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BEEKEEPING: LEADING AGRICULTURAL CHANGE IN NEW ZEALAND

by

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ORIGINAL ARTICLE

BEEKEEPING: LEADING AGRICULTURAL CHANGE IN NEW ZEALAND

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Introduction

Despite its small size and relative isolation from other countries, New Zealand has an active and progressive beekeeping industry which is a world leader in many areas. The industry is innovative, and has adapted to numerous changes in the past decade.

This article describes beekeeping and the beekeeping industry in New Zealand, emphasizing those features of interest or use to other countries. The first part, in this issue, outlines bees and beekeeping methods used in New Zealand. The concluding part, in the next issue of *Bee World*, covers industry infrastructure, legislation and pests and diseases.

The country

New Zealand is a nation in the south-west Pacific Ocean. Approximately the size of Britain or the state of California, it consists of two main islands and a number of smaller ones lying principally between latitudes 33 and 47 degrees south (Fig. 1).

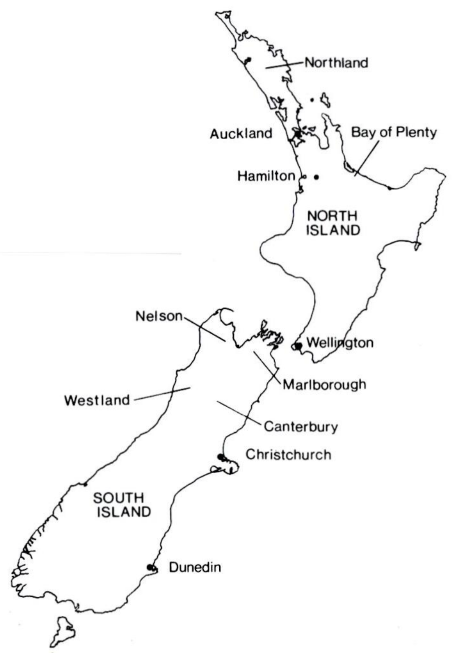

FIG. 1. Main islands of New Zealand, showing places mentioned in the text.

The country is mostly rolling or mountainous. Much of the land is developed for pastoral farming, with some used for intensive horticulture, some for exotic forestry and other land remaining under indigenous forest cover.

The first inhabitants arrived from Polynesia about 1000 years ago, with European settlement beginning about 800 years later. Today New Zealand is a westernized, independent, democratic country of 3.3 million people, with an economy based on agriculture, fishing, light industry, forestry, horticulture and tourism.

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Bees and beehives

Bees

Honey bees in New Zealand are free from many pests and diseases found elsewhere, because of the country's isolation and strict border quarantine measures. The stock is predominantly Italian type, with varying degrees of darker (mainly European) stock also present.

The first recorded introduction of the honey bee, *Apis mellifera*, to New Zealand was in 1839, when a missionary's sister, Mary Bumby, arrived at Mangungu in Northland with two skep hives containing colonies of European bees[10]. The mission house used by Rev. James Bumby has recently been restored by the New Zealand Historic Places Trust, and it now stands near the former mission church on the shores of the Hokianga harbour. In March 1991 Miss Bumby's portrait was put on display in the house, to commemorate the link between the settlement and the beginning of New Zealand's beekeeping industry. Bees were introduced to the South Island from Australia in 1842[15].

Further introductions of black honey bee races were probably made fairly regularly during the next few decades. Italian bees were first brought to New Zealand in 1880, when two colonies arrived from California. More Italian bees were introduced in that year: twenty-two hives also from the USA, and in 1884 two shipments totalling 10 queens arrived direct from Italy. Isaac Hopkins imported a number of different races in the 1880s, which he described as Italian, Swiss Alpine, Syrian, Holylander, Cyprian and Carniolan[10].

No importation of bees has been permitted since the 1950s, except for the introduction under strict quarantine of semen of Italian honey bees from Western Australia in 1989, 1990 and 1991. These importations were made to improve the characteristics of the country's commercial bee stock, while not risking the importation of pests and diseases.

New Zealand's only native bees are approximately 36 species of solitary bees of the family Colletidae and four from the Halictidae[4]. Four species of bumble bees (*Bombus terrestris, B. hortorum, B. ruderatus* and *B. subterraneus*) were introduced from England between 1885 and 1905 to improve red clover pollination[24]. More recently two North American bee species have been established to aid lucerne pollination: the alkali bee, *Nomia melanderi*, from 1964[5] and the lucerne leafcutting bee, *Megachile rotundata*, from 1971[6].

Hives

In New Zealand beekeeping is permitted only with movable-frame hives, and Langstroth hives are universal. This standardization has many benefits for the commercial industry as well as hobbyist beekeepers: equipment is interchangeable, and both manufacture of new equipment and trade in old are made simpler and cheaper.

Early beekeepers used fixed-comb hives, particularly ones made of convenient boxes such as cases for gin, petrol cans or explosives. Movable-frame hives were first used in New Zealand in the 1870s. In 1878 Isaac Hopkins[10] began using the Langstroth hive, and recommended it in its simplified ten-frame form in his books published from 1881[9]. Fixed-comb hives were outlawed in 1906.

The metric system of measurement (SI) was adopted in New Zealand between 1969 and 1976. The introduction of metric measurements gave an opportunity to rationalize and standardize hive dimensions: to create a standard that was effectively interchangeable with

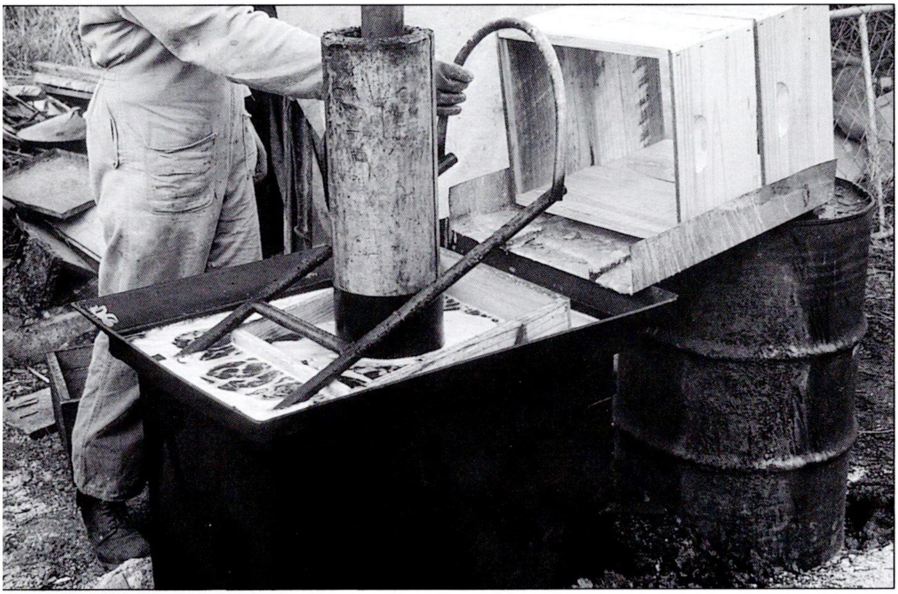

FIG. 2. Immersing hives in hot paraffin wax for preservation

the former hive but which rectified any shortcomings of existing equipment. The metric standard also had to take into account the availability of standard size timber, and be made up of convenient metric measurements[32].

The New Zealand standard measurements for the Langstroth hive have also been adopted in a number of other countries.

A variety of timber is used for hive parts. Native timbers have been used because of their durability, but these are becoming increasingly scarce. Pine (mostly *Pinus radiata*) is the wood most commonly used now for hive components. It is relatively soft and has a limited life when used outdoors untreated in New Zealand's generally warm and moist climate, so a number of preservation treatments are employed.

Several different fungicide treatments are used, especially copper naphthenate. It is diluted with kerosene, and components are soaked for periods ranging from several minutes to 12 hours. Water-soluble copper-based fungicides are also used. Any treated material must be well aired before use.

Commercial beekeepers make extensive use of dipping hive parts in very hot paraffin wax (Fig. 2). This technique appears to have been used in New Zealand more widely and for a longer period than anywhere else in the world. It was first described in 1939[30] and had been in use for a number of years before that. Most commercial beekeepers now have their own dipper or access to one[13].

Hive parts other than frames are immersed in paraffin wax at about 160°C, which soaks into the wood to form a protective coating. New woodware is dipped for about two minutes, allowed to cool very briefly, and then is usually painted on the outside with water-based paint. The paint is drawn into the wood by the cooling wax, forming a good bond.

TABLE 1. New Zealand beekeeping at a glance.

Beekeepers[A]	Apiaries[A]	Hives[A]	Honey production[B,C] (tonnes)	Honey exports[C] (tonnes)
6210	25 786	318 203	8677 (26.5 kg/hive)	1976

[A] As at 31 May 1990[29]
[B] Production of surplus honey available for sale (in excess of feed requirements)
[C] Annual average 1985–90[19,29]

Old hive parts can be waxed and repainted, and equipment from colonies infected with American foul brood (*Bacillus larvae*) can be sterilized by dipping for 10 minutes at 160°C. Beekeepers without access to paraffin dippers usually paint their hives on the outside, sometimes after fungicide treatment.

Beekeeping industry

Beekeeping has grown steadily in New Zealand over the past 20 years, except for a period of slight consolidation in the past three years. During the past two decades hive numbers have increased by over 60%. The current size of the industry is shown in Table 1.

In New Zealand, beekeeping is predominantly a commercial operation. Although apiarists owning fewer than 50 hives make up 91% of all beekeepers, they own only 10% of all hives. The remaining 90% are owned by semi commercial and commercial beekeepers, mostly by those having at least 750 hives[19].

During the latest growth phase many people have entered the industry by developing new commercial beekeeping businesses. Usually these people have professional or trade qualifications and began with only hobbyist experience in bees, and have started commercial beekeeping for business as well as lifestyle reasons. As a consequence of this growth the industry contains a lot of younger people with new skills and experience.

Beekeepers tend to be versatile and inventive. Most commercial apiarists rear some or all of their queen bees. Many make at least some of their own hive parts, and it seems that every one is a frustrated inventor – each beekeeper's shed contains a number of inventions or unique pieces of equipment.

The average size of beekeeping enterprises has grown in the last twenty years too, with owner-operator businesses (possibly with one seasonal worker) having to increase from around 600 hives to near 1000 to maintain profitability. Bigger commercial enterprises, employing several permanent staff or supporting several members of a family, run about 3000–4000 hives. There are larger businesses, with the biggest operating close to 18 000 hives.

FIG. 3. White clover, New Zealand's principal source of pasture honey.

Beekeepers operate in a free commercial environment, without market subsidies and price-smoothing or support schemes, and being required to pay most of the costs of advisory, disease-control and export-certification services.

Honey production

Honey production has long been the mainstay of New Zealand commercial beekeeping, and is still the principal source of income for most apiarists. In the past decade or so there has been a significant move from bulk sale of blended honey to the use of more imaginative packaging and niche marketing of unifloral honeys. Honey production figures are given in Table 1.

New Zealand produces a range of honeys from different plant species, many of which are unique to that country (Fig. 3). Some of the more significant sources of surplus honey are listed in Table 2. Many honeys from indigenous plant sources are naturally low in diastase or have unrepresentative pollen counts. The need to have exports to Europe meet Codex Alimentarius standards precipitated a survey of the chemical composition and pollen counts[20] of many different floral honeys.

Commercial apiaries used for honey production are situated on farmland and in or adjacent to native bush areas. Most landowners are happy to have apiaries located on their land, and only a few government departments and commercial forestry operations charge a fee for administering site usage agreements with beekeepers. Beekeepers normally give a few kilograms of honey per apiary to farmers whose land they use.

Commercial apiaries typically contain 20–30 hives, though in honeydew areas (discussed below) vast apiaries containing several hundred hives are possible.

TABLE 2. Sources of surplus honey in New Zealand.

Source	Common name	Botanical name
Important sources		
Pasture:		
	white clover	*Trifolium repens*
	alsike clover	*Trifolium hybridum*
	red clover	*Trifolium pratense*
	lucerne (alfalfa)	*Medicago sativa*
	lotus	*Lotus* spp.
	buttercup	*Ranunculus* spp.
	barberry	*Berberis* spp.
	hawthorn	*Crataegus oxyacantha*
	thistles	*Cirsium* spp., *Carduus* spp., *Silybum* spp.
	pennyroyal	*Mentha pulegium*
Native bush and scrub:		
	rewarewa	*Knightia excelsis*
	kamahi	*Weinmannia racemosa*
	pohutukawa	*Metrosideros excelsis*
	rata	*Metrosideros robusta*
	southern rata	*Metrosideros umbellata*
	tawari	*Ixerba brexioides*
	manuka	*Leptospermum scoparium*
	kanuka	*Leptospermum ericoides*
Other:		
	thyme	*Thymus vulgaris*
	blackberry	*Rubus fruticosus*
	brassicas	*Brassica* spp.
	viper's bugloss	*Echium vulgare*
Minor or regional sources		
	five finger	*Pseudopanax arboreus*
	crack willow	*Salix fragilis*
	cabbage tree	*Cordyline australis*
	hinau	*Elaeocarpus dentatus*
	boxthorn	*Lycium horridum*
	ling heather	*Calluna vulgaris*
	rata vine	*Metrosideros* spp.
	Westland quintinia	*Quintinia acutifolia*
	tawhero/towhai	*Weinmannia sylvicola*

Honey-producing hives may be migrated from winter apiaries to summer sites for the main honey flows, and will often be placed on two different summer locations to take advantage of varied honey flows. Spring work involves feeding with sugar or honey, requeening (using mated queens or cells), disease prevention, swarm prevention, and repairs and maintenance to hives and other equipment.

The timing of the main honey flow depends on the area, but is often between mid-November (late spring) and the end of February (late summer). Areas not affected by drought may have a small autumn honey flow which is useful for ensuring that hives go into winter with adequate food stores.

Commercial beekeepers mostly use bee blowers when harvesting honey: either petrol-driven models or electric, hand-held blowers powered by portable motor-generators which produce mains voltage (220 V). Blowers are used because they require only one trip to the apiary and can be used in all weathers. Fume boards are also employed, with benzaldehyde or sometimes propionic anhydride, though their use is weather-dependent. Hobbyists also use bee-escape boards and bee brushes.

Most commercial beekeepers engaged in honey production operate their own extracting facilities ('honey houses') (Fig. 4), though an increasing number have extraction done by another beekeeper or honey processor under contract. There are a few co-operatively owned extraction plants.

Since 1979 honey houses have been required to conform to the same standards of construction and operation as other food-processing premises, and were subject to hygiene inspection for many years before that. Almost all equipment used is made of stainless steel or other non-tainting substances such as food-grade plastics.

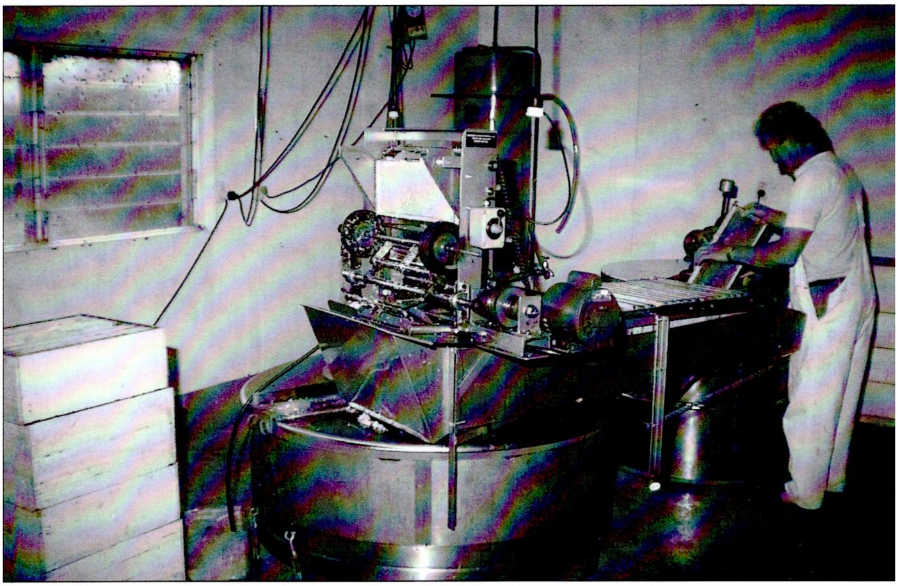

FIG. 4. A typical honey house for a sole proprietor, with uncapping machine, cappings spinner (beneath) and extractor. Heat is provided by circulation of water rather than steam.

Both imported and locally-made honey processing plant is used. The capacity of honey houses ranges from 1 to 10 + per day, and influences the choice of equipment. A typical plant would contain a warm room, uncapping machine, two extractors, cappings-processing equipment, baffle tanks, honey heaters, strainers, pumps and tanks.

In recent years many plants have changed to using cappings spinners, to remove as much honey as possible from wet cappings while minimizing the use of heat. Many spinners have been made by beekeepers[14]. Honey-wax spin-float separators ('centrifuges'), both locally made and imported, are also in use.

Several thixotropic honeys are harvested in New Zealand, notably from the native plants manuka (*Leptospermum scoparium*) and kanuka (*L. ericoides*), and the introduced ling heather (*Calluna vulgaris*). Both hand-operated and mechanical honey prickers are used.

Honey storage at plants is generally in stainless steel tanks (often ones designed for the dairy industry), and bulk honey is usually stored and shipped in 200-litre, food-grade drums.

Export certification of honey is changing from a product inspection basis to a quality assurance system. Exporters are given guidelines and are required to document their production, management and quality control systems. If their plans are approved, both their system and products are subjected to periodic audit by government officials.

Several other aspects of honey production are worth mentioning. Honeydew honey is produced in mountain areas in the northern half of the South Island[23]. The scale insect *Ultracoelostoma assimile* lives on several species of southern beech trees (*Nothofagus* spp.), and produces copious quantities of honeydew which form an important food source for bees in the area.

Prior to the mid-1970s honeydew was regarded by some parts of the honey trade as poor quality, fit only for bee food. Beekeepers couldn't sell it for human consumption and had to be careful of contamination from wet combs. However, in the late 1970s and early 1980s increasing pressure from beekeepers and others opened up both local and export markets[3].

Beech honeydew is produced mainly in Canterbury, and also in Nelson, Marlborough and parts of Westland. Large amounts of the sweet exudate are produced in areas of pure beech forest, and apiaries containing hundreds of hives are possible (Fig.5). The main problems in managing hives in these areas are access, finding room to place hives, predation by wasps, pollen deficiencies and the management problems (especially robbing) caused by such large apiaries.

Comb honey is another important product of New Zealand. Most is sold as cut-comb honey in plastic boxes, with portions of comb weighing a minimum of either 340 g or 250 g. Round sections (200 g) are increasingly popular, and a little honey is still produced in wooden sections. Most comb honey is exported.

Extracted honey in retail packs sold in New Zealand has been mainly as crystallized (granulated) or 'creamed' honey. Although the proportion of liquid honey has increased in recent years, creamed honey still occupies the majority of the market. The technique of producing fine-grained, creamed honey is often referred to as the 'Dyce method', after a Canadian scientist who patented this 'new' method in 1933. The royalties paid for use of this method were assigned to the Ontario government (for Ontario Agricultural College) and Cornell University for licensees in the USA.

However, the UK patent for the Dyce process was revoked in 1935 after an application

FIG. 5. A honeydew honey apiary: hundreds of hives spread along clear land in beech forest.

by the New Zealand Honey Control Board, a statutory marketing body. The application was supported by evidence that the method had been used in New Zealand for many years, and had been written up in New Zealand publications as long ago as 1882. Other applications for patents of the Dyce process were denied because of the New Zealand claim of prior use.

The whole episode is part of New Zealand beekeeping folklore because, as one author put it: "Dr Dyce had visited New Zealand to see first hand the making of an export product with the reputation of the 'the best honey in the world'. That his bulletin contained no references to these techniques may have ruffled more than a few kiwi feathers."[12]

A more recent advance in the New Zealand honey industry has been research into honey's antibacterial properties[21]. Honey has long been known as an antibiotic, though there has been little knowledge of specific chemicals with antibacterial activity.

Research at the University of Waikato has identified a number of compounds which give honey antibiotic activity additional to that caused by hydrogen peroxide and the osmolarity and acidity of the honey. The native plants manuka and kanuka are particularly high in antibacterial activity[22]. This research is continuing, and the identification of honeys with significant antibiotic properties is already being used by some honey packers in their marketing strategies.

Markets are expanding for organically-produced honey. Some producers and packers are negotiating with the Biological Producers' Council and Ministry of Agriculture and Fisheries (MAF) to gain registration as organic producers. Their production systems are subject to audit.

Threats to honey production

Reduction of nectar and pollen sources may affect beekeeping in some areas. To reduce herbicide use by landowners, biological control agents have been introduced to control nectar sources such as thistle (*Carduus* spp., *Silybum* spp., *Cirsium* spp.) and important pollen sources such as gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*).

More significant in reducing nectar sources is browsing damage to native trees by introduced mammals[27]. New Zealand has no indigenous land mammals except for two species of bats, and introduced herbivores (especially the brush-tailed possum *Trichosurus vulpecula*) are seriously damaging some important nectar sources.

Control of possums affects beekeeping also. Poisonous bait laid for possums (a mixture of sodium fluoroacetate (also known as 1080) and apple) can attract and will kill bees, and beekeepers must be notified so that hives can be moved before poisoning programmes begin. Research on adding molasses or oxalic acid to poison baits as a repellent to honey bees[7] means that this extra expense to beekeepers will shortly be unnecessary.

Toxic honeydew is produced when the vine hopper, *Scolypopa australis*, feeds on the plant tutu (*Coriaria arborea*), and honey bees may collect this when there are no nectar flows[25]. Significant amounts of tutu honeydew honey can be stored at certain times of the year by bees in the eastern Bay of Plenty and the Coromandel Peninsula, so beekeeping and the harvesting of honey in these areas are carefully restricted by law.

Wasps (*Vespula germanica* and *V. vulgaris*) compete with honey bees for beech honeydew, and may outnumber bees so dramatically that they can almost prevent access to the tree trunks where the food is available[31].

Honey marketing

Many different marketing strategies are open to beekeepers. There is no state agency for honey marketing, and beekeepers can pack their own honey, sell in bulk to a honey packer, export directly, or use a mixture of those channels. Over recent years more honey has been sold as distinct floral types, and less as honey blended according to broad colour and flavour grades.

Waxed cardboard pots have disappeared, and honey is retailed in plastic, glass or very clear plastic (PET) jars (usually 500 g) with attractive labelling. Honey packers (including many producer-packers) sell to wholesale or directly into supermarkets, which usually use bar-coding to automatically generate orders. The trend in recent years has been for packers to become bigger and more specialized, as local and export markets become more sophisticated.

Domestic honey consumption averages over 2 kg per person annually, which is one of the highest in the world. This historically strong demand for honey is an important support for the beekeeping industry, and there is little generic promotion of the product.

Pollination

Increased demand for pollination services has probably changed the beekeeping industry more than anything else in the past 10–15 years. Now a whole section of the industry is involved in providing commercial pollination services to some extent, with a number of beekeepers producing little or no honey.

FIG. 6. Hives placed in a kiwifruit orchard at up to 10 per hectare.

There has long been a demand for honey bee colonies to pollinate crops; with hives being introduced for a fee to fruit crops including apples, pears and berryfruit, as well as seed crops such as clovers and brassicas.

The scale of the pollination industry in New Zealand changed dramatically in the 1970s with a rapid increase in demand from growers of kiwifruit (*Actinidia deliciosa*) (Fig. 6). Although commercial planting of the crop began in the 1930s it wasn't until 1971, when the area in the crop started to increase significantly, that introducing honey bees at flowering time was recommended.

Research in the early 1970s[26] stressed the importance of honey bee pollination and recommended stocking mature orchards with eight hives per hectare. The number of hives used for kiwifruit pollination rose from 1600 in 1975 to around 80 000 today[18].

The centre of the kiwifruit industry is the Bay of Plenty, and it is there that the most dramatic changes have occurred to beekeepers. Many commercial beekeepers have started businesses in response to the demand for pollination services. In conjunction with MAF apicultural consultants, the industry has developed to include associations of pollination beekeepers; quality standards for colonies[16,17]; management audits of beekeepers by independent assessors; random quality checks of hives in orchards; training and education for pollination beekeepers. Scientists have determined the significance of honey bee pollination[2], the foraging behaviour on kiwifruit flowers of honey bees[11], and the effect of feeding sugar syrup (Fig.7) on increasing the collection of kiwifruit pollen[8].

Pesticide use is a particular concern of pollination beekeepers. Following significant losses of bees from hives used for pollinating seed crops, a law was introduced in 1965 to prohibit the application of insecticides toxic to bees to flowering cruciferous and leguminous crops. This was broadened in 1969 to include all fruit trees.

Further legislative change in 1983 changed the whole approach to pesticide use. Every pesticide registered for use in New Zealand now carries label warnings which form part of the law relating to that product's use. Many of these contain the warning 'Toxic to bees', followed by specific directions about when and how to use the products. Most such restrictions prohibit the deliberate or accidental application of insecticides to flowers that are attractive to bees, thus controlling spray drift to non-target flowers as well as use on crops.

Legislation on pesticide use is of limited value on its own — it must be supported by education of both growers and beekeepers as well as effective publicity. Beekeeper associations in areas where pollination is a significant business put considerable effort into liaison with grower organizations. Voluntary schemes to notify bee movement and chemical use operate in some districts. MAF consultants also work to advise growers of their responsibilities, and danger to bees is an important consideration when spray schedules are planned.

Other beekeeping products and services

Diversification away from production of bulk, extracted honey has been widespread in the last 10–20 years. Trends in the honey industry include niche marketing of unique floral types, development of fruit and honey spreads, increased volumes of comb honey for export, production of high-moisture honey for specific overseas markets, honey drinks, production of significant quantities of dried honey and certification of organic honey.

Queen bees are exported to many countries, including Canada, UK, the middle east and Asia, where entry is permitted because of New Zealand's high bee health status and excellent border protection system. New Zealand plastic queen cages are also used in a number of other countries. Package bees are exported, especially to Canada, and new packaging systems have been developed successfully[1].

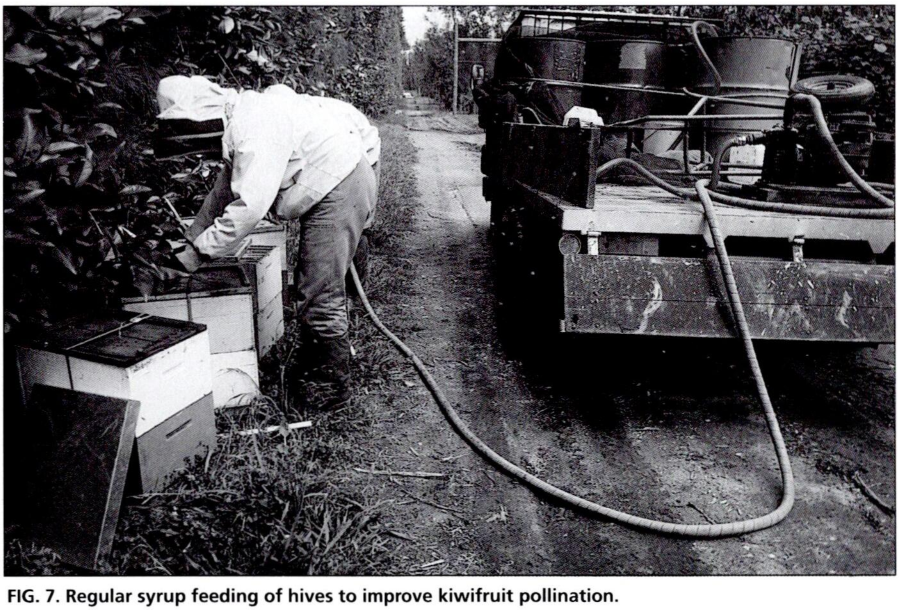

FIG. 7. Regular syrup feeding of hives to improve kiwifruit pollination.

Pollen is collected and processed for health food products, but a new development is seeing increasing amounts of bee-collected pollen being harvested for later mechanical application to kiwifruit flowers[28]. Beeswax is used in a number of industries apart from beekeeping, as well as being exported. Propolis and royal jelly are harvested by increasing numbers of beekeepers for use in health foods and medicines.

The servicing sector in beekeeping is changing too. Pollination brokers act as agents for beekeepers who produce pollination hives but don't deal with individual clients. The beekeepers usually deliver hives to depots. Brokers negotiate contracts with growers for providing pollination services, and are responsible for introducing and removing the hives and other parts of the service. Exports of queens and package bees may also be co-ordinated by a broker or agent. Hive woodware and honey-processing equipment (such as uncapping machines, cappings centrifuges and cappings ovens) are exported to Australia and elsewhere.

Conclusion

This first part of the article has reviewed the bees, hives and beekeeping of New Zealand. The article will conclude in the next issue with a discussion of servicing organizations, legislation and pests and diseases.

BEEKEEPING: LEADING AGRICULTURAL CHANGE IN NEW ZEALAND, part 2

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Introduction

The first part of this article was published in the previous issue of *Bee World*, and reviewed beekeeping in New Zealand — the bees and hives used, the composition of the industry and management methods used by commercial apiarists.

The article concludes by looking at the infrastructure supporting the beekeeping industry — extension, training, research, regulations and industry organizations. This section also reviews the status of honey bee pests, predators and diseases in New Zealand.

Industry servicing

One of the reasons for the success of the beekeeping industry in New Zealand is its level of infrastructure. Beekeepers are well supported by active industry organizations, close relationships with government beekeeping specialists, and a good level of education and training.

Recent changes to government funding policy have threatened some of this network, with the industry now required to either pay for some services or lose them.

Extension and regulatory

The government Ministry of Agriculture and Fisheries (MAF) has been involved in beekeeping extension work since the appointment of Isaac Hopkins as a government apiarist in 1905. Since then a network of personnel with inspection and extension duties has built up, staffed since the 1970s by graduate apicultural advisers (or consultants). In the late 1980s cuts in government spending reduced the number of consultants and put their work on the basis of paid contracts.

There are currently five full-time MAF consultants working in New Zealand, who are responsible for providing all government beekeeping services in their areas. They audit beekeepers' performance of their own disease control responsibilities (particularly for American foul brood), and supervise a team of MAF staff and beekeepers who inspect hives for disease (Fig. 8). MAF has a programme of surveillance for exotic pests and diseases, and ready-response plans to be implemented if such pests are found — these are all managed by MAF apicultural staff.

The basis for programmes to control endemic bee diseases and prevent the establishment of exotic ones is MAF's compulsory register of apiaries and records of disease incidence, which are also used as a basis for issuing export certificates for bees and bee products.

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FIG. 8. The loneliness of a long distance apiary inspector.

The apiary register has been kept on computers since 1979, and the current program has been recognized in an international software competition.

MAF advisers had an important advisory role with beekeepers, especially during the rapid expansion of the industry in the 1970s and 1980s. Now this work must be on a commercial basis, so advisers are becoming consultants and developing business in the horticultural industry as well as among beekeepers.

Even the disease control activities (such as endemic disease control, apiary registration, surveillance and maintaining preparedness for exotic diseases) are all done on contracts, with negotiated performance standards and increased accountability. The government is the client for many of these activities, but the beekeeping industry will soon become the customer for endemic disease control as they fund this work through a new levy on all beekeepers.

MAF apicultural staff have been involved in overseas development consultancies[59], and have achieved a good reputation for providing sound, practicable recommendations. New Zealand projects have taken place mostly in the Pacific region, but also in Asia and the Caribbean.

Research

Research related to apiculture is conducted by MAF, the government's Department of Scientific and Industrial Research (DSIR), and a number of universities, though these bodies are currently being amalgamated into crown research institutes.

The main apicultural research programme is based at MAF's Ruakura Agriculture Centre in Hamilton, and is funded jointly by the government and the beekeeping and kiwifruit industries. Current research projects include aspects of kiwifruit pollination[49], the costs and benefits of feeding fumagillin to honey bee colonies[48], wasp control and the epidemiology of American foul brood.

The DSIR employed a honey bee pathologist between 1984 and 1990, partly funded by the beekeeping industry. The work done means that knowledge of the diseases and pests present in New Zealand is as good as that for any country. The DSIR has also worked on managing bumble bees[52] and solitary bees[42,45] for pollination, the impact of wasp predation on beekeeping[39], and the biological control of wasps[44].

University-based research of use to the beekeeping industry has included the initial work on feeding sugar syrup to kiwifruit pollination colonies[47], antibiotic properties of honey[60], legume pollination in high country, bee neurophysiology[58], and chemical methods of identifying floral sources of honey[68].

Training and education

Courses for hobbyist beekeepers are run regularly by a number of polytechnics, often with MAF consultants as tutors[38]. These courses cover material from introductory to advanced levels, and specific courses are also held on particular subjects such as queen rearing and disease diagnosis.

MAF runs courses at agricultural training institutes for commercial beekeepers, including ones on expanding into commercial beekeeping, queen rearing and financial management.

A correspondence course for beekeepers both in New Zealand and overseas was set up at the Bay of Plenty Polytechnic[71], and is now operated by Telford Rural Polytechnic. Telford has its own 800-hive beekeeping operation, and also offers one-year residential courses for prospective commercial beekeepers and specific courses for trainees from other countries[53].

Industry organizations

National Beekeepers' Association The principal organization for beekeepers is the National Beekeepers' Association of New Zealand, better known as the NBA. It has been in existence for over 100 years, and acts to represent beekeepers and provide a forum for beekeeper discussion and contact. The role and effectiveness of the NBA changed significantly in 1984, when the association adopted a formalized planning system.

Of the approximately 6200 beekeepers in New Zealand, about 5600 are categorized as 'hobbyist' (with fewer than 50 hives) and 600 as semi-commercial or commercial with 50 hives or more. The latter group own 90% of the beehives in the country.

The NBA has 1200 beekeeper members, made up of the 600 commercial beekeepers who pay a statutory levy to support its activities, and another 600 members paying a subscription to be able to take part in the association's activities. All members receive a quarterly magazine and a monthly newsletter.

The administrative structure of the NBA consists of 15 branches, a voluntary national executive of six elected members, and a part-time secretarial service. Members can be involved in decision making at different levels: at their local branches; in the annual election of executive members; through branch representation to the national executive and through submissions to the annual conference, where recommendations are made directly to the national executive on important issues.

Branch activities include regular meetings with guest speakers, field days (Fig. 9), liaison with other organizations such as farmer and horticulture groups, publicity on local beekeeping issues and social events. Branches also assist with disease inspection days organized by MAF, go on study visits to other areas, and arrange co-operative ventures such as bulk sugar purchase. Enthusiastic and well-run branches are a great encouragement to beekeepers in their areas, especially newcomers to the industry.

In 1984 the NBA underwent a significant change, by adopting a strategic planning system based on Management by Objectives (MbO)[51]. This system had been used successfully by commercial businesses, but its adoption by a voluntary organization presented some challenges.

The system was implemented at a workshop involving NBA executive members and other industry leaders, led by MAF consultants. The result was that the NBA formulated an achievable organizational purpose, for which long-term goals were set. From an analysis of the industry's current situation a series of more short-term objectives were established. From these a set of immediate actions was drawn up, for completion by the executive, the secretariat, branches and members. Objectives and action plans are formulated annually.

FIG. 9. Swapping ideas at a National Beekeepers' Association branch field day.

Over the past seven years the planning system has enabled the NBA to become a proactive body rather than reactive: anticipating problems and formulating responses, seeing potential opportunities and moving to exploit them. A close relationship with MAF, and the involvement of MAF consultants at every annual planning workshop, have helped to align the activities of the industry organization and the government agency responsible for beekeeping.

As a result of this work, the beekeeping industry in many areas stands out from other agricultural and horticultural groups as being quite progressive, especially given its small size.

Activities carried out under the industry plan have included: initiating a programme of meetings with politicians and senior government executives; preparing an industry profile[57] for distribution to politicians, rural reporters and other primary industry groups; designing and printing a membership brochure which has been distributed to all beekeepers, and which has generated a significant increase in membership; printing information material for distribution by MAF border protection staff. The publications have been updated and reprinted. The industry plan has also guided the NBA through considerable negotiations with the government over funding of goverment bee disease inspection and research, and changes to legislation. Ensuring adequate education and training for beekeepers has been an important part of the plan. A part-time executive officer has been employed on contract to implement some areas of it.

The main benefits of the industry planning system have been to ensure continuity of activity despite changes in personnel, accountability to make certain that the plans are carried out, and efficiency of operation.

Other beekeeper organizations A specialist group exists within the beekeeping industry for producers of queen bees: the New Zealand Queen Bee Producers' Association. It exists mainly to enable concerted action on matters such as export access and the education of members. A regular newsletter is produced for members by a contract editor.

Honey exporters and packers have a good information network within New Zealand, as well as links to the International Honey Exporters Organization (IHEO).

Pollination associations exist in the principal horticultural areas, so that beekeepers involved in that industry can address relevant matters. There are loose groups in New Zealand for producers of comb honey and honeydew honey. Hobbyist beekeeping clubs exist in many areas, meeting regularly to learn and share ideas, and often owning apiaries and honey extracting equipment. Many hobbyist groups have good links with their local NBA branch.

Information sources

Beekeepers have good access to information sources. Members of the NBA receive the *New Zealand Beekeeper*, an A4-sized quarterly journal which began publication in 1939 and which follows on from publications dating back to 1883. The magazine contains industry news, items from beekeepers, and scientific and technical articles from scientists and MAF consultants.

Because modern business demands more rapid information flow than can be provided within the deadlines imposed by a quarterly publication, in 1987 the NBA began a monthly newsletter for members called *Buzzwords*. This is compiled under contract by a MAF consultant, and the use of desk-top publishing means that information can be included up to within a few hours of going to press.

The NBA also provides a comprehensive library for members, operated by a volunteer and circulating books by mail. A bibliography published by MAF in 1988[65] lists all research or significant technical articles published about New Zealand beekeeping and related topics. There is a standard beekeeping manual written for New Zealand conditions[56].

Good contacts are maintained overseas through study and marketing trips by MAF consultants and beekeepers, the organization of study and lecture tours by overseas specialists, and active links with organizations such as the International Bee Research Association, IHEO and Apimondia.

Legislation

Since the early years of this century the beekeeping industry in New Zealand has enjoyed good legislative support for disease control and prevention measures, especially the banning of fixed-comb hives, compulsory registration of apiaries and the mandatory eradication of American foul brood. Beekeepers have also had statutory responsibility for carrying out their own hive inspection and disease control since that time. Current legislation gives the beekeeping industry a high degree of protection from serious exotic pests and diseases.

The first proposals for beekeeping legislation in New Zealand came in 1888, when a subcommittee of the New Zealand Beekeepers' Association (including the pioneer beekeeper Isaac Hopkins) wrote a draft bill. This was introduced into parliament but was not enacted[50].

Nothing further happened until Isaac Hopkins, by then Government Apiarist, was asked to draft an Apiaries Act in 1906. This was passed, and the powers in it were strengthened in subsequent revisions. The first Apiaries Act forbade the use of fixed-comb hives, gave powers to government inspectors, prevented the removal of bees or equipment from infected apiaries and enforced the treatment of diseased colonies.

Major revisions of the Apiaries Act took place in 1927 and 1969. The current legislation exists to protect and encourage the beekeeping industry, and to encourage honey production and pollination services. The Act requires that:

* All apiaries must be registered with MAF.
* Apiaries not at a beekeeper's residence must be identified with a code number.
* Only movable-frame hives are to be kept.
* Apiaries are to be kept in reasonable order. Abandoned or neglected apiaries may be destroyed by government inspectors.
* American foul brood is a notifiable disease, and infected colonies must be destroyed. Some hive equipment may be sterilized by approved paraffin dipping, but other infected material must be burnt.

- ✻ There are very strict controls on importing bees, bee products and used beekeeping appliances[64].
- ✻ Legislative control also exists for pests and diseases not present in New Zealand, so that immediate steps can be taken if they are discovered.

Beekeepers are affected by other legislation too. Any beekeeper with more than 50 hives is required to pay a levy, which is used to fund the operations of the NBA. Buildings used to process or pack honey for sale need to conform to health standards and be registered with local authorities. Food standard laws ensure that no adulterated or artificial honey may be sold. There are strict controls on the use of pesticides which may be harmful to bees. Regulations set criteria under which honey exports can be certified by MAF.

Pests, diseases and other causes of bee mortality

The beekeeping industry in New Zealand enjoys relative freedom from serious pests and diseases. The status of bee diseases and pests in New Zealand is shown in tables 3, 4 and 5.

American foul brood is the country's most serious disease, with an average annual incidence over the past five years of 1.1% of hives. Nosema is regarded by many as the next most serious bee disease, though the lack of field symptoms means it is often ignored by beekeepers. Other diseases present include chalk brood, sac brood and chronic bee paralysis.

Serious diseases and parasites not present in New Zealand include the mites *Varroa jacobsoni, Tropilaelaps clareae* and *Acarapis woodi*; European foul brood and the bee louse *Braula coeca.* This demonstrable lack of serious parasites as well as the absence of the Africanized honey bee enables New Zealand to export bees worldwide.

New Zealand has compulsory reporting of serious bee diseases, annual declarations

TABLE 3. Honey bee pathogens and parasites present in New Zealand.

Type of organism	Common name	Scientific name	Ref.
Virus	Acute bee paralysis virus		36
Virus	Bee virus X		36
Virus	Bee virus Y		36
Virus	Black queen cell virus		36
Virus	Chronic bee paralysis virus		36
Virus	Cloudy wing virus		36
Virus	Filamentous virus		36
Virus	Kashmir bee virus		33
Virus	Sac brood virus		33
Bacterium	American foul brood	*Bacillus larvae*	36
Protozoan	Amoeba disease	*Malpighamoeba mellificae*	34
Protozoan	Nosema	*Nosema apis*	61
Fungus	Chalk brood	*Ascosphaera apis*	63

TABLE 4. Honey bee diseases, parasites and undesirable genotypes not present in New Zealand.

Type of organism	Common name	Scientific name	Ref.
Bacterium	European foul brood	*Melissococcus pluton*	36
Parasitic fly	Bee louse	*Braula coeca*	63
Internal mite parasite	Honey bee tracheal mite	*Acarapis woodi*	36
External mite parasite	Asian honey bee mite	*Tropilaelaps clareae*	36
External mite parasite	Varroa	*Varroa jacobsoni*	36
Undesirable genotype	Africanized honey bee	*Apis mellifera scutellata*	63

TABLE 5. Significant pests of the beekeeping industry in New Zealand.

Type of organism	Common name	Scientific name	Ref.
Moth	Lesser wax moth	*Achroia grisella*	55
Moth	Greater wax moth	*Galleria mellonella*	55
Wasp	Common wasp	*Vespula vulgaris*	43
Wasp	German wasp	*Vespula germanica*	69

about hive health from beekeepers, a government inspection programme for both endemic and exotic diseases, and very strict border controls.

American foul brood

The most serious brood disease endemic to New Zealand is American foul brood (AFB). It is found present in approximately 1.1% of hives annually, an incidence which has been increasing gradually over the past 10 years.

For over 70 years MAF has kept a register of all beekeepers and apiaries. Every year beekeepers receive a list of their registered apiaries, and they are required by the Apiaries Act to update the list, declare that they have inspected all their hives for AFB, detail any disease found since their last report and record their subsequent actions.

The apiary register and disease declarations are used as a basis for MAF's own inspection programme — about 10% of apiaries are checked each year by MAF staff or beekeepers working under their direction.

This system puts responsibility for disease prevention and control on the beekeeper. MAF inspects targeted areas of likely high disease incidence, and also assists with disease education and diagnostic services.

MAF and industry policy on AFB is to prohibit drug feeding and require the destruction of infected colonies and hives (Fig. 10). The only exception to this is the sterilization of outer hive parts in good condition by immersion in hot paraffin wax at 160°C for 10 minutes[54]. Disease control law is enforced by government officers, and no compensation is paid for any loss.

Beekeepers are firmly opposed to drug feeding, believing that they can keep AFB

FIG. 10. Hives infected with American foul brood being destroyed by fire.

under control with present policies, and they regard themselves as being in the forefront of the current trends to produce chemical-free food products.

Other brood diseases

Chalk brood was reported as early as 1957, though it was regarded as being of no consequence[67]. For some reason the disease became prevalent in the north of the North Island in the early 1980s[70], and it is now found in most parts of New Zealand. This disease is of little significance to beekeepers, as its effects can be minimized by good apiary management and by selecting appropriate bee stock. Beekeepers not paying attention to correct management can experience problems in weak nucleus hives or small queen-mating nuclei.

Sac brood is also a disease of minor importance. Requeening is used to remove the effects whenever the disease becomes significant in a colony.

Nosema disease

As in many countries, the real economic impact of *Nosema apis* infection is almost certainly underestimated by beekeepers: as well as causing losses in honey production it also reduces the pollinating efficiency of colonies[37a]. Feeding fumagillin for prevention and control of nosema disease is permitted in New Zealand — the only drug allowed to be fed to bees — but isn't widely practised.

Surveys of *N. apis* incidence[40,61] have shown the organism to be present in most colonies, at least in spring, sometimes at quite high levels. A preliminary cost-benefit analysis of fumagillin feeding[48] suggests that it is worthwhile, increasing surplus honey production by up to 25%. If these results are typical then nosema disease costs the New Zealand beekeeping industry more than all other diseases and parasites.

Other adult diseases or parasites

Much is known of other infestations of honey bees in New Zealand because of the work of an active bee pathologist and regular hive sampling programmes[35]. Amoeba disease is present in New Zealand, though serious effects of amoeba infestation are not known. Most of the known bee viruses have been found in New Zealand: including acute bee paralysis virus, black queen cell virus, cloudy wing virus, bee virus X, bee virus Y, filamentous virus, chronic bee paralysis virus, sac brood virus and Kashmir bee virus. Many of these can be detected only by injecting dead bee extracts into healthy pupae, and little is known of any effects of such inapparent infections.

Several species of harmless external mites have been found: *Melittiphis alvearius, Acarapis externus, A. dorsalis, Neocypholaelaps zealandicus*. None is common.

Exotic bee diseases and genotypes

Despite extensive sampling[36] European foul brood, *Varroa jacobsoni*, the Asian honey bee mite (*Tropilaelaps clareae*), the tracheal mite (*Acarapis woodi*) and the Africanized honey bee have not been found in New Zealand. This sampling has

FIG. 11. MAF border protection officers screen incoming passengers and freight for pests and diseases (*photo*: MAF).

included checks of bees submitted to diagnostic laboratories for routine *Nosema* counts, a nationwide survey of bee diseases from 1985 to 1987, field inspections by government inspectors, and a new active surveillance programme specifically designed to check for exotic diseases.

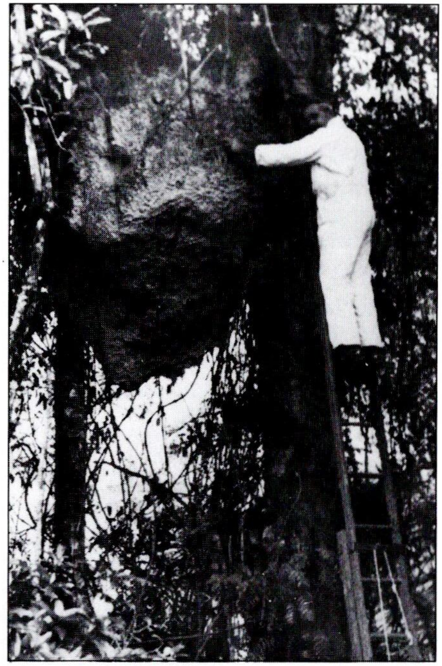

FIG. 12. A German wasp nest of gigantic proportions (*photo*: DSIR).

All travellers and freight entering New Zealand are screened by MAF border protection staff (Fig. 11), who are trained in recognizing material which might harm the beekeeping industry. The beekeeping industry and the Border Protection Service work closely together to maintain public awareness of the quarantine issues affecting the beekeeping industry.

All bees, bee products and used beekeeping appliances may only enter the country under a MAF permit. Honey is generally not allowed in, though bee products may be if their packaging or heat treatment during manufacture means there is little threat to the beekeeping industry. In case exotic pests and diseases do enter New Zealand, MAF has a surveillance programme to help early detection, and ready response plans to enable action to be taken quickly to contain and if possible eradicate the new organism[66].

Pests

Introduced wasps are the most serious pest of the beekeeping industry. The German wasp *Vespula germanica* has been present in New Zealand since the 1940s, and the common wasp *V. vulgaris* since the late 1970s.

Wasps remove honey from hives and prey on bees, and in some areas compete with bees for honeydew which is a valuable food source. Wasp numbers can get very high, with nest densities of up to 75 per ha in some areas. Because overwintering nests are possible in New Zealand's mild climate huge nests sometimes occur (Fig. 12): the largest recorded had a volume of about 4 m^3.

In a recent survey[39] 83% of beekeepers reported wasps to be a nuisance, destroying 2.6% of colonies and seriously affecting the honey production of a further 6.6% in one season.

Wax moths are a significant pest of stored combs[55]: the greater wax moth (*Galleria mellonella*) in warmer areas and the lesser (*Achoria grisella*) in cool places. Wax moth infestations of stored combs are usually prevented by the use of ventilated comb rooms in cool areas, or by freezing supers before storage in sealed rooms.

Other methods sometimes used are exposure to paradichlorobenzene crystals, and fumigation of combs with methyl bromide or ethylene oxide.

Other causes of bee mortality

The native tree karaka (*Corynaecarpus laevigatus*) produces nectar which is both highly attractive and very toxic to bees. Bee mortality can be significant in coastal areas of the North Island, where there are concentrations of the tree and little other forage available in spring when karaka flowers (October). Beekeepers may be forced to move bees out of such areas[62].

Another indigenous tree, kowhai (*Sophora* spp.), produces a nectar which may have a narcotic effect on bees[41]. Affected worker bees may become wet or chilled away from the hive and not return. This phenomenon does not affect colonies very often, and in fact kowhai is a valuable spring nectar source in many areas.

Other problems

Half moon disorder (HMD) was first described as a disease of honey bee brood in New Zealand, and has caused concern in some countries which import bees from that country. The disorder takes its name from the crescent shape of dead larvae, which die at the coiled stage, turn yellow and then dry into a light brown scale positioned part-way up or around the lip of cells. This characteristic, only one of several now recognized in colonies with the disorder, is similar to the appearance of larvae with European foul brood (EFB), but despite intensive investigation the causative agent of EFB (*Melissococcus pluton*) has not been found in bees affected by HMD. The other symptoms now recognized are those normally seen in colonies headed by aged 'failing' queens.

Latest evidence indicates that HMD is an abnormality of young queens caused by poor nutrition during their development[49a]. Queens in colonies with HMD begin to 'fail' soon after they first start laying eggs. They lose control of oviposition and lay eggs on cell walls and together in clumps. Larvae that subsequently develop in worker cells from these clumps may be drone, and may starve and die in the characteristic half-moon position[37].

The mite *Melittiphis alvearius* has been found in beehives in a number of countries including New Zealand, and its presence in live bee shipments from New Zealand to North America has caused some concern. Recent immunoassay studies[46] have shown that *M. alvearius* is not a parasite of honey bees, but is a scavenger of pollen within bee colonies.

Conclusion

Beekeeping in New Zealand has developed rapidly since the introduction of honey bees just over 150 years ago, and the beginnings of a commercial industry at the start of the twentieth century. The pace of change has quickened in the past 10–15 years, with major developments in pollination services, industry organization, the honey market and government services to beekeeping.

The main lessons from this change might be applicable to other beekeeping industries:

* Beekeepers should be prepared to change the type of product or service offered in response to market demands, or create a new market for their outputs.
* In many countries beekeepers have to be in charge of their own destinies: with no product subsidies or price stabilization, and having to fund their own research, disease control and consultancy services.
* Industries must be united to be strong, with effective beekeepers' organizations that are proactive through planning rather than reactive to changes.
* Good communication channels and information sources are important for individuals, businesses and industry groups.
* Hobbyist and commercial sectors are interdependent because of factors such as diseases and marketing, and must work together.
* Government departments and industry groups need to co-operate for beekeeping to prosper.

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