina, Tyroglyphidae) from bee hives in Western Australia." Transactions of the Royal Society of South Australia 86: 155-pp.

A mite, Forcellinia galleriella sp.n., is described from a beehive, in which it was apparently feeding on a large population of larvae and pupae of Galleria mellonella (L.), in Western Australia.

Zhang, Z. (2000). "Notes on *Varroa destructor* (Acari: Varroidae) parasitic on honeybees in New Zealand." Special Publications - Systematic and Applied Acarology(5): 9-14.

The honey bee mite *Varroa destructor*, previously known as V. jacobsoni in Europe, Middle East, South Africa, Asia, North America and South America, is recorded from specimens found in New Zealand. This parasitic mite attacks honey bees (*Apis mellifera*) in the North Island.

Pathogens

(1978). "Queensland Department of Primary Industries: *Nosema* disease." Australasian beekeeper 80(3): 56-58.

Anderson, D. (1993). "Pathogens and queen bees." Australasian beekeeper 94(7): 292-296.

Queen cells containing dead larvae and pupae, and dead adult queen honey bees (*Apis mellifera*) from mating nuclei and queen banks, in Australia, were examined for all microbial bee pathogens. The only pathogens found in brood were black queen cell virus (BQCV), in large quantities in 19% of brood samples, sacbrood virus (SBV) in 10% and Melissococcus pluton in 7%. More sensitive techniques detected at least some BQCV (including unique strains) in 95% of samples and SBV in 15%. *Nosema apis* and BQCV were the only pathogens found in adult queen bees: the latter in every adult tested. Living and dead adult drones were tested by standard techniques and by injection of extracts into healthy white-eyed drone pupae. *Nosema apis*, SBV, bee virus F, Kashmir bee virus (KBC), chronic bee paralysis virus and cloudy wing virus (CWV) were found. KBV and SBV were also detected in drone larvae and pupae. CWV was found in relatively high concentrations in apparently healthy drone pupae. The phenomenon of queens laying multiple eggs in a single cell, stuck together and attached to cell walls, was studied. Patchy brood patterns and drone brood in worker cells are associated symptoms of these 'failing' or 'prematurely ageing' queens. The symptoms are most apparent in spring and autumn when oviposition rates change markedly, and may be seen at low levels in queens in their first year. Examination of changes in queen internal organs associated with ageing is planned.

Anderson, D. L. and H. Giacon (1992). "Reduced pollen collection by honey bee (Hymenoptera: Apidae) colonies infected with *Nosema apis* and sacbrood virus." Journal of economic entomology. 85(1): 47-51.

A study to determine the effect of pathogens on pollen collection by colonies of the honey bee, *Apis mellifera* L., is reported. Colonies fed preparations of 50% sucrose containing sacbrood virus particles or *Nosema apis* Zander spores collected significantly less pollen than colonies fed only the sucrose solution. These findings have important implications for the preparation and use of honey bee colonies for pollinating agricultural crops.

Anderson, D. L. and N. L. Gibson (1998). "New species and isolates of spore-cyst fungi (Plectomycetes: Ascosphaerales) from Australia." Australian Systematic Botany 11(1): 53-72.

Fungi in the genus Ascosphaera (Plectomycetes: Ascosphaerales) are of agricultural and horticultural interest as they are only found, in nature, in association with social and solitary bees. To date, only one member of the genus, A. osmophila, has been described from Australia. In this paper, four new species of Ascosphaera, A. duoformis, A. flava, A. solina and A. subcuticulata, are described from Australia, together with previously unrecorded Australian isolates of A. acerosa, A. atra and the honey bee chalkbrood fungus, A. apis.

Botias, C., et al. (2012). "Further evidence of an oriental origin for *Nosema ceranae* (Microsporidia: Nosematidae)." Journal of Invertebrate Pathology 110(1): 108-113.

Although *Nosema ceranae* was first isolated from the Asian honeybee (*Apis cerana*) in Asia and then subsequently recognized as a widespread gut parasite of the Western honeybee (*Apis mellifera*), its origins and primary host are yet to be accurately established. In this study we examined the possibility of an Asian origin for the parasite by looking for evidence of its ongoing spread out of Asia. To do this, we surveyed for the presence of *N. ceranae* in *A. cerana* and *A. mellifera* on isolated islands of the Solomon Islands (Pacific region), most of which were inhabited with *A. mellifera* that had been introduced from Australia and New Zealand at a time when *N. ceranae* was not present in either country, but on which some had also recently become inhabited with invasive *A. cerana* that originated from Asia with no prior history of contact with *A. mellifera* infected with *N. ceranae*. We also sought to verify previous findings that *N. ceranae* was widespread in Asian honeybees by surveying for its presence in isolated populations of the Asian honeybees, *A. cerana*, A. koschevnikovi, A. nigrocincta and A. florea. We obtained evidence that *A. cerana* introduced *N. ceranae* to A. melhfera in the Solomon Islands and also confirmed the widespread occurrence of the parasite in Asian honeybees, even reporting it for the first time in A. koschevnikovi from Borneo.Our findings provide further support for the hypothesis that *N. ceranae* has only recently emerged from Asia to become a parasite of A. melhfera.

Cooper, R., et al. (1984). "Non-susceptibility of *Apis mellifera* to Culicinomyces clavisporus." Journal of the Australian Entomological Society. 23(3): 173-174.

Djordjevic, S. P., et al. (1998). "Development of a hemi-nested PCR assay for the specific detection of Melissococcus pluton." Journal of Apicultural Research 37(3): 165-174.

A pair of oligonucleotide primers (MP1 and MP2) were used for the polymerase chain reaction (PCR) amplification of a 486 base pair (bp) fragment of the 16S rRNA gene of 26 geographically diverse Australian Melissococcus pluton (causative agent of European foulbrood) isolates. PCR primers spanning a region of the 16S rRNA gene from position 893-1377 failed to amplify a product when template DNA from a wide range of pathogenic and saprophytic bacteria were used including Paenibacillus larvae, Paenibacillus alvei, Enterococcus faecium and Spiroplasma melliferum. The PCR did, however, reliably amplify a 486 bp fragment (when the annealing temperature was lowered by 5 degree C) using template DNA isolated from the phylogenetically-related bacterium Enterococcus faecalis. PCR amplicons generated from E. faecalis and M. pluton were readily distinguished by digestion with the restriction endonuclease Hinfl and electrophoresis in 1.5% agarose or by electrophoresis in 1% agarose containing bisbenzidene/polyethylene glycol. A hemi-nested PCR requiring a combination of primers MP1 and a third primer, MP3, which spanned 25 nucleotides from position 1168-1144 and internal to the 486 bp amplicon generated by primers MP1 and MP2 was developed. The hemi-nested PCR amplified a 276 bp M. pluton-specific product that was not amplified with E. faecalis DNA. In sensitivity studies, the PCR assay could reliably detect approximately 1-10 organisms/ml. This level of sensitivity was achieved using crude DNA templates (boiled cell lysate) prepared using Instagene matrix. The PCR assay could also detect M. pluton in brood with European foulbrood.

Doull, K. M. (1974). "*Nosema* disease of honey bees in South Australia. Harnaj.V (Ed). Apimondia Scientific Bulletin, 1972. Symposia. 1972. 535p. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 407-412.

Doull, K. M. and K. M. Cellier (1961). "A survey of incidence of *Nosema* disease of honey bee in South Australia." Journal of Insect Pathology 3(3): 280

Doull, K. M. and R. A. Winn (1980). "The control of *Nosema* disease." Australasian beekeeper. 82(5): 117-118.

Ferguson, J. A., et al. (2018). "Honey bee (*Apis mellifera*) pollen foraging reflects benefits dependent on individual infection status." Microbial ecology 76(2): 482-491.

Parasites often modify host foraging behaviour, for example, by spurring changes to nutrient intake ratios or triggering self-medication. The gut parasite, *Nosema ceranae*, increases energy needs of the European or Western honey bee (*Apis mellifera*), but little is known about how infection affects foraging behaviour. We used a combination of experiments and observations of caged and free-flying individual bees and hives to determine how *N. ceranae* affects honey bee foraging behaviour. In an experiment with caged bees, we found that infected bees with access to a high-quality pollen were more likely to survive than infected bees with access to a lower quality pollen or no pollen. Non-infected bees showed no difference in survival with pollen quality. We then tested free-flying bees in an arena of artificial flowers and found that pollen foraging bees chose pollen commensurate with their infection status; twice as many infected bees selected the higher quality pollen than the lower quality pollen, while healthy bees showed no preference between pollen types. However, healthy and infected bees visited sucrose and pollen flowers in the same proportions. Among hive-level observations, we found no significant correlations between *N. ceranae* infection intensity in the hive and the proportion of bees returning with pollen. Our results indicate that *N. ceranae*-infected bees benefit from increased pollen quality and will selectively forage for higher quality while foraging for pollen, but infection status does not lead to increased pollen foraging at either the individual or hive levels.

Frazer, J. L., et al. (2015). "First detection of *Nosema ceranae* in New Zealand honey bees." Journal of Apicultural Research 54(4): 358-365.

Nosema is a genus of 81 microsporidian parasites, two of which affect honey bees. The advent of molecular methods has facilitated the differentiation between *Nosema apis* and *Nosema ceranae*. *N. ceranae* infection was detected by polymerase chain reaction (PCR) in an apiary on the Coromandel Peninsula of New Zealand during investigation into unusual colony losses in early spring 2010, and was subsequently found in other areas of the

country. While no association could be confirmed between apiary health status and presence of *N. ceranae*, a significantly higher proportion of positive apiaries were detected in spring compared with autumn. PCR for *N. ceranae* conducted in three different laboratories showed fair agreement. Minor assay differences and sample level variation in *Nosema* are the most likely explanation for differences in results. © 2016 International Bee Research Association.

Gatehouse, H. S. and L. A. Malone (1999). "Genetic variability among *Nosema apis* isolates." Journal of apicultural research. 38(1-2): 79-85.

Goodman, M., et al. (1990). "Cost benefit analysis of using fumagillin to treat *Nosema*." New Zealand beekeeper(208): 11-12.

In trials in New Zealand a single spring treatment of 20 *Apis mellifera* colonies with fumagillin (100 mg/4.5 litres syrup) reduced the incidence of *Nosema* disease and levels of infection. One month after treatment, the average number of *Nosema apis* spores in bees in the 20 treated colonies was 620 000/bee compared with 2 220 000/bee in untreated colonies. Treated colonies produced on average 13.9% more honey, but differences were not significant except at one apiary. In 80 colonies treated in both autumn and spring, honey production was 23.2% higher than in untreated colonies. In a further 100 colonies that were treated twice, the average spore level 1 month after the spring treatment was 1 830 000 spores/bee (4 010 000 spores/bee in untreated controls). The treated colonies produced 28.6% more honey. It is concluded that fumagillin treatment is cost-effective. However, many New Zealand beekeepers do not realize the significance of *Nosema* disease because colonies do not show obvious symptoms.

Goodwin, R. M., et al. (2013). "Effect of honey bee extracts, and honey on the in vitro germination of Paenibacillus larvae spores." Journal of Apicultural Research 52(2): 52-52.

Hornitzky, M. (1983). "Bacterial diseases of the honeybee." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 66-71.

Kleinschmidt, G. (1993). "*Nosema* disease in warm climates." Australasian beekeeper 95(2): 66-68.

Experiments in Queensland, Australia, are reported.

Kleinschmidt, G. J. (1979). "Influence of management on the effects of *Nosema* disease." Australasian beekeeper. 81(2): 34-35.

Langridge, D. F. (1966). "Flagellated protozoa (Trypanosomidae) in the honey bee, *Apis mellifera*, in Australia." Journal of Invertebrate Pathology 8(1): 124-125.

Langridge, D. F. (1972). "Crithidia mellificae of the honey bee." Australian bee journal 53(12): 24-26.

Langridge, D. F. and R. B. McGhee (1967). "Crithidia mellificae n. sp. an Acidophilic Trypanosomatid of the Honey Bee *Apis mellifera*." The Journal of Protozoology 14(3): 485-487.

SYNOPSIS. Crithidia mellificae n. sp. is described from the honey bee *Apis mellifera* in apiaries of Victoria, Australia. Organisms were isolated and cultured in a modified NNN medium with Cowper-thwaite's medium as an overlay. In contrast to other isolates of Crithidia, C. mellificae grows best at a pH between 4.5 and 5.5 with optimum near pH 5. In Cowperthwaite's medium alone, buffered at pH 4.5–5.5, the organism will survive apparently indefinite passages. The organism has so far as known, no pathologic effects in the hymenopteran host. Copyright © 1967, Wiley Blackwell. All rights reserved

Malone, L. A. and H. A. Giacon (1996). "Effects of *Nosema apis* Zander on inbred New Zealand honey bees (*Apis mellifera* ligustica L)." Apidologie 27(6): 479-486.

Inbred bees (*Apis mellifera* ligustica) from seven different colonies were dosed individually with spores of *Nosema apis* and kept in cages. Longevity and spores carried at the time of death were recorded for each bee. The

experiment was repeated on three different dates. Control bee longevity varied with experiment date, although the pattern of this response varied from colony to colony. Dosing significantly reduced the lifespans of bees in all but three colonies. Results suggest that bees with superior ability to survive in cages may also withstand *N. apis* infection better. Each cage of dosed bees produced a number of dead bees without detectable spore loads. Survival data comparisons suggest that dosing newly-emerged bees with *N. apis* may result in a relatively fast death for some bees and a slower death for the majority. Spore loads were very variable with no clear relationship to survival time.

Malone, L. A., et al. (1992). "Response of New Zealand honey bee colonies to *Nosema apis*." Journal of apicultural research. 31(3-4): 135-140.

Malone, L. A. and D. Stefanovic (1999). "Comparison of the responses of two races of honeybees to infection with *Nosema apis* Zander." Apidologie 30(5): 375-382.

Responses of New Zealand bees from Italian (*Apis mellifera* ligustica) and dark (*Apis mellifera* mellifera) races to infection with *Nosema apis* were compared. Newly emerged adults from five colonies of Italian bees and three colonies of dark bees were tagged, dosed individually with *N. apis* spores and placed in cages with undosed companion bees from the same colony. Dosed individuals were removed and examined at different times to measure progress of infection. At the end of the experiment, companion bees were examined to determine the spread of infection from dosed to undosed bees. There were no significant differences between the two races in either of these measures of response to *N. apis*. Bees from the different colonies were pooled according to race, and their responses (percentage infection and longevity of infected bees) to a range of doses of *N. apis* spores determined. These data also showed no significant differences due to race.

Manning, R. (1993). "The effect of using fumagillin in queen candy as a treatment for the control of *Nosema apis* L., in Western Australian honeybee colonies." Australasian beekeeper 94(7): 281-290.

During a winter nectar flow, 30 colonies with nosema disease were each given a candy patty containing 100 mg fumagillin, and the treatment was repeated 21 days later. Test colonies and control colonies (fed with candy patty) were assessed on days 9, 21 and 58. Test colonies showed greater average increases than controls in number of frames covered with bees, brood area and weight gain. The *Nosema apis* spore count decreased more in treated colonies. However, over the whole period, differences were not significant and results were probably affected by removal of the colonies to a new nectar flow, between days 21 and 58. At day 21, test colonies showed a very low spore count compared with controls. Honey sampled on day 8 contained 0.07 mg fumagillin/kg (test colonies) and 0.01 mg/kg (controls).

Manning, R., et al. (2007). "Survey of feral honey bee (*Apis mellifera*) colonies for *Nosema apis* in Western Australia." Australian journal of experimental agriculture. 47(7): 883-886.

May, V. and E. J. McBarron (1973). "Occurrence of the blue-green alga, *Anabaena circinalis* Rabenh., in New South Wales and toxicity to mice and honey bees." Journal of the Australian Institute of Agricultural Science.

McIvor, C. A. and L. A. Malone (1995). "*Nosema bombi*, a microsporidian pathogen of the bumble bee *Bombus terrestris* (L.)." New Zealand Journal of Zoology 22(1): 25-31.

The developmental cycle and morphology of a microsporidian pathogen *Nosema bombi* Fantham & Porter 1914, of the bumble bee, *Bombus terrestris*, are described. In experimentally infected bees, spherical meronts were the first stages observed. These varied in size from 2.66 to 7.35 mu m, and had 1-4 nuclei. Uninucleate, binucleate, and occasionally tetranucleate sporonts were oval or fusiform in shape, and measured 5.32-8.05 mu m x 2.80-4.41 mu m. Oval binucleate sporoblasts, measuring 4.64-5.78 mu m x 3.03-3.94 mu m, appeared in large numbers prior to spore morphogenesis. Spores varied in size from 4.20-5.39 mu m x 2.13-3.50 mu m in unstained preparations, and were significantly smaller than spores of the honey bee pathogen, *Nosema apis* ($P < 0.001$, $n = 50$). Spores developed primarily in the Malpighian tubules. Electron microscopic examination of spores showed the polar filament to have 14-18 coils, compared with *N. apis* which has 18-44.

Murray, Z. L. and P. J. Lester (2015). "Confirmation of *Nosema ceranae* in New Zealand and a phylogenetic comparison of Nosema spp. strains." Journal of Apicultural Research 54(2): 101-104.

Rhodes, J. (1973). "Flagellated protozoa (Trypanosomidae) in the honey bee (*Apis mellifera*) in Queensland." Queensland journal of agricultural and animal sciences.: 275-275.

Rhodes, J. (1983). "Diseases of bees--fungal diseases." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 72-75.

Shanks, J. L., et al. (2017). "First confirmed report of a bacterial brood disease in stingless bees." Journal of Invertebrate Pathology 144: 7-10.

Susceptibility to brood pathogens in eusocial stingless bees (Meliponini), alternative pollinators to honey bees, is unknown. Brood losses in managed colonies of the Australian stingless bee, Tetragonula carbonaria, were studied over 20 months. We isolated a disease-causing bacterium, Lysinibacillus sphaericus (Firmicutes, Bacillaceae), from worker and queen larvae, brood cell provisions and honey stores. Pathogenicity experiments confirmed this bacterium as the causal organism. It took 22 days from infection to first appearance of brood disease symptoms. This is the first confirmed record of a brood pathogen in stingless bees. (C) 2017 Elsevier Inc. All rights reserved.

Spence, R. P., et al. (2013). "Surveillance of New Zealand apiaries for Paenibacillus alvei." New Zealand entomologist. 36(2): 82-86.

Paenibacillus alvei is a facultative spore forming Gram positive bacterium. In relation to bees, P. alvei can invade honey bee larvae after European foulbrood occurs, although there is no evidence that P. alvei is pathogenic. In August 2008 P. alvei was isolated in New Zealand from a dead bumble bee (*Bombus terrestris*). Due to the association of P. alvei with bees and bee products, and the possibility the organism may be present in imported honey, a pilot surveillance programme for the presence or absence of P. alvei was carried out using samples collected as part of a larger surveillance programme on honey bee exotic disease. Of the 510 honey, hive floor and soil samples tested, two soil samples collected from the entrance of hives were shown to contain P. alvei based on macroscopic appearance, microscopic appearance, biochemical test results and sequencing results. In this study, three isolates of P. alvei were identified from three geographically disparate locations. These findings confirm that P. alvei is present in New Zealand.

Tham, V. L. (1978). "Isolation of Streptococcus pluton from the larvae of European honey bees in Australia." Australian veterinary journal.: 406-407.

Thomas, G., et al. (2009). "*Nosema ceranae* infects honey bees (*Apis mellifera*) and contaminates honey in Australia." Apidologie 40(2): 117-123.

Polymerase chain reaction (PCR), restriction fragment length polymorphism (RFLP) analysis and microscopy were used to test 307 adult bee and 37 honey samples collected in Australia for the presence of two microsporidia, *Nosema ceranae* and *Nosema apis*. *N. ceranae* was detected in samples from 4 states (Queensland, New South Wales, Victoria and South Australia) and was most commonly found in samples from Queensland where 28 (33.7%) of 83 samples were positive. New South Wales had the second highest prevalence with 15 (15.8%) of 95 samples positive. South Australia and Victoria had 4 (16%) of 25 and 2 (4.5%) of 44 samples positive respectively. *N. ceranae* was not detected in samples from Western Australia and Tasmania. *N. apis* was detected in samples from all states. Three honey samples (8.1%) were PCR positive for *N. ceranae*. These positive honey samples originated from beekeepers in Queensland. Six imported honey samples tested were negative for both Nosema spp. [ABSTRACT FROM AUTHOR] Copyright of Apidologie is the property of Springer Nature and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Vandenberg, J. D. and H. Shimanuki (1990). "Isolation and characterization of Bacillus coagulans associated with half-moon disorder of honey bees." Apidologie 21(3): 233-241.

Twenty dead larvae were collected in New Zealand from colonies with half-moon disorder. Nine different isolates of B. coagulans were obtained from them. Although this bacterium has been found in adult honeybees, this is the first report of its presence in larvae. One of the isolates was studied further. Laboratory-reared larvae became infected when inoculated with it at 1 or 2 days old, but no infection was observed in larvae (in combs) that were inoculated and then put in small colonies in outdoor cages. It is concluded that B. coagulans is probably not the cause of half-moon disorder.

RESOURCE

(1979). "Cost/benefit analysis of the biological control of Salvation Jane." Australian bee journal 60(11): 2-12.

The likely effects on honey production of controlling Salvation Jane (Echium lycopsis), a noxious weed in South Australia pastures, are analysed. The maximum benefit to pasture production is unlikely to be more than $800 000 annually, compared with an estimated maximum loss to the honey industry of $ 2 080 000. On average, E. lycopsis provides 50% of the honey produced in S. Australia, and its removal would involve a reduction in the number of hives, or an increase in supplementary feeding during the period when E. lycopsis normally flowers. J. M. Gedye

(1980). "Information from the National Resource Conservation League." Australian bee journal 61(9): 11-12.

Lists plants in Victoria according to honey and pollen yields, and notes those giving noxious honey.

(1985). "The Echium inquiry: a progress report." Australian bee journal 66(6): 7-8.

Concerns the nectar plant Echium lycopsis; see e.g. AA 216/81.

(1996). "Improving honey and tree seed production in Indonesia and Australia." ACIAR Research Notes(RN 17): 4-pp.

This research note summarizes results from a project to improve beekeeping management for honey production and pollination in the tropical forests of Indonesia. In trials in Australia and Indonesia, the importance of high quality pollen sources (at least 20% crude protein) or the feeding of pollen supplements based on yeast, soyabean flour and pollen, was established. In Indonesia, in 1994, feeding before the kapok [Ceiba pentandra] honey flow increased average colony populations from 8 to 10.5 combs of bees, and increased honey yields (kapok plus rubber [Hevea brasiliensis]) from 24.4 kg/hive to 68.7 kg/hive. The introduction of hives to Eucalyptus plantations increased seeds/fruit and mean seed weight in E. alba and E. camaldulensis but not in E. globulus or E. nitens.

Arundel, J., et al. (2016). "A web-based application for beekeepers to visualise patterns of growth in floral resources using MODIS data." Environmental Modelling & Software 83: 116-125.

The honey bee industry is of immense importance to global agriculture. In many countries beekeepers are migratory and move their hives between flowering events. Predicting such flowering events is particularly difficult in Australia due to the irregular flowering of eucalypts. We have developed a web-based application for Victorian beekeepers to visualise patterns of growth in floral resources using MODIS and other data, and thus make remote predictions about whether flowering will occur at their apiary sites. We demonstrate the use of this application through comparing ironbark (Eucalyptus tricarpa) growth patterns with flowering and honey production records. While the scientific community as a whole has embraced the use of satellite imagery as a tool for phenological studies, our prototype represents the first attempt to make this same information available to a more general audience.

Ausseil, A. G. E., et al. (2018). "Mapping floral resources for honey bees in New Zealand at the catchment scale." Ecological Applications 28(5): 1182-1196.

Honey bees require nectar and pollen from flowers: nectar for energy and pollen for growth. The demand for nectar and pollen varies during the year, with more pollen needed in spring for colony population growth and more nectar needed in summer to sustain the maximum colony size and collect surplus nectar stores for winter. Sufficient bee forage is therefore necessary to ensure a healthy bee colony. Land-use changes can reduce the availability of floral resources suitable for bees, thereby increasing the susceptibility of bees to other stressors such as disease and pesticides. In contrast, land-based management decisions to protect or plant bee forage can enhance pollen and nectar supply to bees while meeting other goals such as riparian planting for water-quality improvement. Commercial demand for honey can also put pressure on floral resources through over-crowding of hives. To help understand and manage floral resources for bees, we developed a spatial model for mapping monthly nectar and pollen production from maps of land cover. Based on monthly estimated production data we mapped potential monthly supply of nectar and pollen to a given apiary location in the landscape. This is done by summing the total production within the foraging range of the apiary while subtracting the estimated nectar converted to energy for collection. Ratios of estimated supply over theoretical hive demand may then be used to infer a potential landscape carrying capacity to sustain hives. This model framework is quantitative and spatial, utilizing estimated flight energy

costs for nectar foraging. It can contribute to management decisions such as where apiaries could be placed in the landscape depending on floral resources and where nectar limited areas may be located. It can contribute to planning areas for bee protection or planting such as in riparian vegetation. This would aid managed bee health, wild pollinator protection, and honey production. We demonstrate the methods in a case study in New Zealand where there is a growing demand for manuka (Leptospermum scoparium) honey production.

Bacles, C. F. E., et al. (2009). "Reproductive biology of Corymbia citriodora subsp. variegata and effective pollination across its native range in Queensland, Australia." Southern Forests: a Journal of Forest Science 71(2): 125-132.

The spotted gum species complex represents a group of four eucalypt hardwood taxa that have a native range that spans the east coast of Australia, with a morphological cline from Victoria to northern Queensland. Of this group, Corymbia [Eucalyptus] citriodora subsp. variegata (CCV) is widespread in south-eastern Queensland and northern New South Wales. It is currently the most commonly harvested native hardwood in Queensland. However, little basic knowledge of the reproductive biology of the species is available to inform genetic improvement and resource management programmes. Here, we take an integrative approach, using both field and molecular data, to identify ecological factors important to mating patterns in native populations of CCV. Field observation of pollinator visitation and flowering phenology of 20 trees showed that foraging behaviour of pollinator guilds varies depending on flowering phenology and canopy structure. A positive effect of tree mean flowering effort was found on insect visitation, while bat visitation was predicted by tree height and by the number of trees simultaneously bearing flowers. Moreover, introduced honeybees were observed frequently, performing 73% of detected flower visits. Conversely, nectar-feeding birds and mammals were observed sporadically with lorikeets and honeyeaters each contributing to 11% of visits. Fruit bats, represented solely by the grey-headed flying fox, performed less than 2% of visits. Genotyping at six microsatellite markers in 301 seeds from 17 families sampled from four of Queensland's native forests showed that CCV displays a mixed-mating system that is mostly outcrossing (tm=0.899+or-0.021). Preferential effective pollination from near-neighbours was detected by means of maximum-likelihood paternity analysis with up to 16% of reproduction events resulting from selfing. Forty to 48% of fertilizing pollen was also carried from longer distance (>60 m). Marked differences in foraging behaviour and visitation frequency between observed pollinator guilds suggests that the observed dichotomy of effective pollen movement in spotted gums may be due to frequent visit from introduced honeybees favouring geitonogamy and sporadic visits from honeyeaters and fruit bats resulting in potential long-distance pollinations.

Barker, K. R. (1990). "Beetle induced dieback at Yeoval [Australia]: an appreciation." Australasian beekeeper 91(11): 479-479.

In parts of NSW, Australia, Eucalyptus and other tree species are being attacked and eventually killed by beetles, especially Christmas beetles [the scarabaeid Anoplognathus chloropyrus and related species]. Up to a quarter of live trees of some species are affected, particularly E. conica. Yellowbox, E. melliodora, is less seriously affected, although some trees are completely stripped by a small black scarab beetle, and its valuable nectar flow could be reduced.

Baur, G. (1974). "Multiple Use of the Forest Resource." Search 5(8): 374-374.

The multiple use of the forest resource to conserve and maintain environmental Quality is reported. The multiple benefits that can be obtained from the forest include: wood, drugs, oil, resins, decorative materials, honey, outdoor recreation, habitat for native animals, and beautification of the landscape. Multiple use involves certain added costs and compromise, but also promises multiple benefits. It can serve as an extremely efficient and flexible tool for meeting a wide range of valid community requirements.

Beckhouse, J. (1981). "Eucalypt dieback." Australasian beekeeper 83(2): 34-37.

History and recent occurrences.

Bellis, G. A. and A. M. Profke (2003). "Rainbow bee-eaters (Merops ornatus) as a monitoring tool for honeybees (*Apis mellifera* L.; Hymenoptera: Apidae)." Australian Journal of Entomology 42(3): 266-270.

Regurgitated pellets were collected from underneath roosts of rainbow bee-eaters in suburban Darwin, Australia, and examined for the presence of wings of honeybees. The proportion of pellets containing wings was compared prior to and after placement or removal of honeybee hives in the vicinity of four roosts. On each occasion,

the addition or removal of hives was reflected in proportions of pellets containing wings. The results suggest that examination of pellets beneath bee-eater roosts would be a useful technique for monitoring the occurrence of feral honeybees. Potential uses for this technique in eradication of unwanted bees are discussed.

Berkin, A. (1987). "Banksia ornata and bee keeping at Mt. Shaugh, S.A." Australian bee journal 68(8): 20-20.

In the Mt. Shaugh area, South Australia, this desert plant flowers from late April to early August. It can withstand temperatures of -50 degrees C. At its peak of nectar production, 300 ml nectar can drip from one flower spike in 14 h. B. ornata can be a valuable winter honey source; records kept at a 400-hive apiary from 1974 to 1976 show that, although in 2 years no honey was harvested, in 6 years the mean yield was more than 20 kg/hive (max. 35.8 kg) for the period May-July. B. ornata pollen has a high protein content (39%) and is useful for overwintering colonies.P. Walker.

Bernhardt, P. (1987). "A comparison of the diversity, density, and foraging behavior of bees and wasps on Australian Acacia." Annals of the Missouri Botanical Garden 74: 42-50.

The 8 Acacia species selected for study (in Victoria) together represented the year-round flowering season of the genus, with more flowering in late winter to early spring than at other times. *Apis mellifera* was abundant on Acacia longifolia - on which it was the dominant forager - and on A. pycnantha, A. retinodes and A. terminalis. Other bees and wasps, foraging for pollen on the flowers or on the extrafloral nectaries, were collected for identification and their pollen loads analysed. Almost all of the 457 bees collected were from two families of short-tongued bees, the Halictidae (mainly Lasioglossum species) and Colletidae (especially 2 Leioproctus species). Some bees foraged on the extrafloral nectaries of A. longifolia, A. myrtifolia, A. pycnantha and A. terminalis. Most of the pollen loads (63-91%) collected in late spring to late summer contained pollen from other species as well as from Acacia; in the autumn and winter 21-55% of loads were mixed. Of the 58 wasps recorded, 66% were from the Sphecidae and Tiphiidae, and 34% from 5 other families. Wasps observed on Acacia longifolia, A. myrtifolia and A. terminalis consistently foraged on the extrafloral nectaries before attempting to collect nectar from the nectarless flowers.P. Walker.

Bernhardt, P. and K. Walker (1984). "Bee foraging on 3 sympatric species of Australian acacia." International Journal of Entomology 26(4): 322-330.

Nine bee taxa [*Apis mellifera*, Callomelitta sp., Euhesma sp. nr. halictoides, Homalictus punctatus, H. megastigmus, Lasioglossum (Chilalictus), L. (Paraphecoides), Leioproctus-sp., and Nomia sp.] from 3 families (Apidae, Colletidae and Halictidae) were collected on the inflorescences of Acacia mitchelii, A. myrtifolia, and A. pycnantha at the Brisbane Ranges National Park, Victoria. The most commonly collected insects belonged to 2 subgenera [Chilalictus and Parasphecodes] within Lasioglossum (Halictidae) and the genus Leioproctus (Colletidae). All bee taxa analyzed, excluding Homalictus punctatus (Halictidae), carried polyads of Acacia in their corbiculae or scopae. More bee taxa were taken on the summer-flowering A. mitchellii than on the late-winter-early-spring-flowering A. myrtifolia and A. pycnantha. Analysis of pollen loads suggest that the foraging patterns of most bee taxa range from oligolectic (specialist) through narrowly polylectic (moderately generalist). Oligolecty declined sharpy during spring. About 42% of the bees collected on Acacia spp. also carried the pollen of 1 or more plant taxa sympatric with Acacia. Most of these plants belong to families with nectariferous flowers: Myrtaceae, Rhamnaceae and Proteaceae. Although the distribution and flowering seasons of A. myrtifolia and A. pycnantha overlap broadly, bees tend to forage perferentially on A. pycnantha.

Bernhardt, P. and K. Walker (1985). "Insect foraging on Acacia retinodes var. retinodes in Victoria, Australia." International Journal of Entomology 27(1-2): 97-101.

Insects foraging on the flowers of montane populations of A. retinodes were from 3 orders: Coleoptera, Diptera, and Hymenoptera. Of the 75 insects collected, 68 were Apoidea, representing 3 native families (Anthophoridae, Colletidae, Halictidae) and the introduced *Apis mellifera*. Twelve taxa of Apoidea were identified on A. retinodes. Most (80%) insects (82% of the bees) carried pollen of at least 1 other sympatric plant mixed with the polyads of A. retinodes. A mean of 2 pollen genera were recorded per insect, with one bee carrying 4. Compared with the insect fauna collected on A. retinodes var. uncifolia, the bees on var. retinodes showed a 25% greater taxonomic diversity and a 20% higher rate of polylectic (generalist) foraging.Author.

Bernhardt, P. and P. H. Weston (1996). "The pollination ecology of Persoonia (Proteaceae) in eastern Australia." Telopia 6(4): 775-804.

Wild populations of 20 Persoonia species and 2 hybrids were studied. Bees constituted 99% of insects collected while they were probing or foraging on flowers and their pollen loads included Persoonia pollen. The most common bee genus was Leioproctus (subgenus Cladocerapis; Colletidae). *Apis mellifera* (9% of total) was collected from 8 Persoonia species, with highest numbers on P. pinifolia and P. mollis. At 2 sites, 28% of the bees collected were carrying pollen of more than one Persoonia species; this, together with the overlapping distributions and flowering periods of some species, explains in part the high frequency of first-generation hybrids.

Berry, I. (1983). "Winter feeding: feeding dry raw sugar to honeybees, New Zealand." New Zealand beekeeper.: 25-25.

Birtchnell, M. and M. Gibson (2010). "Friend or foe: exotic flora and ecosystem function." Victorian Naturalist (Blackburn) 127(4): 124-136.

Exotic flora, particularly weeds, are renowned for out-competing and displacing native flora, consequently affecting native fauna and pollinator relationships. Nonetheless, it stands to reason that weeds must provide some compensatory ecological value. This study assessed whether weeds are friend or foe to ecosystem function by considering the quality and quantity of pollen offered by widespread weeds in Australian ecosystems. Using the Honeybee *Apis mellifera* as a case study, and information derived from highly experienced commercial apiarists, we determined that 32 exotic plants are important pollen sources. Most species offered high to very high quality pollen. Pollen quality varied temporally, spatially and infraspecifically. Fifteen species were considered more beneficial to *A. mellifera* than others; only seven species were considered less beneficial. Thus, exotic flora contribute pollen resources that are valuable to maintain ecosystem function, particularly at times when flowering native species are few. (The Victorian Naturalist 127 (4) 2010, 124-136)

Birtchnell, M. J. and M. Gibson (2006). "Long-term flowering patterns of melliferous Eucalyptus (Myrtaceae) species." Australian Journal of Botany 54(8): 745-754.

The flowering patterns of 28 Victorian melliferous (honey-producing) eucalypts were investigated by using long-term observations of highly experienced, commercial apiarists. Frequency, timing, duration and intensity of flowering were determined, as were spatial differences within and among species. Data were obtained by face-to-face interviews with 25 Victorian apiarists, each of whom had operated a minimum of 350 hives for a minimum of 30 years. Flowering frequency ranged from 1 to 7 years, and most species flowered once every 2-4 years. Long-term flowering frequency, timing and duration were reported as constant, although short-term perturbations could occur. Most melliferous species flowered during spring and summer for a period of 3 months or more. Only few species had shorter flowering periods. Information provided by apiarists compared well with available published information (e.g. flowering period reported in field guides) and revealed a reliable, largely untapped source of long-term data, the use of which could benefit many ecological research endeavours.

Bishop, H. (2006). "The secret life of bees." Gourmet 66(7): 108-115.

The article discusses the author's experience of traveling to Tasmania in order to witness the bees producing the leatherwood honey. Being a beekeeper for seven years, she admired the fragrant spiciness and the seductive lingering taste of the Tasmanian honey. Her visitation of the island made her realized that specialty honeys are produced by persuading the bees to concentrate their foraging in a single type of flower.

Blake, S. T. and C. Roff (1972). "The honey flora of Queensland." The honey flora of Queensland.: 234-pp.

This is a systematic account of plants providing bee forage in Queensland; some sections are revised from e.g. AA 211/55, 288/57, 59/60. Honey and pollen yields are assessed and honeys characterized. Main sources are species of Eucalyptus, Tristania, tea-trees, Banksia, Callistemon, Acacia, Avicennia, Casuarina, crop plants and weeds.E.E. Crane.

Boomsma, C. D. (1972). "Native trees of South Australia." Bulletin, Woods and Forests Department of South Australia(19): 224-pp.

The descriptions and illustrations of 106 species of trees and mallees are intended primarily as an aid to their identification; there are 3 keys for identification in the field, including one for 55 Eucalyptus species. Notes on honey and pollen are given under each plant, and information on colour of honey, quality of pollen, and honey and pollen yields and yield frequencies, are presented for all species in a table. (pp. 19-21). P. Walker ADDITIONAL ABSTRACT: Gives brief descriptions and line drawings of > 100 species of trees, including 55 species of Eucalyptus, commonly found in South Australia. Three keys are provided: (1) to species and genera, based on foliage; (2) to genera, based on fruits; and (3) to species of Eucalyptus, based on a variety of characters. Tables show honey and pollen yields for all the species, and flowering periods of Eucalyptus species.

Boutland, A., et al. (1993). "Alternative products from trees and shrubs." Forestry Sciences; The role of trees in sustainable agriculture: 25-58.

Braybrook, L. H. (1984). "Forest and flora - their economic value for beekeeping." Australasian beekeeper 86(4): 72-78.

This is a report to the Workshop on Apiculture (Standing Committee on Agriculture). It is stressed that the beekeeping industry in Australia must work to ensure that apiculture is accepted as an essential part of agriculture. Research is needed to establish, among other things, the benefits of pollination by honeybees. Beekeepers should be more active on committees and management boards concerned with forest areas, and should work with those who are fighting to preserve forests for other reasons. In particular, beekeepers must ensure that their rights of access to forests are preserved. Submissions from the Public Resource Managers of the Australian States are summarized; none quotes figures for honey production per hectare.P. Walker.

Briggs, L. (1985). "Echium; curse or salvation." Pests and parasites as migrants / edited by A.J. Gibbs and H.R.C. Meischke.: 152-159.

Briggs, L. (1993). "Apiculture in box and ironbark forests." Victorian Naturalist (South Yarra) 110(1): 38-44.

Brooker, M. I. H. and S. D. Hopper (1991). "A taxonomic revision of Eucalyptus wandoo, Eucalyptus redunca and allied species eucalyptus series Levispermae maiden myrtaceae In Western Australia." Nuytsia 8(1): 1-189.

Eucalyptus series Levispermae, a taxonomically distinct series of 28 species all endemic in Western Australia is revised. The Levispermae comprise many trees, mallets and mallees of the Western Australian wheatbelt, and include the important timber and honey-producing wandoo or white gum (Eucalyptus wandoo Blakely), the striking blue mallet (E. gardneri Maiden), and several common mallees previously included as variants in E. redunca Schauer. This revision is based on field studies, seedlings raised in the glasshouse, and standard herbarium research. Two new subseries are established in Eucalyptus series Levispermae - subseries Levispermae, comprising 27 species (20 of which are newly described and three others here raised to specific rank), and subseries Desmondenses, consisting of the single species E. desmondensis Maiden and Blakely. E. subangusta (Blakely) Brooker and Hopper is a new combination for E. redunca var. subangusta Blakely. E. arachnaea Brooker and Hopper (= E. redunca var. melanophloia Benth.) and E. flavida Brooker and Hopper (= E. redunca var. oxymitra Blakely) are necessary new names for taxa here elevated to specific rank. Other new species and subspecies described here for the first time are E. abdita, E. arachnaea subsp. arrecta, E. capillosa with two subspecies (capillosa and polyclada), E. clivicola, E. crispata, E. densa with two subspecies (densa and improcera), E. gardneri subsp. ravensthorpensis, E. hebetifolia, E. histophylla, E. livida, E. luteola, E. medialis, E. melanophitra, E. microschema, E. nigrifunda, E. phaenophylla with two subspecies (phaenophylla and interjacens), E. pluricaulis with two subspecies (pluricaulis and porphyrea), E. praetermissa, E. sparsicoma, E. subtilis, E. subangusta subspp. cerina, pusilla and virescens, E. tumida, E. varia with two subspecies (varia and salsuginosa), E. wandoo subsp. pulverea and E. xanthonema subsp. apposita.

Brophy, J. J., et al. (2013). "Melaleucas: Their Botany, Essential Oils and Uses." Melaleucas: Their Botany, Essential Oils and Uses.

This 408-page book is part of a series on Melaleucas-their botany, essential oils and uses. The book is organized into seven chapters, which are further divided into different topics. The first chapter deals with taxonomic history and systematics,which includes studies based on morphological evidence, and incorporating DNA evidence in classification. The second chapter deals with introduction to the genus Melaleuca, which includes general

information, botanical features, and geographical distribution and ecology. The third chapter deals with uses, which includes ethnobotanical, ornamental, landcare, honey, bark and wood, and extractives. The remaining chapters deals with propagation, silviculture and management, pests, diseases and other limitations, conservation and prospects, and species accounts. The book highlights a list of contributorsand their respective institutions. Each chapter contains a list of references. The text is written in English and indexed by subject with tables, and figures. Users of this book will include entomologists, botanists, and agriculturists.

Bukovac, Z., et al. (2017). "Why background colour matters to bees and flowers." Journal of Comparative Physiology a-Neuroethology Sensory Neural and Behavioral Physiology 203(5): 369-380.

Flowers are often viewed by bee pollinators against a variety of different backgrounds. On the Australian continent, backgrounds are very diverse and include surface examples of all major geological stages of the Earth's history, which have been present during the entire evolutionary period of Angiosperms. Flower signals in Australia are also representative of typical worldwide evolutionary spectral adaptations that enable successful pollination. We measured the spectral properties of 581 natural surfaces, including rocks, sand, green leaves, and dry plant materials, sampled from tropical Cairns through to the southern tip of mainland Australia. We modelled in a hexagon colour space, how interactions between background spectra and flower-like colour stimuli affect reliable discrimination and detection in bee pollinators. We calculated the extent to which a given locus would be conflated with the loci of a different flower-colour stimulus using empirically determined colour discrimination regions for bee vision. Our results reveal that whilst colour signals are robust in homogeneous background viewing conditions, there could be significant pressure on plant flowers to evolve saliently-different colours to overcome background spectral noise. We thus show that perceptual noise has a large influence on how colour information can be used in natural conditions.

Burking, R. C. (1986). "The effects of wildfires on the Western Australian beekeeping industry." Australasian beekeeper 87(12): 255-258.

Between January 1984 and January 1986, fires at 6 locations in Western Australia damaged over 100 000 ha. A total of 189 apiary sites were affected, with 25-100% of bee forage being burnt. Most were in areas of coastal heath where Hakea trifurcata and Dryandra sessilis (two important nectar plants) grow, or in areas of Banksia woodland with associated ground flora useful for wintering colonies. A formula was developed for estimating losses to the beekeeping industry; it is calculated that the overall projected loss for the 5-year period 1985-89 will be $A130 000. Several proposals are made for assistance to be given to beekeepers, and for fire control management.P. Walker.

Burking, R. C. and A. C. Kessell (1985). "Regeneration proposals for beekeepers' reserves in Western Australia." Australasian beekeeper 87(6): 117-119.

Areas damaged by fire are being reseeded with the nectar plants Dryandra sessilis and Hakea trifurcata.

Butz Huryn, V. M. (1995). "Use of native New Zealand plants by honey bees (*Apis mellifera* L.): A review." New Zealand Journal of Botany 33(4): 497-512.

A review of the literature indicated that honey bees collect pollen or nectar from 224 native plant taxa including 188 species, 119 genera, and 67 families in New Zealand. However, only 12 families contain the majority of honey bee forage sources. Plant taxa providing surplus quantities of honey and taxa with most citations were used to indicate intensity of honey bee use and revealed that only a very small proportion is used intensively. Potential effects on animal species overlapping in resource use with honey bees in the few specialised plant-pollinator relationships in New Zealand are discussed as well as potential impacts on the native flora. Forage sources used by honey bees are compared with those plants known or suspected to be threatened or rare.

Campbell, T., et al. (2020). "Machine learning regression model for predicting honey harvests." Agriculture 10(4).

Honey yield from apiary sites varies significantly between years. This affects the beekeeper's ability to manage hive health, as well as honey production. This also has implications for ecosystem services, such as forage availability for nectarivores or seed sets. This study investigates whether machine learning methods can develop predictive harvest models of a key nectar source for honeybees, Corymbia calophylla (marri) trees from South West Australia, using data from weather stations and remotely sensed datasets. Honey harvest data, weather and

vegetation-related datasets from satellite sensors were input features for machine learning algorithms. Regression trees were able to predict the marri honey harvested per hive to a Mean Average Error (MAE) of 10.3 kg. Reducing input features based on their relative model importance achieved a MAE of 11.7 kg using the November temperature as the sole input feature, two months before marri trees typically start to produce nectar. Combining weather and satellite data and machine learning has delivered a model that quantitatively predicts harvest potential per hive. This can be used by beekeepers to adaptively manage their apiary. This approach may be readily applied to other regions or forage species, or used for the assessment of some ecosystem services.

Campbell, T. and P. Fearns (2018). "Simple remote sensing detection of Corymbia calophylla flowers using common 3 -band imaging sensors." Remote sensing applications. 11(11): 51-63.

With *Apis mellifera* (the European Honey Bee) having an average forage radius of less than one kilometre from their hive, selecting the best location for beehives is critical for commercial beekeepers to optimise their honey production. In this study, we have used standard three-band digital cameras to develop and assess a simple parallelpiped algorithm to detect the flowers of the Corymbia calophylla tree in Western Australia, the largest source of honey in the state.The algorithm has been tested in a number of situations and, within the bounds of the study, works to a better than 90% classification accuracy for Digital Single Lens Reflex camera images of trees within 15 m distance, and often better than 95%.To determine how this approach could be used by Unmanned Aerial Vehicle platforms to detect flowering Corymbia calophylla flowering, image resolution was progressively degraded until flowers could not be detected. It was found that the cluster size of flowers (i.e. whether flowers occur individually or in groups) played an important role in determining the accuracy of flower detection, but overall a minimum resolution of 10 pixels per flower is required for reliable detection of flower pixels. While there is some improvement above this resolution, the effect is minimal. The key to accurate measurement of percentage flower cover is the accuracy of the classification of the background. If the background classification error is known for an image or scene, the percentage flower cover can be calculated with as little as 2% flower cover.Based on this study, UAV platforms with standard RGB cameras appear to be suitable for detection of Corymbia calophylla flowers if surveys are designed within the bounds described. Thus, UAV surveys may prove to be useful for beekeepers to optimise the location of their beehives amongst a choice of different locations.

Chippendale, G. M. (1976). "Eucalyptus nomenclature." Australian Forest Research 7: 69-107.

Many of the species discussed are bee forage plants (though this aspect is not covered in this paper).

Clearwater, M. J., et al. (2018). "Influence of genotype, floral stage, and water stress on floral nectar yield and composition of m(a)over-barnuka (Leptospermum scoparium)." Annals of Botany 121(3): 501-512.

Background and Aims Floral nectar can be variable in composition, influencing pollinator behaviour and the composition of honey derived from it. The non-peroxide antibacterial activity of m (a) over bar nuka (Leptospermum scoparium, Myrtaceae) honey results from the chemical conversion of the triose sugar dihydroxyacetone (DHA), after DHA accumulates for an unknown reason in the nectar. This study examined variation in nectar DHA, glucose, fructose and sucrose content with floral stage of development, between m (a) over bar nuka genotypes with differing flower morphology, and in response to water stress. Methods Six m (a) over bar nuka genotypes were grown without nectar-feeding insects. Stages of flower development were defined, nectar was harvested and its composition was compared between stages and genotypes, and with floral morphology. Water stress was imposed and its effect on nectar composition was examined. Key Results Nectar was present from soon after flower opening until the end of petal abscission, with the quantity of accumulated nectar sugars rising, then stabilizing or falling, indicating nectar secretion followed by reabsorption in some genotypes. The quantity of DHA, the ratio of DHA to other nectar sugars and the fructose to glucose ratio also varied with stage of development, indicating differences in rates of production and reabsorption between nectar components. Nectar composition and yield per flower also differed between genotypes, although neither was positively related to nectary area or stomatal density. Drying soil had no effect on nectar composition or yield, but variation in nectar yield was correlated with temperature prior to nectar sampling. Conclusions M (a) over bar nuka nectar yield and composition are strongly influenced by plant genotype, flower age and the environment. There were clear stoichiometric relationships between glucose, fructose and sucrose per flower, but DHA per flower was only weakly correlated with the amount of other sugars, suggesting that accumulation of the triose sugar is indirectly coupled to secretion of the larger sugars by the nectary parenchyma.

Clemson, A. (1985). "Honey and pollen flora." Honey and pollen flora.

Although primarily written for the NSW beekeeper, this book is an exceptional production covering over 300 species of bee forage plants in the eastern states of Australia. The book is based on a series of articles that were published in Australasian Beekeeper over 7 years. It is illustrated with over 700 superb colour photographs, almost all taken by the author. The introductory pages are devoted to a map of the geographical districts, sections on nectar and pollen, and on management of bees particularly when experiencing some of the difficulties associated with certain honey flows, e.g. pollen-deficient flows. The largest part of the book is devoted to trees and shrubs, particularly eucalypts (pp. 13-100) and other native species (pp. 101-178). Three further chapters cover crops, weeds, and ornamental trees, shrubs and garden plants. The entry for each species gives details of nomenclature (botanical and common names), morphology, distribution, flowering cycle, apicultural value, and general value. Each entry has one or (usually) more photographs. The final section of the book contains detailed distribution guides, a flowering calendar and a glossary of technical terms. There is also an index of common and scientific names. The author refers to several publications consulted in the preparation of this volume, but there is no bibliography as such. As well as its value to beekeepers, especially in NSW, this book should be of particular interest to botanists as it represents the latest and most definitive work on Eucalyptus spp., as well as many other Australian trees and shrubs.R.B. Gulliford.

Clemson, A. A. (1977). "Honey and pollen plants of N.S.W.. 30. Darling pea (Swainsona galegifolia)." Australasian beekeeper: 228-231.

Clemson, A. A. (1981). "Honey and pollen plants of NSW. Cucurbits - family Cucurbitaceae." Australasian beekeeper 82(7): 173-176.

Collins, B. G., et al. (1984). "Nectar utilization and pollination by Australian honeyeaters and insects visiting Calothamnus quadrifidus (Myrtaceae)." Australian journal of ecology. 9(4): 353-365.

Corbet, S. A. and E. S. Delfosse (1984). "Honeybees and the nectar of Echium plantagineum L. in south-eastern Australia." Australian Journal of Ecology 9: 125-139.

Flowering and nectar secretion were studied at 5 sites. The concentration of nectar solutes varied with time of day, date and site; means varied from 2 to 62% (expressed as g sucrose/100g solution). There was a significant negative correlation between nectar solute concentration and ambient RH. Rate of nectar secretion varied with method of bagging, time, date and site. Maximum rates in short-term bagging experiments were c. 300 micro g sugar/flower/h (equivalent to more than 2 mg/flower/24 h). Secretion rate was correlated negatively with flower density.Honeybees foraged on the flowers only at ambient temperatures above 17 degrees C (unless irradiance exceeded 750 W/msuperscript 2), collecting nectar and/or pollen. At nectar solute concentrations below 35% most bees collected pollen only; above 40% most took nectar. The mean standing crop of nectar was generally less than 100 micro g/flower when most bees were foraging for nectar, but exceeded 1000 micro g/flower when they were foraging for pollen or absent. Bees did not always remove all nectar from the flowers they visited.P. Walker.

Culvenor, C. C. J. (1985). "Patteron's curse and toxic alkaloids." Search, Australia 16(7/8): 219-223.

Paterson's Curse (Echium plantagineum) contains pyrrolizidine alkaloids which exert a slowly developing toxicity in grazing animals. The effects of the alkaloids are cumulative and progressive even at low intake rates. Under these conditions, poisoning may be difficult to associate with the responsible plant. The properties of pyrrolizidine alkaloids which cause them to produce long term effects are briefly described. Field evidence strongly indicates that horses, pigs and, to a lesser but significant extent, sheep are poisoned. Humans are also exposed to low levels of pyrrolizidine alkaloids in foodstuffs in Australia, one of the main sources being honey.

Curtis, K., et al. (2019). "Can native plantings encourage native and beneficial invertebrates on Canterbury dairy farms?" New Zealand entomologist. 42(2): 67-78.

Farming intensification negatively effects native habitat and associated biodiversity in New Zealand. Planting native species around field margins has been proposed as a means of restoring biodiversity within this highly modified landscape. To test this hypothesis, we collected invertebrates on a dairy farm at Lincoln, Canterbury, in

three habitat types: native plantings in field corners, native plantings along a double fence line, and pasture. Invertebrates were collected from pitfall traps, yellow pan traps, wooden discs and leaf litter samples were collected from the sites over summer. Assemblages of spiders, flying insects, slugs and litter mites in the planted areas had distinct compositions compared with those found in adjacent pasture. Species richness of native spiders was increased in the planted areas compared with adjacent pasture, as was the abundance of ecosystem service providers, such as honeybees, parasitoid wasps and hoverflies. Exotic slugs were significantly more abundant under discs in pasture than in planted areas. However, not all native or beneficial invertebrates responded positively to the planted areas. Further research is required to examine whether these results are repeatable at other locations, if invertebrate assemblages at this location develop further over time, and to evaluate whether any perceived benefits of these service providers can be quantified in terms of meaningful endpoints such as reduced pest levels and/or increases in yield.

Davies, D. J. G. and R. P. Macfarlane (1979). "Multiple-purpose trees for pastoral farming in New Zealand: with emphasis on tree legumes." New Zealand Agricultural Science 13(4): 177-186.

The potential for soil conservation and agroforestry of several native and exotic legumes is discussed. Flowering period, chemical composition of leaves/pods, hardiness to frost and drought, timber value, forage potential for livestock and bees, ornamental value and other products are tabulated with information on up to 38 species. Two low-growing species that have proved useful for slope stabilization as well as forage are tree lucerne (Cytisus palmensis) and tree medick (Medicago arborea), the latter being shrubby and more suitable for cold districts. Gleditsia triacanthos is recommended as a shade and fodder tree for farm pasture.

Davis, A. R. (1991). "Mixed loading of pollen from Echium plantagineum L. (Boraginaceae) and Hirschfeldia incana (L.) Lagreze-Foss. (Brassicaceae) by an individual honey bee (*Apis mellifera* L.)." American bee journal. 131(10): 649-655.

Davis, A. R. (1997). "Influence of floral visitation on nectar-sugar composition and nectary surface changes in Eucalyptus." Apidologie 28(1): 27-42.

Floral nectaries and their production of major nectar carbohydrates were studied in three species of Eucalyptus in Australia. In E. cosmophylla, E. grandis and E. pulverulenta, the nectary is located on the inner surface of the hypanthium, below the stamen filaments. Nectary surfaces possessed hundreds of modified stomata that were solitary, distributed uniformly, asynchronous in development, and served as exits for nectar flow. Nectar yields per bagged flower were greatest in E. cosmophylla and least in E. grandis, correlating with flower size but not nectary stomatal density. The nectar of E. pulverulenta was sucrose-rich, but hexose-rich for the others. Few changes in nectar carbohydrate composition were detected between flowers whether protected or continually exposed to visitors (eg, honeybees), and whether young or old, indicating an overall constancy in composition for the long period of nectar availability.

Donovan, B. J. (1979). "Vitex negundo incisa, its potential for bee forage in New Zealand (Verbenaceae)." Proceedings, Conference on alternative land uses in New Zealand with emphasis on temperate tree crops, Lincoln College, Canterbury, New Zealand.: 189-192.

Eaton, C. v. (1984). "Amenity and farm shelter trees for bees, Southland/South Otago." Amenity and farm shelter trees for bees, Southland/South Otago.(Ed. 2): 19-pp.

This pamphlet gives details of over 100 species which provide forage for honeybees, including planting requirements, uses, climatic tolerances, etc.

Effah, E., et al. (2020). "Seasonal and environmental variation in volatile emissions of the New Zealand native plant Leptospermum scoparium in weed-invaded and non-invaded sites." Scientific Reports 10(1): 11736-11736.

The New Zealand tea tree Leptospermun scoparium (manuka) is widely known for the antimicrobial properties of its honey. Manuka is native to New Zealand, growing in a range of environments, including the Central Volcanic Plateau of the North Island, where it is currently threatened by the spread of exotic invasive weeds such as heather (Calluna vulgaris) and Scotch broom (Cytisus scoparius). Here, we characterise for the first time the aboveground volatile organic compounds (VOCs) produced by manuka in this area, during summer and winter seasons, in weed-invaded and non-invaded stands. We measured plant volatiles at four sites, each with a distinct

combination of woody species: (1) conspecific stands of manuka; (2) manuka and another native species (Dracophyllum subulatum); and manuka with one of two European invasive plants, (3) heather or (4) Scotch broom. We also quantified herbivore damage on target manuka plants and analysed microclimatic variables (soil nutrients, air temperature and soil water content) to investigate their impact on volatile emissions. Our results reveal a strong seasonal effect on volatile emissions, but also significant differences between sites associated with biotic and abiotic changes partly driven by invasive plants. Overall, volatile emission rates from manuka were typically lower at sites where invaders were present. We point to several factors that could contribute to the observed emission patterns and areas of interest for future research to provide a comprehensive understanding of VOC emissions in nature. Given the vital role of volatile compounds in plant communication, we also recommend future studies to be performed in multiple seasons, with larger sample sizes and more study sites to expand on these findings and explore the ecological impacts of changes in VOC emissions during plant invasion.

ElQadi, M. M., et al. (2017). "Mapping species distributions with social media geo-tagged images: Case studies of bees and flowering plants in Australia." Ecological Informatics 39: 23-31.

Data sources on species distribution and range are typically expensive and time consuming to build, and traditional survey techniques often have spatial, temporal, or scale-related gaps. Social network sites, on the other hand, can provide massive amounts of cost effective data that may potentially yield information of direct benefit to supplement and understand ecological phenomena. Previous research explored using social network site content to enhance information collected by experts or professional surveys in domains including species distribution and land cover. However, the data quality and general suitability of social network sites data for answering questions related to species distribution and range is highly variable and this aspect of its value to science remains underexplored.In this research we investigate some causes of social network site data unreliability and explore how to mitigate them. We filter data points based on our estimates of reliability and relevance. We then use the filtered data to infer species ranges and distributions in concert with Global Biodiversity Information Facility (GBIF) data. Our proposed methodology was applied to four Australian case studies including two insect pollinators, and two flowering plants. The case studies were chosen from Australia because of its unique geographical features, large landmass, sparse population, and the many tourists and residents who travel across it taking photos and sharing them through social media. We show that, despite some barriers, there are instances where the social network site data clearly complement the existing source, making our technique a valuable means of making repeatable, efficient additions to traditional species distribution data. (C) 2017 Elsevier B.V. All rights reserved.

Farrow, R. A. and R. J. Roberts (1986). "Growing trees for bees in the 1900's." Australasian beekeeper 88(6): 122-128.

Fenselau, I. (1983). "Guide to honey flora for reafforestation." Australian bee journal 64(10;11): 11-21.

In Australia over the past one hundred years large areas of forest have been cleared, to the concern of conservationists and beekeepers who advocate massive replanting programmes. In Victoria, where 80% of honey is produced from eucalypts, further planting of certain species is recommended. A list of 38 suitable trees and shrubs (including 27 Eucalyptus species) is given, with brief notes on suitable sites and plant characteristics.P. Walker.

Ferguson, F. (1988). "Honey bee body protein management in napunyah (Eucalyptus ochrophloia) country." Australasian beekeeper 89(10): 193-194.

This is a brief summary of first results of a study on plant pollens and nosema disease in 1987 in some commercial apiaries in Queensland, Australia. Trapped pollen came from 2 or 3 major sources and 3 or 4 minor sources, but no napunyah pollen was found in the traps. Nosema levels fluctuated during the season. Crude protein in samples of bees ranged from 26 to 45%, mean 32%.^CENTREQUAD~P. Walker.

Fluence, T. (2013). "Urban hives." Habitat Australia 41(2): 23-23.

The author focuses on the importance of honeybees towards the food supply of Australia, as they have been known for pollinating food crops including almonds, cherries, and pears. He believes that the bee population has decline due to Colony Collapse Disorder outbreaks, pesticides, and climate change. The author tells that inhabitants of Melbourne, Victoria has produced honey from bees roosting at hives created on rooftops, balconies, and backyards.

Free, J. B. and I. H. Williams (1980). "The value of white clover *Trifolium repens* L., Cultivar S100 planted on motorway verges to honeybees *Apis mellifera* L." Biological Conservation 18(2): 89-92.

During two years the preferences shown by bees for five cultivars of white clover (S100, S184, Sabeda, Kent Wild and New Zealand Huia) were tested. Honeybees and bumblebees visited all the cultivars, but S100, the cultivar commonly planted on motorway verges, was one of the most attractive to them. © 1980, All rights reserved.

Goebel, R. L. (1987). "The search for a tropical island bee sanctuary." Australasian beekeeper 88(10): 197-208.

The requirements of a honeybee sanctuary or isolated mating station are considered. The suitability of 5 islands (or groups of islands) off the Queensland coast, Australia, was assessed. The information reported for each includes the number of honeybee colonies already kept, and the bee forage plants recorded. Plans are being made for the establishment of 2 isolated closed honeybee populations. P. Walker.

Goodman, R. (1983). "Planting honey and pollen flora for bees." Agnote, Department of Agriculture, Government of Victoria(Adgex 300/38): 2-pp.

Harris, J. W. (1978). "Trees, bees and Ashburton." Farm Forestry 20(4): 87-90.

A discussion of some species useful for bees [*Apis mellifera*] in New Zealand, and their management, with reference to a [farm] conference at Ashburton. A succession of willow species gives a good run of nectar and pollen, and a supply of summer fodder (for cattle or sheep). At times of pollen shortage, bees have been found to collect spores of poplar rust diseases.

Hingston, A. B., et al. (2004). "Pollinators in seed orchards of Eucalyptus nitens (Myrtaceae)." Australian Journal of Botany 52(2): 209-222.

Flowers of the commercially important tree Eucalyptus nitens were visited by a diverse array of insects, but not by birds, in Tasmanian seed orchards in Australia. Most species of insects that visited the flowers of E. nitens are likely to be effective pollinators because all common species of visitors carried many grains of Eucalyptus pollen, and the open floral structure facilitates frequent insect contact with stigmas. Seed production also suggested that a wide variety of insects were effective pollinators because flowers were consistently well pollinated, despite differences in flower-visitor communities among orchards and particular branches of flowers. The generalized entomophilous pollination system of E. nitens suggests that effective pollinators should occur in seed orchards of this tree throughout the world, provided that flowering occurs at a time of year conducive to insect activity. Although a wide variety of insects appear to be effective pollinators of E. nitens, introduced honeybees, *Apis mellifera*, that are often deployed as pollinators in seed orchards were consistently not attracted to the flowers. The reliance on wild insects as pollinators suggests that seed production in E. nitens may benefit from reduced use of broad-spectrum insecticides in, and near, seed orchards.

Hingston, A. B., et al. (2004). "Pollination services provided by various size classes of flower visitors to Eucalyptus globulus ssp. globulus (Myrtaceae)." Australian Journal of Botany 52(3): 353-369.

Flowers of the commercially important tree Eucalyptus globulus subsp. globulus were visited by a wide variety of insects and birds within its natural distribution in Tasmania, Australia. Flowers were visited so frequently that most available nectar was consumed, but seed production within 5 m of the ground was consistently far less than the maximum possible, indicating the presence of large numbers of inefficient pollinators and few efficient pollinators. Pollen limitation was more severe on fully self-incompatible trees than on partially self-compatible trees, demonstrating that pollinator inefficiency resulted from infrequent outcrossing rather than inability to deposit pollen on stigmas. The flower visitors that were responsible for almost all nectar consumption from flowers within 5 m of the ground were insects that were able to permeate cages with 5-mm apertures but not cages with 1-mm apertures, the most abundant of which was the introduced honeybee *Apis mellifera*. These insects contributed less than 20% of the maximum possible seed set, indicating that they were inefficient pollinators. Birds and smaller insects made lesser contributions to seed production, but consumed little nectar within 5 m of the ground. However, anthophilous birds appeared to mostly forage higher in the trees and probably consumed more nectar from, and provided more pollination services to, flowers higher in the trees.

Hingston, A. B., et al. (2004). "The swift parrot Lathamus discolor (Psittacidae), social bees (Apidae), and native insects as pollinators of Eucalyptus globulus ssp. globulus (Myrtaceae)." Australian journal of botany. 52(3): 371-379.

Holmes, N. (1982). "Bee forage trees; a valuable alternative." New Zealand Journal of Agriculture(July): 37-38.
Species suitable for growing in shelter belts.

Howlett, B. G., et al. (2015). "Pollination of macadamia: Review and opportunities for improving yields." Scientia Horticulturae 197: 411-419.
Macadamia nuts are a valuable culinary resource, but yields can vary substantially between varieties, orchards and seasons. The nuts are harvested from commercial varieties derived from two endemic Australian tree species; *Macadamia integrifolia* Maiden & Betche and Macadamia tetraphylla L.A.S. Johnson. While some aspects of crop management for this relatively new crop are well known and generally well applied-including variety selection, irrigation and pesticide application-progress towards increasing quantity and reliability of yield has proven elusive. Hand pollination studies indicate that inadequate cross pollination contributes to low nut set and thus low yield. Typically just 0.3% of flowers develop into harvestable nuts. Lack of nut development after flowering and early abscission are indicators of poor fertilisation of the ovule. Honey bees (*Apis mellifera* Linnaeus, 1758) are routinely reported as the most common insect visitor to macadamia flowers, and are widely regarded as the most important agent for transferring pollen between flowers. Stingless bees, beetles, flies and birds also visit flowers and have been considered as pollinators. In this review, we aim to collate what is currently known about the pollination of macadamia varieties, assess the factors that may hinder effective pollination and subsequent yield, and identify opportunities to improve both pollination and yield in commercial macadamia orchards. © 2015 Elsevier B.V.

Huryn, V. M. B. (1995). "Use of native New Zealand plants by honey bees (*Apis mellifera* L): A review." New Zealand Journal of Botany 33(4): 497-512.
A review of the literature indicated that honey bees collect pollen or nectar from 224 native plant taxa including 188 species, 119 genera, and 67 families in New Zealand. However, only 12 families contain the majority of honey bee forage sources. Plant taxa providing surplus quantities of honey and taxa with most citations were used to indicate intensity of honey bee use and revealed that only a very small proportion is used intensively. Potential effects an animal species overlapping in resource use with honey bees in the few specialised plant-pollinator relationships in New Zealand are discussed as well as potential impacts on the native flora. Forage sources used by honey bees are compared with those plants known or suspected to be threatened or rare.

Kilenschmidt, G. L. (1983). "Nutrition for long life bees." Apiculture Workshop Papers : Workshop papers and documents for the Standing Committee on Agriculture Workshop held at Hawkesbury Agricultural College, Richmond, N.S.W., 18-22 July 1983.: 161-187.

Kleinschmidt, G. (1993). "Colony nutrition on the Atherton tableland." Australasian beekeeper 94(11): 453-464.
Between July 1991 and January 1992 pollen was trapped from 6 honey bee (*Apis mellifera*) colonies in north Queensland, Australia. Of the 75 plant species represented in the samples (61 of which are named), 43 provided more than 90% of the pollen collected in the traps. Pollen from Eucalyptus spp. contained 24-37% crude protein (CP), and other species 15-31% CP. Two plants, flat weed (Hypochoeris radicata) and blue billygoat weed (Ageratum conyzoides), contributed significantly to the volume of pollen collected (24-79.5% of trap contents for 42% of the samples) but were of low CP (15-21%). Analysis of honey bee CP levels from 56 colonies (50 bees per colony per month) showed that decreases in pollen CP levels were correlated with decreases in honey bee CP levels. It is suggested that when poor-quality pollens abound, attention must be given to the protein nutrition of colonies to maintain productivity.

Kleinschmidt, G. J. and F. Furguson (1989). "Honey bee protein fluctuations in the Channel Country of south-west Queensland." Australasian beekeeper 91(4): 163-165.
In 1987 and 1988, the value and quality of available plant pollens varied widely between sites in this area and from month to month. Strong colonies with sufficient brood and protein reserves were able to forage actively for nectar during pollen dearths, but weaker colonies produced less honey during such periods. Colonies that had been foraging on nectar sources such as *Helianthus annuus* or Eucalyptus moluccana had low protein reserves and at

some sites were unable to build up satisfactorily before the E. ochrophloia flow. Such colonies would benefit from pollen supplements, perhaps given before migration to remote sites.

Kleinschmidt, G. J. and A. C. Kondos (1978). "The effect of dietary protein on colony performance." Australasian beekeeper 79(12): 251-257.

Protein in adult bees examined in Queensland constituted between 21 and 67% of body weight; it was directly related to the quantity and composition of pollen available. During heavy nectar flows, bees in colonies with a rapid decrease in body protein lived for 20-26 days; in colonies in which body protein remained above 40%, workers lived for 46-50 days. In the latter, large populations were maintained during a flow lasting 12 weeks. Thus it is recommended that body protein levels should be kept above 40%, and a suitable management system used in Queensland is described. P. Walker

Law, B. S. and M. Chidel (2008). "Quantifying the canopy nectar resource and the impact of logging and climate in spotted gum Corymbia maculata forests." Austral Ecology 33(8): 999-1014.

Nectar in tall forest canopies is a significant, but unquantified resource for Australian fauna. We investigated the impact of logging on nectar production in the canopy of spotted gum Corymbia maculata in southern New South Wales. In addition, we quantified the magnitude of canopy nectar production and how this varied with climate over 2 years. In 2005 flowers were bagged on large and small trees in replicate recently logged, regrowth and mature forest. Neither logging history nor tree size significantly affected overnight nectar production per flower, although there was a significant interaction. When nectar production was scaled up to the forest stand (incorporating flower and tree density) mature forest produced almost 10 times as much sugar per ha as recently logged forest, with regrowth being intermediate. Under current forest practices at the compartment scale, the difference between mature forest and recently logged forest was reduced to a factor of two times. One distinctive characteristic of C. maculata nectar in 2005 was its high sugar content (40–60%) compared with the concentrations measured in 2003 (∼18%). Nectar was only slightly depleted in unbagged flowers in 2005 when flowering was unusually extensive. We estimated that, on average, mature spotted gum forest produced a vast resource of nectar overnight: 35 000 Kj ha−1. Flowers measured in 2003 provided a strong contrast with only occasional stands of trees flowering, much less sugar per flower early in the morning and unmeasurable quantities by mid-morning, indicating that nectar was limiting. Measurements at sites in 2003 indicated that regrowth sites could be more productive than mature forest; however, few sites were measured. We suggest that management should focus mitigations on poor flowering years when the nectar resource is limiting. Models of nectar production collated over both years, using climate and site variables, indicated nectar volumes and sugar concentration respond differently to environmental conditions. Predicting the nectar resource, which is made up of both components, was most consistently related to recent conditions that were unfavourable to foliage production. [ABSTRACT FROM AUTHOR]

Lewis, B. M. (1977). "Native flora and honey production in South Australia." Native flora and honey production in South Australia.: 30-pp.

About 20% of Australian honey is produced in this state, where the bushland areas are particularly valuable for their good sources of nectar and pollen during autumn and winter. About 40% of South Australian honey comes from introduced crops and plants. Over 80 indigenous plant species are listed, with information on their distribution and value as a nectar/pollen source [based partly on AA 942L/70]. The importance of preserving and encouraging these plants is emphasized. About one-sixth of South Australian honey comes from introduced Echium vulgare (Salvation Jane), but this is now regarded as an agricultural pest and is being eradicated. P. Walker

Lewis, D. H. and J. A. Considine (1999). "Pollination and fruit set in the tamarillo (Cyphomandra betacea (Cav.) Sendt.). 1. Floral biology." New Zealand Journal of Crop and Horticultural Science 27(2): 101-112.

The floral biology of the tamarillo cv. Oratia Round was examined using field-grown (in Oratia, New Zealand) and glasshouse-grown plants. The tamarillo exhibits a modular growth pattern, initiating a number of leaves (usually 3-4) and then a terminal inflorescence. Inflorescence structure is compound and may consist of up to 50 flowers.

Flowers open sequentially along each axis of the inflorescence. Individual flowers close at night but reopen each day, for up to 5 days. The stigma is wet and although exudate was present from 3 days before to 7 days after flower opening (Day -3 to Day +7), the effective pollination period (by hand pollination) was from Day -1 until Day +1 only. An insect vector is required for pollination and both honey bees and bumble bees were observed to visit and pollinate tamarillo flowers. The tamarillo is self-compatible, although the nature of pollen release onto the thorax and abdomen of bees visiting the flowers could effect both self-pollination and cross-pollination. No parthenocarpic fruits were set under any of the circumstances investigated.

Loneragan, O. W. (1979). "Karri (Eucalyptus diversicolor F. Muell.). Phenological studies in relation to reforestation." Bulletin, Forests Department, Western Australia(90): vii-pp.

Describes detailed observations of karri floral cycles in Western Australia from 1956 to 1967, and less detailed observations of crops of honey and seeds since 1926. Regular seed cycles can be expected only when soil moisture is adequate. Results are discussed with reference to natural and artificial regeneration and honey production. From author's summary.

Low, T. (2006). "Sweet country." Australian Geographic(81): 68-79.

The article presents information on the nectar kingdom of Australia. In Australia, birds take nectar from banksias, grass trees, grevilleas, bottlebrushes, eucalypts and tea-trees. Most of the State floral emblems are visited by birds, such as the New South Wales waratah, pink common heath in Victoria, Tasmanian blue gum, Sturt's desert pea in South Australia and Mangles kangaroo paw in Western Australia. In Europe, by comparison, not one single plant is adapted for pollination by birds. The oaks, elms and conifers of Europe and North America bear dull little flowers that rely for pollination on the whim of the wind. Australia's larger nectar birds are giants by comparison. The yellow wattlebird in Tasmania, a honey-eater, is the world's biggest nectar-specialised bird, 10 times the bulk of any hummer or sunbird. And the honey-lapping birds in Australia reach numbers unmatched in any other country. The number of Australian mammals that eat some nectar is also exceptional. There are sugar, squirrel, yellow-bellied and feather-tailed gliders, honey possums and striped possums, pygmy-possums, flying-foxes, blossom-bats, antechinuses, phascogales, dibblers and more.

Macfarlane, R. P. (1992). "An initial assessment of blueberry pollinators in New Zealand." New Zealand Journal of Crop & Horticultural Science 20(1): 91-95.

The short tongued bumble bee, *Bombus terrestris* (L.), followed by the honey bee, *Apis mellifera* L., were the commonest blueberry pollinators at Lincoln, New Zealand. At most, 7% of honey bee visits and 24% of *B. terrestris* visits to blueberry flowers could have resulted in pollination. Honey bees visited flowering shelter adjacent to the blueberries more often than the bumble bees did. The long tongued bumble bees, B. hortorum (L.) and B. ruderatus (Fabr.), consistently pollinated blueberry flowers, but low populations restricted their value in pollination. There were no other effective insect pollinators of blueberries.

Macfarlane, R. P. and R. M. Beresford (1982). "Tree lucerne in New Zealand." Proceedings of a workshop held by Crop Research Division, DSIR, at Lincoln College, Canterbury on 8th September, 1982.: 38-47.

Cytisus palmensis is foraged by honeybees and bumble bees for pollen and nectar.

Manning, R. and M. Harvey (2002). "Fatty acids in honeybee-collected pollens from six endemic Western Australian eucalypts and the possible significance to the Western Australian beekeeping industry." Australian journal of experimental agriculture. 42(2): 217-223.

Mathison, A. (1988). "Floral resources and limiting factors affecting commercial bee keeping in Australia." Bee keeping in the year 2000. Proceedings of the Second Australian and International Beekeeping Congress, Surfers Paradise, Gold Coast, Queensland, Australia, July 21-26, 1988.: 159-160.

McBrydie, H. M., et al. (2017). "Relative abundance and movement of flower visitors within 'Black Doris' plum orchards in Hawke's Bay, New Zealand." New Zealand Plant Protection 70: 58-62.

The Japanese plum 'Black Doris' (Prunus salicina) is a self-infertile early-flowering crop so insufficient cross pollination and lack of pollinators could be factors to explain reported poor fruit set. This project assessed the

relative abundance of flower visitors within a plum orchard and their movements among three orchards, as part of a wider study on plum pollination. Insect surveys conducted over three days across one orchard in 2014 identified a total of 479 individual pollinators. Honey bees represented 94.6% of all pollinators observed. To assess pollinator movement across the crop, 140 individual flower visitors were followed over a five-day period in 2014 and again in 2015 across three orchards. Bumble bees moved further within the orchard and visited more trees per minute than foraging honey bees, while silvereyes visited more than twice as many flowers per minute than any other insect flower visitor.

McPherson, A. J. (2016). "Manuka - a viable alternative land use for New Zealand's hill country?" New Zealand Journal of Forestry 61(3): 11-19.

Plantation manuka for honey and oil production has emerged as an alternative land use for New Zealand's hill country. This paper examines the background to manuka's emergence, what is driving this increase in demand and its impact on the honey and pollination services sectors. It then looks at manuka harvesting, apiculture and management, and the factors influencing honey yield, before outlining the business case for manuka (both natural forest and plantation) and making conclusions about its viability.

Mocatta, G. (2005). "Turning honey into woodchips." Australian Geographic(80): 21-21.

The article presents information on turning honey into woodchips. About 70 per cent of Tasmania's honey industry is based on leatherwood. But this unique and coveted honey may be disappearing because of clearfelling in old-growth forests. According to the Tasmanian Beekeepers Association's Simon Pigot, who is an expert in spatial imaging and surveying says that leatherwood honey is very aromatic. He demonstrated that loggers' maps underreported leatherwood because the species is overshadowed by taller eucalypts, and the maps are based on aerial photographs. Jill Saunders, who owns Tasmanian honey-based cosmetic company Beauty and the Bees states that the problem is that beekeepers are very reticent and unassertive in their demands. She is encouraging beekeepers to resist Forestry Tasmania, to protect their livelihood, helping them to put up a website and trying to get them to organize a delegation to the Government.

Molan, P. (1998). "The limitations of the methods of identifying the floral source of honeys." Bee World 79(2): 59-68.

The pollen grains in honey reveal the types of plants that were around when the bees produced the honey, thus it is valid to use melissopalynology to determine the geographical origin of honeys, but there are several reasons why it is less valid for determining the botanical origin of honeys.

Moncur, M. W., et al. (1993). "Can honeybees increase seed production in blue gum, Eucalyptus globulus?" Australasian beekeeper 95(6): 248-253.

In Tasmania, Australia, 20 colonies of honey bees (*Apis mellifera*) were placed in a 10-ha seed orchard of Eucalyptus globulus for 17 days. Pollen was trapped from 3 colonies, and brood areas and adult bee crude protein (CP) levels were measured at the beginning and end of the trial. The introduction of honey bees coincided with an increase in E. globulus seed production: from 20.8 to 25.3 ($P < 0.05$) seeds per capsule and from 0.046 to 0.055 g per seed ($P < 0.05$). During their time in the orchard, the average brood area per colony increased by 9.6% and the worker CP from 31.1% to 46% of body weight. E. globulus pollen has a CP of 28-30%. It is suggested that Eucalyptus seed producers could benefit from introducing honey bee colonies and that such arrangements could also benefit beekeepers.

Moncur, M. W. and G. J. Kleinschmidt (1993). "A role for honey bees (*Apis mellifera*) in eucalypt plantations." Bee Briefs 9(4): 1-5.

In this review [which lacks full references], the potential use of honey bee pollination to improve eucalypt forests in Australia is discussed, and research results are summarized. Honey production from eucalypts is important in some areas; the potential in other areas has yet to be evaluated.

Moncur, M. W., et al. (1995). "The role of honey bees (*Apis mellifera*) in eucalypt and acacia seed production areas." Commonwealth Forestry Review 74(4): 350-388.

In many countries Eucalyptus and Acacia seed orchards are being established to provide a reliable source of genetically improved seed for reforestation. Yield of seed from some orchards has been low and a lack of

appropriate pollinators has been suggested as a possible cause. This paper reviews the role of honey bees in plantation forestry (both as pollen vectors and for products), and reports on recent studies in Australia and Indonesia. The studies, with Eucalyptus spp., were carried out to determine the causes of limited seed production, and showed that the number of seeds formed per capsule through natural open pollination was low in relation to the number of ovules in the flower. Controlled pollination generally increased the number of seeds per capsule, indicating that the amount of pollen reaching the stigma under open pollination may be a limiting factor in seed production. Placing hives in seed production areas increased seed quantity and quality (outcrossing rate) at the same time producing useful amounts of honey. Beekeeping products such as honey, honeydew, pollen and propolis, have significant economic value in a number of countries and play an important role in many forestry enterprises.

Moncur, M. W. and D. Somerville (1989). "The use of honey bees for pollen transfer and increased pod set in black wattle (Acacia mearnsii)." Australasian beekeeper 91(2): 73-89.

This acacia, which flowers in mid-summer in Australia, produces much pollen but no nectar. Low pod set has been reported in Australia and China. Pollen traps were fitted to 12 hives at a site in New South Wales during flowering of A. mearnsii (Am); flatweed (Hypochoeris radicata) was abundant in the area and was in flower. Results are given for the 2 most active colonies. In 18 days total pollen yields were 4.5 kg and 3.5 kg; pollen collection was maximal on warm sunny days. At the start of Am flowering, its pollen constituted 4% and 15% of total pollen and flatweed pollen 94% and 76%, respectively. At maximum Am flowering, its pollen constituted 6% and 2% and flatweed pollen 87% and 67% of total pollen respectively; one trap contained 20% pollen from Onopordium acanthium. Crude protein levels in the pollens were: Am 24.2%, flatweed 20.4% and O. acanthium 36.4%. Pod set in Am was not increased significantly by the presence of honeybees.

Nepia, R. E. and B. D. Clarkson (2018). "Biological flora of New Zealand (15): Ixerba brexioides, tawari." New Zealand Journal of Botany 56(1): 2-25.

This review summarises the biology and ecology of the distinctive North Island New Zealand endemic tree Ixerba brexioides (A.Cunn.). The genus Ixerba is monotypic and belongs to the family Strasburgeriaceae found only in New Zealand and New Caledonia. Ixerba brexioides (twari) is a New Zealand tree restricted to rain forests north of 39 degrees S latitude in areas of mature soil in mild, moist climates. With conspicuous white flowers displayed en masse between November and January each year and dark green, long and toothed leaves arranged in whorls, it has earned recognition as one of New Zealand's most attractive trees. Inflorescences are predominantly insect pollinated, with occasional bird visitation. Capsular fruit are produced in early autumn and dehisce to reveal dark black-purple seeds with an orange fleshy aril that are bird dispersed. Seeds germinate quickly, without a dormancy period, most commonly on soil, logs and mounds, but grow slowly (1.6-2.4mm year diameter growth rate) in shade conditions until canopy gaps open. Chemicals associated with its leaves include ursolic acid and proanthocyanidins, but their significance is unknown. Agglomerative hierarchical cluster analysis defined four main forest types dominated by I.brexioides centred on Northland, Waikato, Coromandel and Urewera, the floristically richest occurring in Northland. The genus first appeared in the fossil record in New Zealand in the late Eocene. Flowers of I.brexioides (whkou) were historically used by maori in garlands and necklaces, while peak flowering was a signal to harvest certain crops. Ixerba brexioides honey is popular and honey crops are sought after in areas where the trees are abundant and accessible to beekeepers. Though not currently threatened, the distinctive and geographically limited I.brexioides is one of the many New Zealand trees requiring additional research. Priorities include potential threats of climate change, susceptibility to inbreeding depression and the role of birds as dispersers.

Ng, K. (2019). ""Bee aware' when weeding! Network analysis of bee-flower visits in the Victorian Alps." Austral Ecology 44(2): 351-351.

Nickless, E. M., et al. (2017). "Soil influences on plant growth, floral density and nectar yield in three cultivars of mānuka (Leptospermum scoparium)." New Zealand Journal of Botany 55(2): 100-117.

Honey derived from the nectar of Leptospermum scoparium J.R. et G. Forst. Myrtaceae (mānuka) is a high-value product and there is considerable potential for economic growth in honey-growing regions of New Zealand through increased nectar yield from mānuka plantations. Leptospermum scoparium exhibits a significant amount of phenotypic plasticity throughout regions in New Zealand where it has established, although the influences on this plasticity are unknown. When assessing L. scoparium as a nectar source for honey in marginal land areas, the

possible effect of soil on nectar chemistry and yield should be considered. We investigated whether phenological patterns of flowering, plant growth, nectar composition and nectar yield were influenced by soil composition. Three different cultivars of L. scoparium were grown on 10 different soils in glasshouse conditions. The soils chosen were representative of the range of New Zealand soils where mānuka is being considered as a commercial crop for the honey industry. ANOVA and general linear models revealed no significant effect of soils on nectar composition or production; however, significant but complex interactions between cultivars and soils influenced plant growth and flowering ($P \leq 0.05$). Accordingly, the overall nectar yield was influenced by cultivar and soil interaction. Measured attributes of the soil such as cation exchange capacity, sulphate, iron, manganese, calcium and chloride were shown to influence the plant parameters assessed. Results allowed modelling of nectar potential against each soil type and established a mānuka soil index to determine the most appropriate soil for each cultivar. The results indicated that potential nectar yield increases will be dependent on cultivars being deployed according to the nature of the soil present. Furthermore, the mānuka cultivars displayed significantly greater growth in response to increased nutrients and some cultivars increased floral density, suggesting potential to improve nectar yield by greater plant growth using targeted fertilisation.

Noe, S., et al. (2019). "Floral nectar of wild manuka (Leptospermum scoparium) varies more among plants than among sites." New Zealand Journal of Crop and Horticultural Science 47(4): 282-296.

Understanding of the genetic and environmental controls of floral nectar production by manuka (Leptospermum scoparium J.R.Forst. et G.Forst.) and other species is limited by high levels of variation. This study partitioned variation in manuka floral nectar traits between sites, plants, and branches, and tested plant and environmental variables that might contribute to variation. Wild manuka plants were sampled at five sites across the North Island of New Zealand at the time of flowering for each site. Nectar traits differed significantly between sites, but for most traits plant-to-plant variation within sites was the largest source of variation (40%-70%) identified by linear mixed-effect modelling. Nectar total sugar, dihydroxyacetone (DHA) and hexose and sucrose ratios varied more between plants within sites, than they did between sites or branches within plants. Radiation and night-time temperature accounted for approximately 80% of between-site variation in mean total sugar per flower, and DHA/total sugar, respectively. Nectar total sugar and DHA were correlated across years when nectar was sampled again from the same plants two years later at one site, confirming stable variation between plants over time. Variation in nectar traits between adjacent wild plants suggests interactions between genotype, environment and flowering phenology among plants.

Palmer Jones, T. and L. J. S. Line (1962). "Poisoning of honey bees by nectar from the Karaka tree (Corynocarpus laevigata J. R. et G. Forst.)." New Zealand Journal of Agricultural Research 5(5/6): 433-436.

Nectar from the Karaka tree, which flowers in the spring and is very attractive to honey bees, is highly toxic to adult bees. The problem can be dealt with by re-siting apiaries or moving them out of range of Karakas during the flowering period. Authors' summary. KEYWORDS: Bees, toxicity \ some nectars \ Corynocarpus laevigata

Panter, S., et al. (2015). "Development and validation of protocols for product stewardship in transgenic white clover (*Trifolium repens* L.): detection of the AMV CP and npt2 transgenes in pollen, honey and honey bees." Crop & Pasture Science 66(5): 474-480.

There are no current commercial releases of genetically modified white clover, but several research groups are working on traits such as virus resistance, stress tolerance and bloat safety that are likely to provide large economic benefits for livestock farmers. However, white clover pollen is a common constituent of honey produced by bees foraging white clover flowers. Therefore, there is a need to develop tools to detect the presence of genetically modified pollen in white clover honey. The results presented in this paper describe the development and application of PCR-based techniques to detect the Alfalfa mosaic virus coat protein gene (AMV CP) and the neomycin phosphotransferase 2 selectable marker gene (npt2) in genetically modified white clover pollen, whether this pollen is collected fresh, from honey bees that have been foraging white clover, or from honey. Further research and development will be required to develop 'field-ready' tools for the detection and quantification of these transgenes in pollen and honey products. However, this paper demonstrates prospects and principles in pollen and honey from honeybees foraging transgenic white clover.

Paton, D. C. (1990). "Budgets for the use of floral resources in mallee-heath Australia." NOBLE, J. C., P. J. JOSS AND G. K. JONES (ED.). THE MALLEE LANDS: A CONSERVATION PERSPECTIVE; CONFERENCE, ADELAIDE, SOUTH AUSTRALIA, AUSTRALIA, APRIL 18-21, 1989. XVII+322P. CSIRO PUBLICATIONS: EAST MELBOURNE, VICTORIA, AUSTRALIA. ILLUS. MAPS. PAPER: 189-193.

Porter, J. W. (1978). "Relationships between flowering and honey production of red ironbark, Eucalyptus sideroxylon (A. Cunn.) Benth., and climate in the Bendigo district of Victoria." Australian Journal of Agricultural Research 29(4): 815-829.

Annual growth of red Eucalyptus sideroxylon was bimodal, occurring during autumn and spring. It required a threshold temperature of 16-17 deg C and a monthly rainfall of 45-60 mm. The rate at which flower buds developed in exposed umbels was related to the temperature and rainfall during the spring growing season. Flowering started in January, reached a maximum in July, and ended in September. Temperature and rainfall in the 2-5 years before harvest influenced honey production. Annual honey production per hive was above average after a sequence of warm wet summers favourable to foliage growth, alternating with warm dry winters favouring photosynthesis. A wet winter 2 years before harvest encouraged flower bud initiation. Cool temperatures during flowering in the harvest year favoured the flow of nectar. An equation for predicting honey production per hive is presented, based on temperature and rainfall measurements. The strength of honeybee colonies left in E. sideroxylon forests for a long period declined because they were unable to obtain sufficient pollen. J. M. Gedye

Rayner, C. J. and D. F. Langridge (1985). "Amino acids in bee-collected pollens from Australian indigenous and exotic plants." Australian journal of experimental agriculture. 25(3): 722-726.

Revell, L. E., et al. (2014). "Analysis of volatile compounds in New Zealand unifloral honeys by SPME-GC-MS and chemometric-based classification of floral source." Journal of Food Measurement and Characterization 8(2): 81-91.

New Zealand unifloral honeys have a higher commercial value than polyfloral honeys; however identification of floral source can be difficult and time-consuming. In this study, we aimed to establish a rapid and semi-automated method for identifying the floral source of New Zealand honeys. Volatile compounds from ten types of New Zealand unifloral honeys (a total of 234 samples) were analyzed by solid-phase microextraction (SPME) and gas chromatography coupled to mass spectrometry (GC-MS). For 37 compounds, probability plots of log10[GC-MS peak area] versus cumulative probability enabled visual identification of those that could be possible markers used to discriminate floral source. GC-MS peak areas were also analyzed by hierarchical cluster analysis and principal component analysis. Results showed data falling into groups based on floral source, indicating that supervised pattern recognition could be used to build a model with which to classify honeys based on floral source. A model was built using WEKA (Waikato Environment for Knowledge Analysis) machine-learning software. The logistic model tree algorithm in WEKA produced a model that classified 89.8% of samples correctly. Overall, results show that the methods employed here have the potential to be used as a basis for routine testing and classification of New Zealand unifloral honeys.

Rhodes, J. (1974). "The longevity of worker honey bees on the Darling Downs." HARNAJ, V. (ED.). APIMONDIA SCIENTIFIC BULLETIN, 1972. SYMPOSIA. 1972. 535P. ILLUS. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 359-362.

Rowland, C. Y., et al. (1995). "Comparison of organic extractives found in leatherwood (*Eucryphia lucida*) honey and leatherwood flowers and leaves." Journal of Agricultural and Food Chemistry 43(3): 753-763.

The principle volatile flavour components were identified in mature and unripe honey of leatherwood (*Eucryphia lucida*), and related to the chemical constituents of extracts of flowers, particularly nectar and stamens, collected from the Picton River area, Tasmania. Hotrienol and 2,6-dimethyl-3,7-octadiene-2,6-diol were the major terpenes in both methylated and unmethylated extracts of honey. The diol was also detected in nectar and all plant extracts except leaves, but hotrienol was not detected in flower extracts or unripe honey. Many other aromatic substances found in the honey were also detected in the flower extracts. ADDITIONAL ABSTRACT: In headspace analysis of leatherwood honey aroma, the principal component was hotrienol (3,7-dimethyl-1,5,7-octatrien-3-ol). This compound results from the dehydration of the principal terpene found in ether extracts of leatherwood honey; the same terpene was present in leatherwood plant extracts. Methylated ether extracts of the honey also contained

methyl 2-hydroxy-2 (4-methoxyphenyl)acetate, a compound not previously reported from honey, but also found in the plant extract.

Somerville, D. (1991). "Honey and pollen flora suitable for planting in south-east NSW." Bee Briefs 8(2): 11-14.
A table gives details of 84 species, including 57 species of Eucalyptus.

Somerville, D. (1995). "Pollen quality - woollybutt (Eucalyptus longifolia)." Bee Briefs 12(2): 12-13.
Beekeepers in Narooma State Forests, NSW, Australia, consider this tree to be a nectar and pollen source of medium importance. It flowers every 3-4 years, and honey yields from the nectar flow average 27 kg/colony. The pollen contains 24.9% crude protein.

Somerville, D. (1996). "Central Murray Valley Forestry Area apiary management survey results." Bee Briefs 13(1): 7-12.
This area of 98 000 ha in New South Wales contains one of the largest naturally occurring populations of river red gum (*Eucalyptus camaldulensis*) in Australia. *E. camaldulensis* produces heavy yields of nectar, yielding high quality honey, and is a major source of pollen. Apiary permits for the area are held by 39 beekeepers, with over 16 000 hives (100-150/site). Results from a 1995 survey are summarized in this report and other good sources of bee forage are listed. Forestry practices as they affect the beekeeping industry are discussed and responses to survey comments by the State Forests department are included; flooding is a major problem.

Somerville, D. C. (2005). "Lipid content of honey bee-collected pollen from south-east Australia." Australian journal of experimental agriculture. 45(12): 1659-1661.

Somerville, D. C. and D. Nicholson (2005). "The primary melliferous flora and other aspects associated with beekeeping within State forests of New South Wales as determined by surveys of beekeepers." Australian Forestry 68(1): 9-16.
The State forests of New South Wales (NSW) are a very important resource for the NSW beekeeping industry. In 1995/96, 3749 occupation permits were issued for bee farming, and this number increased to 3843 in 1997. On average, 100-120 beehives were periodically placed on each occupation permit site, the number and location being determined by the flowering of species which beekeepers regarded as reliable producers of nectar and pollen. Commercial apiaries were also periodically placed adjacent to State forests, allowing the bees to fly to the floral resources of these forests. The fraction of sites located on private property in this way varied from 5% to 57%, depending on the forestry district, with an average of 34%. Thus the actual number of commercial honey bees accessing the State forest floral resources was much higher than occupation permits indicated. The main floral species of importance for beekeeping within the NSW coastal forests were Banksia ericifolia, Corymbia maculata, C. variegata, Eucalyptus muelleriana, E. paniculata, E. siderophloia, Lophostemon confertus, E. acmenoides and E. longifolia. The ironbark group of eucalypts was a major source of nectar for honey bees throughout the State forests of NSW. The main tablelands species were E. viminalis and E. pauciflora, although as there are fewer forest districts on the tablelands the frequency of mention across more than one forest district was reduced. The species of importance in the western forests included C. trachyphloia, E. camaldulensis, E. crebra, E. largiflorens, E. microcarpa, E. sideroxylon and E. fibrosa. This paper provides a collective anecdote of the most important nectar- and pollen-producing flora of value to commercial beekeepers within the forests under the management of Forests NSW.

Somerville, D. C. and H. I. Nicol (2002). "Mineral content of honeybee-collected pollen from southern New South Wales." Australian journal of experimental agriculture. 42(8): 1131-1136.

Somerville, D. C. and H. I. Nicol (2006). "Crude protein and amino acid composition of honey bee-collected pollen pellets from south-east Australia and a note on laboratory disparity." Australian journal of experimental agriculture. 46(1): 141-149.

Stace, P. (1988). "Beekeeping and National Parks. To bee or not to bee." Australian bee journal 69(12): 14-20.
The NSW National Parks and Wildlife Service's policy is to remove commercial beekeeping from the conservation areas under its control. The reasons given are that honeybees (1) take floral resources needed by

native animals, (2) take nectar from, and damage, bird-pollinated flowers, (3) after swarming, occupy nest sites in hollow logs that are needed by native animals, (4) accelerate hybridization of native plants. Each of these reasons is discussed in this paper, with evidence from relevant studies reported in the literature. It is concluded that properly managed migratory beekeeping in the National Parks of New South Wales does not conflict with the objectives for these areas.

Stace, P. (1992). "Pollen quality - Paterson's curse (Echium plantagineum)." Australasian beekeeper 93(12): 504-504.
This plant is a useful source of nectar and pollen in SE Australia. In analyses of 2 samples of pollen, crude protein contents were 31% and 33%, which are higher than in most other pollens analysed. Contents of individual amino acids are also reported. The collection of E. plantagineum pollen for feeding to bees (0.5 kg/wk) is recommended, especially for colonies on winter honey flows with little or no pollen.

Stace, P. (1992). "Pollens suitable to collect, store and feed back to bees." Australasian beekeeper 94(6): 247-247.
A list of 14 plants which produce pollens with 20-33% crude protein is presented.

Stace, P. (1993). "The Tenterfield Forestry District environmental impact study." Bee Briefs 9(4): 12-16.
A table lists 27 tree species (including 22 eucalypts) that are important for honey production in this forest (NSW, Australia). Flowering period, flowering frequency and honey characteristics are given. Suggestions are made for changes in forest management that would help beekeepers, including improved access to apiary sites and multi-species planting.

Stace, P. (1996). "Nutritional problems with white mahogany (Eucalyptus acmenioides)." Bee Briefs 13(1): 2-3.
Eucalyptus acmenioides is a major nectar source on the north coast of NSW and Queensland. Bees also collect pollen from the flowers and, although its protein content is reasonable, it contains little isoleucine. It is therefore necessary to feed soyaflour patties to maintain colony population and brood area. Protein and individual amino acid contents are tabulated for E. acmenioides pollen from 4 locations.

Stace, P. and J. Hayter (1994). "Palatability of five protein feedstuffs by honey bees (*Apis mellifera*)." Australasian beekeeper 96(1): 23-25.
Five colonies of honey bees (*Apis mellifera*) in NSW, Australia, were each fed 5 times with patties of c. 100 g of a vegetable protein supplement made with 3 parts honey to 4 parts of one of the following: expeller-processed soyabean flour (A), Torula yeast (B), solvent-extracted soyabean flour (C), solvent-extracted sunflower flour (D) and solvent-extracted canola flour (E). Average daily consumption (g/day) was 4.65, 2.96, 2.26, 1.42 and 1.29 respectively, with A consumed at a significantly faster rate than the others. This product has 6-8% fat compared with 2% for C: it is suggested that a fat content of 6-10% in protein supplements could increase consumption.

Stace, P. and E. White (1994). "The use of iso-leucine as a supplement feed for honey bees (*Apis mellifera*) in Australia." Australasian beekeeper 96(4): 159-166.
The brood area of honey bee (*Apis mellifera*) colonies fed 4 g of isoleucine in 2 litres of sugar syrup increased significantly more than in colonies fed sugar only over a 6-week period when colonies were located in an area with adequate pollen sources, but did not do so in an area with poor pollen supplies. It is thought that isoleucine may help bees to utilize available pollen. When colonies used for queen rearing were fed 4 g isoleucine per week in sugar syrup there was increased acceptance of queen cells after grafting and cell production per colony, and decreased consumption of supplementary food [protein supplement?].

Tan, S. T., et al. (1989). "A chemical approach to the determination of floral sources of New Zealand honeys." Journal of apicultural research. 28(4): 212-222.

Tan, S. T., et al. (1986). "Floral source identification: a chemical approach." New Zealand beekeeper(190): 21-23.
Thirty New Zealand honeys, most of which were described as monofloral, were examined by GC. The patterns obtained for 5 of them are reproduced here to show that each honey has a characteristic pattern which can be used as a "fingerprint". The presence or absence of certain peaks is discussed for honeys produced mainly from

the following plants: *Trifolium repens*, "heather", Knightia excelsa, Leptospermum scoparium, L. ericoides, "nodding thistle".P. Walker.

Tan, S. T., et al. (1988). "A chemical approach to the characterization of New Zealand ling heather honey." New Zealand beekeeper(199): 31-33.

Earlier studies [AA 1025/87] indicated that GC analysis of organic substances in a honey could assist in the identification of its floral origins. Analyses of further honey samples collected during 1986-87 from N. Island, New Zealand, have now shown that some organic substances (known as degraded carotenoids) occur only in Calluna vulgaris honey. The substances were represented by peaks 10, 37, 41, 44, 45 and 46 in the studies described; the highest concentrations found were 100-180 micro g/g (peak 45) and 27-36 micro g/g. The results also indicated that high quality heather honey is essentially devoid of 2-hydroxy-3-phenylpropionic acid, and that the ratio of peak 45 to peak 25 (35:1 in this study) may be a useful indicator of floral source integrity.^CENTREQUAD~D.G. Lowe.

Taylor, M. A., et al. (2019). "The effect of carbohydrate sources: Sucrose, invert sugar and components of mānuka honey, on core bacteria in the digestive tract of adult honey bees (*Apis mellifera*)." PLoS One 14(12): e0225845-e0225845.

Bacteria within the digestive tract of adult honey bees are likely to play a key role in the digestion of sugar-rich foods. However, the influence of diet on honey bee gut bacteria is not well understood. During periods of low floral abundance, beekeepers often supplement the natural sources of carbohydrate that honey bees collect, such as nectar, with various forms of carbohydrates such as sucrose (a disaccharide) and invert sugar (a mixture of the monosaccharides glucose and fructose). We compared the effect of these sugar supplements on the relative abundance of bacteria in the gut of bees by feeding bees from a single colony, two natural diets: mānuka honey, a monofloral honey with known antibacterial properties, and a hive diet; and artificial diets of invert sugar, sucrose solution, and sucrose solutions containing synthesised compounds associated with the antibacterial properties of mānuka honey. 16S ribosomal RNA (rRNA)-based sequencing showed that dietary regimes containing mānuka honey, sucrose and invert sugar did not alter the relative abundance of dominant core bacteria after 6 days of being fed these diets. However, sucrose-rich diets increased the relative abundances of three sub-dominant core bacteria, Rhizobiaceae, Acetobacteraceae, and Lactobacillus kunkeei, and decreased the relative abundance of Frischella perrara, all which significantly altered the bacterial composition. Acetogenic bacteria from the Rhizobiaceae and Acetobacteraceae families increased two- to five-fold when bees were fed sucrose. These results suggest that sucrose fuels the proliferation of specific low abundance primary sucrose-feeders, which metabolise sugars into monosaccharides, and then to acetate.

Thorp, R. W. and E. A. Sugden (1990). "Extrafloral nectaries producing rewards for pollinator attraction in *Acacia longifolia* (Andr.) Willd." Israel Journal of Botany 39(1-2): 177-186.

An investigation was made of the extent to which extrafloral nectaries (EFN) of *Acacia longifolia* serve as sources of rewards for pollinating insects. Most behavioural observations of insects were made in September 1985 and September 1986 on one large *A. longifolia* shrub in New South Wales. Other observations were made on populations of *A. longifolia* in New South Wales. The size and distance from the stem of EFN were measured. The lengths and number of flowers per inflorescence and position relative to EFN were also measured. The results indicate that bees (*Apis mellifera* and others) and wasps feed at EFN, often crawling over inflorescences and passively vectoring pollen. The position of EFN in relation to inflorescences, timing of secretion in relation to flowering, and visiting behaviour of pollinating insects support this hypothesis.

To Tan, S., et al. (1989). "A chemical approach to the determination of floral sources of New Zealand honeys." Journal of Apicultural Research 28(4): 212-222.

The results of gas chromatagraphic analyses of the concentrated diethyl ether liquid-liquid extracts of 10 honey samples from a variety of floral sources are presented. The chemical composition was compared with the pollen composition and found to be related to the floral source. The gas chromatographic profile of honey extractives is proposed as a guide to the purity of unifloral honeys. © 1989 International Bee Research Association.

Turner, J. W., et al. (1972). "Studies on populations of honey bee colonies foraging in two species of eucalypts." Australasian beekeeper 74(6): 166-169.

Eucalyptus siderophloia and *E. hemiphloia* are important honey sources in S. Australia, but colony populations sometimes decrease severely when working these plants. Examination of the amount and types of pollen collected by the bees showed that the main pollen sources were not Eucalyptus but shrubs and ground-cover plants. Thus, such pollen sources need to be plentiful if population decrease is to be prevented. The life span of workers and the incidence of Nosema disease are also discussed. It is recommended that hives taken to Eucalyptus areas should contain at least 40 000 workers with a minimum of 13 combs of brood, and good pollen stores. P. Walker

Turner, J. W., et al. (1974). "Studies on populations of honey bee colonies foraging on two species of eucalypts." HARNAJ, V. (ED.). APIMONDIA SCIENTIFIC BULLETIN, 1972. SYMPOSIA. 1972. 535P. ILLUS. APIMONDIA PUBLISHING HOUSE: BUCHAREST, ROMANIA: 367-372.

Webb, C. J. and J. E. Shand (1985). "Reproductive biology of tree lucerne (Chamaecytisus palmensis, Leguminosae)." New Zealand Journal of Botany 23: 597-606.

The reproductive biology of tree lucerne or tagasaste, C. palmensis (a potential fodder crop), was investigated for two populations, one naturalized and one cultivated, on the Port Hills, Canterbury, New Zealand, in 1983-84. The populations flowered in late winter and spring. The numerous white blossoms contained nectar and were visited by a variety of insects, but only bumble bees were effective in operating the flowers: both bumble bees and honeybees robbed the flowers of nectar through the calyx but this did not usually directly damage the ovary. Self-pollination was recorded at the late bud stage. Under open pollination, fruit production varied from 4 to 55% for individual trees. Although many ovules began to develop into seeds, abortion reduced seed production per pod to about 50% for both populations. Of the ovules available to be fertilized at flowering, only 5% for the naturalized population and 16% for the cultivated population developed into seeds. The difference between the two populations was largely a result of a difference in the proportion of flowers setting fruit rather than in seed production per pod.^CENTREQUAD~Author.

Webby, R. (2004). "Floral origin and seasonal variation of bee-collected pollens from individual colonies in New Zealand." Journal of apicultural research. 43(3): 83-92.

Wicaksono, W. A., et al. (2015). "Endophytic bacteria isolated from Leptospermum scoparium produce compounds that inhibit Ilyonectria and Neofusicoccum species in vitro." New Zealand Plant Protection 68: 445-445.

Leptospermum scoparium J.R.Forst. et G.Forst. var. scoparium, or manuka, is a New Zealand indigenous shrub. This shrub is valued for the essential oil and medicinal honey it produces that have antimicrobial properties. International research has demonstrated that endophytic bacteria can either directly produce, or modify, metabolites in planta. Therefore, bacteria within the manuka endomicrobiome may also produce antimicrobial compounds. A total of 192 endophytic bacteria were recovered from surface sterilised leaf, stem and root tissue from three different sites. These bacteria were assessed in dual culture assays against the grapevine pathogens Ilyonectria spp. and Neofusicoccum spp. Eleven and three endophytic bacteria showed ability to inhibit I. liriodendri and N. luteum, respectively. These endophytic bacteria produced both diffusible and volatile compounds that inhibited the pathogens. Isolate W4R11 inhibited the growth of Ilyonectria spp. by 41-64% after 7 days incubation. Isolate W1R33 could inhibit the faster growing Neofusicoccum spp. by 20-53% after 3 days incubation. Microscopy showed that diffusible compound produced by isolate I1R21 caused hyphae and spore abnormality of Ilyonectria spp. This study indicated that manuka can potentially provide a new source of microorganisms for use in sustainable agriculture.

Williams, C. J. (2010). "Medicinal plants in Australia. Volume 1: bush pharmacy." Medicinal plants in Australia. Volume 1: bush pharmacy.

This book is the first of a 4-volume series on Australia's medicinal plants. This volume presents the story of the discovery of the practical use of the Australian flora. It comprises the following chapters: Plants of the pioneers: first impressions and improvizations; Herbal inspirations: remedies from the bush; Sarsaparilla and sassafras: old remedies in a new country; Xanthorrhoea: grass-tree medicine; Floral emissaries; Bush beverages; Bush tucker bugs; Sweet surprises: medicinal and toxic honeys; Uniquely Australian: flowers, flavours and fragrance; Sandalwood: the aromatic export; The famous Australian gum tree.

Williams, D. (1983). "Plantings for bees." New Zealand beekeeper(180): 25-26.

Williams, G. A. and P. Adam (1997). "The composition of the bee (Apoidea: Hymenoptera) fauna visiting flowering trees in New South Wales lowland subtropical rainforest remnants." Proceedings of the Linnean Society of New South Wales 118(0): 69-95.

Native and exotic bees were sampled visiting mass-flowering rainforest trees in lowland subtropical rainforest remnants in the Manning Valley, on the New South Wales north coast. The number of bee species varied between individual rainforest sites and native bee taxa exhibited differential occurrence at individual plant species and in different rainforest subformations. Bees exhibited increased recruitment responses to peak-phase flowering of individual trees. Flowers visited by bees exhibited a number of different floral morphologies. Colletidae-Hylaeinae was the most diverse native bee group collected but individual taxa were in general not restricted to single plant species. Exotic *Apis mellifera* were most abundant at flowers during peak-phase flowering. *Apis mellifera* foraged at most plants sampled and foraging activities resulted in disturbance to small native hylaeine bees on flowers. Native Trigona carbonaria bees were recorded on fewer species of flowering trees than was *Apis mellifera*.

Williams, S., et al. (2014). "Regional, Annual, and Individual Variations in the Dihydroxyacetone Content of the Nectar of Manuka (Leptospermum scoparium) in New Zealand." Journal of Agricultural & Food Chemistry 62(42): 10332-10340.

A method was designed and validated for the analysis of dihydroxyacetone in the floral nectar of ma?nuka (Leptospermum scoparium). The method was applied to samples collected from different regions of the North Island and the Nelson region of the upper South Island of New Zealand during the period 20092012 as well as to nectar samples from some Australian Leptospermum species. The ratio of dihydroxyacetone to total sugar (DHA/Tsugar) was classified as low (<0.001 mg/mg), moderate (0.0010.002 mg/mg), or high (>0.002 mg/mg). Inter- and intraregional variation were observed as well as interannual variation with variation from low to high classification occurring within one region and from low to moderate between years. Australian species also demonstrated elevated levels of dihydroxyacetone in the nectar. Some garden cultivars were shown to produce very high nectar DHA/Tsugar, and a survey of cultivars was undertaken; cultivars with single-flowered red or pink flowers were the most common producers of very high nectar DHA/Tsugar.

Williams, S. D., et al. (2018). "Dihydroxyacetone Production in the Nectar of Australian Leptospermum Is Species Dependent." Journal of Agricultural & Food Chemistry 66(42): 11133-11140.

This study is the first large-scale survey of the presence of dihydroxyacetone (DHA) in the nectar of the Australian Leptospermum tree species. The work undertaken supports the growing global demand for bioactive Leptospermum honey. Leptospermum honey derived from L. scoparium in New Zealand, also referred to as Manuka honey, has a reputation for wound-healing and antimicrobial properties, which is based on its methylglyoxal (MGO) content. High-DHA nectar correlates to high-MGO honey, but not all Leptospermum species produce DHA in their nectar. This study investigates 55 of the 84 Leptospermum species native to Australia for their DHA-producing capability, with the DHA to total sugar (DHA:Tsugar) ratio of nectar samples determined by HPLC-PDA. DHA:Tsugar ranged from nondetectable in L. laevigatum, L. coriaceum, and L. trinervium to >16 000 mg/kg in L. speciosum and L. whitei. High-DHA Leptospermum species were identified for beekeepers to target for honey production and plantation development.

Willis, R. T. and D. T. Bell (1987). "European honeybee foraging patterns associated with flowering in heathlands of Southwest Australia." International Botanical Congress Abstracts 17: 375-375.

Wills, R. T. (1989). "Management of the flora utilised by the European honey bee in kwongan of the Northern Sandplain of Western Australia." Management of the flora utilised by the European honey bee in kwongan of the Northern Sandplain of Western Australia.: xviii-pp.

Beekeeping in Western Australia relies on the native sclerophyll shrublands ('kwongan') of the Northern Sandplain as a source of pollen and nectar over winter. Loss of floral resources as a result of fire can have dramatic consequences on the apicultural industry. This study was directed at identifying environmental and biological factors of importance in determining the forage for honey bees in this region and to use these data to explore ecologically-

based management strategies which would enhance apicultural production without deleteriously affecting the conservation values of the region. A total of 413 vascular plant species from 192 genera in 66 families were identified from the study region, with the Myrtaceae and the Proteaceae contributing the largest number of species. The range of community types which was found throughout the study area was largely explained by geology, soil types, moisture gradients, distance from other plant communities and the effects of fire. Variations in patterns of plant flowering and plant reproductive strategies in response to environmental factors were quantified over a period of 30 months. The timing of flowering was largely seasonally constrained, resulting in a flowering peak of 241 species in late winter. The duration of flowering appeared to be largely a reflection of phylogeny and growth form. Flowering patterns also varied in relation to pollination biology and post-fire regenerative strategy. The importance of all flowering plant species as a resource for honey bees (*Apis mellifera*) was evaluated. Honey bees foraged widely amongst the available species, visiting 30% of all species as a source of pollen and/or nectar, but showed preferences for plant species with particular attributes. Honey bees tended to use plants which: flowered for longer; were woody perennial dicotyledons of particular taxa; were vertebrate-pollinated species; regenerated from seed after fire; were widespread and/or locally abundant; and occurred in the more diverse plant communities. Honey bees selected the longer flowering species, and it is suggested that length of flowering period may be indicative of plant reproductive effort so that species with a longer average duration of flowering may also provide the best floral resource. The possible ecological effects of honey bees are considered and management requirements for areas used for apiculture are explored based on the attributes of bee plant species identified in the study. The need for an ecological approach to management is discussed.

Wills, R. T., et al. (1990). "The European honey bee in Western Australian kwongan: foraging preferences and some implications for management." Australian ecosystems. Proc. symposium, Geraldton, W.A., 1988: 167-176.

Utilization of floral resources in native shrublands in the Northern Sandplain of Western Australia by the introduced *Apis mellifera* was examined. Honey bees used 30% of the 413 species recorded as a source of pollen and/or nectar, preferentially foraging on the most common species. Native bees also favoured species with high relative cover values and foraged on 70% of the 51 plant species visited by honey bees in the same period. Although only 30% of the regional flora are post-fire seed regenerators, these species were preferentially used by both the honey bee and native bee foragers. Fire, especially close-interval recurrent fire, can have a deleterious effect on the major melliferous species. Perennial reseeding species had a higher projective foliage cover than perennial sprouting species, but had lower cover at sites with shorter intervals between fires. A short interval between fires which decreases the local abundance of reseeding species may reduce the ability of a population to attract pollinators and, combined with the effect of a short interval between fires, may lead to the decline and eventual extinction of the population. -from Authors

Wills, R. T. and C. J. Robinson (1994). "Threats to flora-based industries in Western Australia from plant disease." Journal of the Royal Society of Western Australia 77(4): 159-162.

Yamani, H., et al. (2014). "Analysis of the volatile organic compounds from leaves, flower spikes, and nectar of Australian grown Agastache rugosa." BMC Complementary and Alternative Medicine 14(495).

Background: The foraging choices of honey bees are influenced by many factors, such as floral aroma. The composition of volatile compounds influences the bioactivity of the aromatic plants and honey produced from them. In this study, Agastache rugosa was evaluated as part of a project to select the most promising medicinal plant species for production of bioactive honey. Methods: Headspace solid-phase microextraction HS-SPME /GC-MS was optimized to identify the volatile bioactive compounds in the leaves, flower spikes, and for the first time, the flower nectar of Australian grown A. rugosa. Results: Methyl chavicol (=estragole) was the predominant headspace volatile compound in the flowers with nectar, flower spikes, and leaves, with a total of 97.16%, 96.74% and 94.35%, respectively. Current results indicate that HS-SPME/GC-MS could be a useful tool for screening estragole concentration in herbal products. Conclusion: Recently, estragole was suspected to be carcinogenic and genotoxic, according to the European Union Committee on Herbal Medicinal Products. Further studies are needed on safe daily intake of Agastache as herbal tea or honey, as well as for topical uses.

Australian Government
Department of Industry, Science, Energy and Resources

AusIndustry
Cooperative Research Centres Program