Andrew Matheson.

MINISTRY OF AGRICULTURE AND FISHERIES
TE MANATU AHUWHENUA AHUMOANA

MAF

FEEDING DRUGS TO HONEY BEES TO CONTROL DISEASES - some of the issues

MAF Quality Management
RUAKURA

November 1990

INDEX

INTRODUCTION

The executive of the National Beekeepers Association, and the industry Trustees, commissioned MAF Quality Management to research the literature and present a summary of research and beekeeping experience in the use of drugs to control American foulbrood disease.

As the industry is looking at establishing policies and funding mechanisms for disease control it was decided to widen the scope of the report. The implications, problems and cost benefits of using drugs or chemicals to control both endemic diseases or exotic diseases is examined.

This report is not a recommendation for any particular option, nor does it represent MAF policy. The New Zealand beekeeping industry, in association with MAF, needs to develop policies and action plans to control endemic bee diseases and respond to the arrival of an exotic bee disease.

Material in this report can help this process by identifying the issues that need to be addressed and supplying the relevant scientific or beekeeping experience on some of the available options.

G Murray Reid
National Manager Apiculture
for National Apiculture Business Unit

AMERICAN FOULBROOD (AFB)

This disease, which affects honey bee larvae, is caused by the spore-forming bacterium *Bacillus larvae* and is one of the few bee diseases capable of killing a colony. The spores are very resistant and have been known to survive for 35 years as scale, the term given to the dried remains of a larvae dead from AFB (Haseman 1961).

While the vegetative stage of AFB is not infective spores eaten by larvae can germinate within a day in the larval gut. After penetrating the stomach lining and entering the body cavity the bacteria multiply rapidly. This break in the gut wall allows other inapparent pathogens, such as Kashmir Bee Virus, to have a toxic effect as well (Anderson, 1985).

The susceptibility of larvae to AFB decreases with increasing age. Larvae less than 24 hours old need only 35 spores to cause an infection, while larvae 53 hours of age may require many millions of spores (Morse, 1978). However, one infected larva may contain 2500 million spores (Bailey, 1981). Most commercial beekeepers offer apparently conflicting evidence when talking about how susceptible hives are to AFB. Diseased hives can be robbed of all honey stores and no AFB ever shows up in adjacent apiaries. On the other hand a queen from an infected hive can cause a breakdown in a healthy hive when introduced into it. Hives with one cell of AFB have appeared to clean it out on occasions and remain apparently free of the disease. Conversely other hives that appeared to clean out the disease have broken down up to 2 years later.

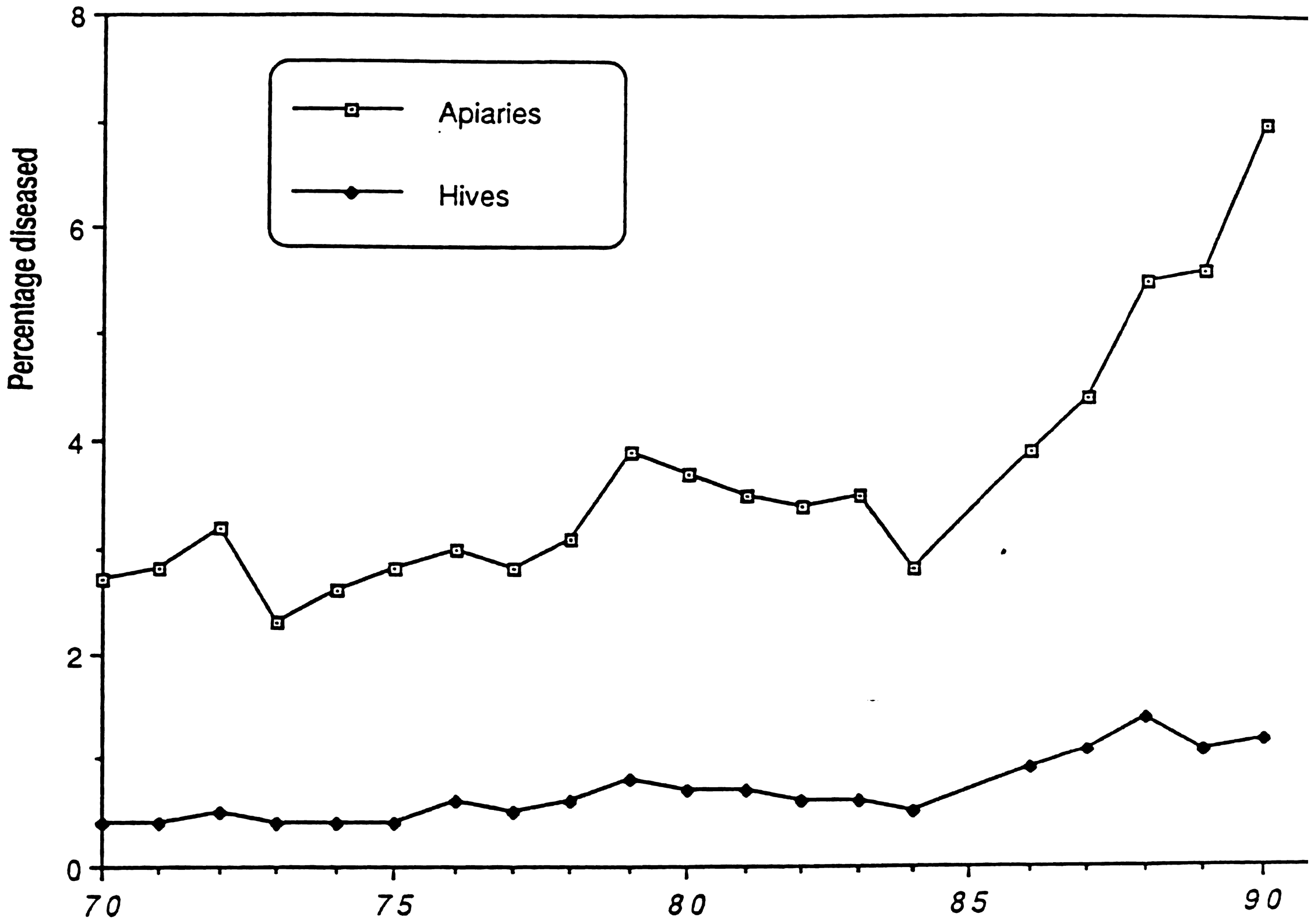
Experiments on infecting nucleus colonies have found that the minimum number of spores in sugar syrup required to innoculate colonies with AFB was 50 million (Leighton, 1982 a). However, the actual number of spores required may be much lower than this with other infection pathways.

DEVELOPMENT OF AMERICAN FOULBROOD IN NEW ZEALAND

Honey bees were first introduced into New Zealand on 13 March 1839 at Mangungu in the Hokianga. Isaac Hopkins reported finding AFB in Auckland in 1877 and it was subsequently found in many other parts of New Zealand. The disease threatened to destroy New Zealand's developing beekeeping industry An Apiaries Bill was presented to Parliament in 1888 in an attempt to control AFB but the Bill did not became law until 1906. Many of the provisions established in 1906 are still retained in the current Apiaries Act of 1969 (Hopkins 1916).

Levels of infected apiaries and hives continues to increase in line with expanding hive numbers but also as a percentage (Figure I). The 15 year average from 1964-1979 saw 2.9% of apiaries and 0.5% of hives infected with AFB. The last 5 years has seen over 5% of apiaries and 1.2% of hives infected (Appendix II).

Fig. 1 AFB disease levels in New Zealand (MAF)



Many reasons can be found to explain the rapid expansion in numbers of apiaries and hives infected with AFB in the past 5 years. These include:

* The rapid increase in hive and beekeeper numbers to meet the demand for kiwifruit pollination. Many part time beekeepers, orchardists and others operating with venture capital, were attracted into the pollination business without the necessary skills to maintain disease free hives. Many of these hives were, and are, at risk because of business failures, lack of beekeeping skills or loss of interest, and numerous disease outbreaks can be traced to hives owned, or formerly owned, by these people.

* Reduced MAF surveillance in Auckland and Christchurch districts in particular.

* Management of hives for pollination whereby brood, bees and food supplies are frequently interchanged, bees drift from hive to hive especially in depot apiaries, hive recording systems are not adequate to allow traceback, and large concentrations of hives are in small areas where any diseased hive is prone to being robbed out.

* Inadequate levels of comb inspection.

All these situations are likely to persist, and even increase, in the beekeeping industry in the future and any discussion on the use of antibiotics should recognise this.

DISEASE RESISTANT STRAINS OF BEES

A number of researchers report variability in infection rate of colonies inoculated with AFB and not fed drugs. Leighton (1982 a) believes this is due to variability of the genetics of disease resistance.

Rothenbuhler and his associates have demonstrated a range of hereditary factors that contributed towards resistance. These are;

* The efficiency of the hygienic behaviour of adults in removing diseased larvae, which was further separable into a factor for uncapping the cells and a factor for removing the larvae. (Rothenbuhler, 1964).

* The rate at which young larvae became innately resistant to infection with increasing age (Bambrick and Rothenbuhler, 1961).

* The efficiency of adults in filtering the spores of *B. larvae* from food by means of their proventriculus and/or the efficiency of a bactericidal factor in the gland secretions of nurse bees (Thompson and Rothenbuhler, 1957).

An important feature about the hygienic behaviour of the susceptible and resistant strains of bees selected by Rothenbuhler, was that the genes which determined both the prompt uncapping of cells and the efficient removal of the larvae in them were recessive. The propagation of these characteristics

unfortunately entails inbreeding, which, apart from its practical difficulties can have undesirable consequences (Bailey 1981).

Hornitzky (1990) concludes that the differences found between resistant bees and average strains of bees appear, at this stage not to be sufficient to sustain hopes of eventually being able to select immune strains; and the task of separating the desirable from the undesirable characteristics, combining them and maintaining them would be difficult in present circumstances.

Even if immune bees were to exist, it would be difficult to replace common strains with them before virulent mutants of the pathogens found their way back from the reservoir of susceptible bees. This is not to suggest that genetic resistance to disease should not be sought, but to be aware that it is not the path that will end all our disease problems. However, progress in the area of genetic engineering may provide answers quicker than we had hoped (Hornitzky 1990).

The current policy in New Zealand of destroying colonies infected with AFB makes it impossible to maintain and breed from any apparently resistant strain. Others have argued that burning AFB colonies is a form of genetic selection whereby all susceptible colonies are destroyed.

CONTROLLING AFB BY MANAGEMENT IN NEW ZEALAND

Currently in New Zealand, approximately 1.2% of hives are infected with AFB per year. Many commercial beekeepers through geographic location and good management have less than 0.5% of their hives infected per year. Some have no apparent AFB infection at all. Beekeepers can best control AFB by operating apiaries in reasonably isolated areas, by not buying hives, by limiting the interchange of hive equipment and the shifting of hives, by inspecting a high proportion of combs in all brood boxes each time a hive is manipulated and by being part of MAF organised disease surveillance program. These options are not available to many beekeepers and enhanced levels of AFB are the result.

The use of ethylene oxide, and gamma radiation are not likely to be available or approved for use in New Zealand because of carcinogenic residues or the perceived risk of environmental contamination with radiation. Destruction of bees, and frames, and sterilisation of other hive parts by dipping for 10 minutes in paraffin wax heated to 160°C is the only approved treatment system available at the moment.

CAN ANTIBIOTICS CURE AMERICAN FOULBROOD?

Oxytetracycline (OTC) is the only antibiotic approved for foulbrood control in many countries. It is widely used in North America and Tasmania for routine control of AFB and scientists in both those countries have reported on its effectiveness.

a) AUSTRALIA

Hornitzky (1990) made a study for the Honey Research Council of the disease situation in Tasmania. He reported that 3 of the 9 beekeepers interviewed had had AFB in their hives in 1989, with one beekeeper reporting losing 10% of his hives with AFB in 1989.

Hornitzky concluded that beekeepers with the most reoccurrence of AFB were feeding incorrect doses of OTC. In general AFB was found to be so widespread that many beekeepers were totally dependent on OTC and this despite an ideal environment in which to control AFB ie annual predictable cycle of bee population building, harvesting of honey and a winter period with little bee activity and no brood.

Oldroyd et al (1988) conducted experiments using EFB treatment protocols for AFB. This involved dusting dry antibiotic and icing sugar or sprinkling sugar syrup over the colonies. All signs of disease were eliminated after 30 days. However, 12 (60%) of the test hives developed AFB up to 14 months after treatment.

Hornitzky et al (1988) found that when OTC was fed as a 1 or 3 dose treatment (total active ingredient applied in either treatment was 1 g of OTC), protection could be expected to last for only 1 to 9 days

b) USA AND CANADA

Katznelson and Jamieson (1953, 1955) were some of the first researchers to study the effectiveness of OTC on AFB infected bees. They found that in hives artificially inoculated with AFB spores no disease showed up for at least 78 days after feeding OTC, whereas control hives had many infected cells. However, a slight reoccurrence did occur in one hive one year after being declared clear.

Wilson et al (1973) demonstrated that antibiotic extender patties and paper packs were useful in suppressing AFB disease but noted that neither method was completely effective. The apparent 'cure' rate was from 40.9 to 74.1%. Knox et al (1975) carried out experiments using various OTC treatments and/or ethylene oxide fumigation of contaminated equipment. They found that with only OTC treatment 100% of hives became reinfected within 3 months and that with a combination of ethylene oxide fumigation of equipment and OTC treatment no disease signs were evident in hives up to 13 months after treatment, but recurrence occurred in 4% of hives after 15 months and 8% after 18 months.

More recently Hoopingarner and Nelson (1988) carried out experiments using OTC in sugar syrup, OTC dust and OTC patty preparations to treat hives with AFB. They found that all hives became free of disease within 30 days. Unfortunately they were not able to monitor their hives for any significant period after the 30 days and were thus unable to determine whether the disease had only been masked as has been demonstrated by previous workers. This reduced the significance of this work.

Other researchers (Wilson et al, 1971) have reported varying degrees of success with OTC feeding but no work could be found reporting 100% freedom from AFB for periods longer than 10 months. A number of the researchers fed amounts of the drugs at times of the year and for periods that would not be acceptable to commercial beekeepers. For example one researcher, evaluating compounds for

effectiveness against AFB, fed the drugs in 500 mls of syrup every week through July and twice a week in August, a total of ten 500 ml feeds in the middle of the honey flow.

Definitive work on the effectiveness of OTC to cure AFB remains to be done. Such experiments would need to allow for:

* Genetic variability (Rothenbuhler, 1964).
* Longevity of AFB spores.
* Practicalities of feeding recommended dosages of drug at intervals economic for commercial beekeepers.
* AFB being present as an inapparent infection requiring analyses of adult bees (Hornitzky, 1988).
* Possible contamination of bee products, especially honey.

The conclusion is that feeding OTC to eradicate AFB is not 100% effective even under the best scientific experimental design.

INCREASE IN AMERICAN FOULBROOD WITH ANTIBIOTIC USE

A number of commentators report increased levels of AFB when antibiotics are used to control either AFB or EFB (Peer, pers. comm, 1972, Rendall; 1981, Hornitzky; 1990).

This is due to a number of factors:

* Antibiotics do not kill AFB spores which are present in honey and on hive equipment and can cause reinfection.
* Beekeepers may not be using antibiotics correctly with respect to dosage and timing.
* The possibility exists of antibiotic resistant strains of *Bacillus larvae* developing.
* The limited protection of oxytetracycline (OTC) when fed for EFB control. Most beekeepers feed only once for EFB (1 g active ingredient OTC) whereas to control AFB several feeds may be required.

* Incorrect diagnosis of AFB. Reports from Australia suggest some beekeepers believed their hives have EFB and they treat for this disease when the real problem is their hives have AFB or most probably both diseases.

ANTIBIOTIC RESISTANT STRAINS OF AFB

Leighton (1982) isolated a number of *B. larvae* strains from AFB infections occurring in OTC treated hives. In all cases these strains were susceptible to OTC when applied at higher dose rates ie 2 g per hive. One isolate grew very rapidly when cultured and did not harbour the bacteriophages usually found with other strains of *B. larvae*. This 'super' strain was sensitive to the viral bacteriophage found on

naturally occurring isolates. Application of these bacterio phages to AFB infected colonies may increase the effectiveness of drug treatments.

Glinski and Rzedzicki (1977) reported strains of *Bacillus larvae* that were resistant to OTC. Johansson and Johansson (1971) proposed mechanisms for resistance to develop and recommended that any colony showing symptoms of AFB, despite drug feeding, should be burnt. Many commercial beekeepers follow this practice (Peer, 1972 pers. comm).

AMERICAN FOULBROOD SPORES IN HONEY

Spores may end up in honey and other bee products for a number of reasons eg

* Beekeepers may deliberately or inadvertently harvest honey from AFB infected hives.
* Bees may rob honey from diseased hives.
* Honey drums could be contaminated if not washed before recycling.
* If OTC is being fed disease symptoms may be suppressed.
* Many colonies may harbour inapparent infections even when OTC is not being administered.

Gochnauer (1981) studied the distribution of AFB spores in heavily infected colonies of bees. The honey extracted from the combs had the highest spore count, followed by wax and trapped pollen. Some spores were recovered from hive bodies but none from soil in front of the hives.

Studies in Denmark showed that 81% of the foreign honeys (60 of 75 different honey samples) and 23% of Danish honeys (13 of 56 samples) found in local markets contained AFB spores. The foreign honey came from over 22 different countries (Hansen, 1984). Similar results have been found by Shimanuki in the USA (pers. comm).

Australian laboratories now routinely examine honey from packing plants for AFB (Hornitzky, 1990). In 1989, 393 samples were cultured from honey supplied by 258 beekeepers. Of these 40 (10.1%) were positive for AFB. Fifteen beekeepers (5.8%) had AFB infected hives when a traceback was done. Of these 15 beekeepers 5 were aware they had AFB but 10 claimed they were not aware their hives were infected.

In Tasmania 19 samples of honey were tested and 13 of them (68.4%) contained AFB spores. Hornitzky (1990). This suggests some degree of masking by OTC. Recent tests of 8 samples of retail New Zealand honey showed 3 of them to be infected with AFB. (Goodwin, pers comm). It is proposed to increase the surveillance of retail honeys in New Zealand to:

* Provide a tool in tracing outbreaks of AFB, or potential outbreaks.
* To monitor the possible illegal feeding of antibiotics.

At the moment the presence of AFB spores in honey is not being used as a trade barrier but the potential exists.

CONTAMINATION OF HONEY WITH OTC

Whether OTC residues can end up in extracted honey or not depends on:

* How the medication is applied eg by spray, by dusting, by syrup feeding or by extender patty.
* The concentration of drug used.
* The formulation ie whether soluble or insoluble.
* The time lapse between dosing and honey harvesting.
* The time and temperature that extracted honey is held at and the acidity of the honey.

Residues have recently been found in Australian honey exported to Japan (Hornitzky , 1990). The honey had been produced 8 months before shipment and stored under cover.

Gilliam et al (1979) recommended that 6-9 weeks should be allowed between the last feeding of OTC in syrup and extraction of honey. Dust preparations can be stable for years and do not degrade to any degree until they are dissolved in syrup, water or honey. If beekeepers inadvertently use insoluble formulations or sprinkle OTC powder mixed with icing sugar on top of queen excluders the drug may lodge on the excluder wires and not be incorporated into stores and degraded until the flow occurs.

Gilliam and Argauer (1981) fed OTC in patties, as a dust (applied in the brood nest) and in syrup sprays and monitored the degradation of the antibiotic. They found that OTC had degraded in brood nest honey and extractable honey by 4 weeks after ceasing medication. They didn't find any residues in brood nest or surplus honey from colonies treated with extender patties nor in larvae from colonies treated by any of the three methods.

Hornitzky (1990) argues that present analytical techniques (High Performance Liquid Chromatography) are much more sensitive than the methods used by Gilliam and Argauer and suggests that the 6-8 week withholding period should be a conservative estimate. He also recommends that OTC dosage rates be kept to a minimum.

Oka et al (1987) developed a technique for finding OTC in honey with a detection limit of 0.02 ppm. As the use of High Performance Liquid Chromatography becomes routine more OTC residues will be found in honey.

OTC RESIDUES AND EFFECT ON LOCAL AND EXPORT MARKETS

New Zealand honey was routinely tested for antibiotics in Japan until 1983 at considerable cost to the exporter. These costs were the fees for the test plus storage, and costs associated with recovering samples and retesting in New Zealand for the occasional sample declared to be contaminated by the Japanese. No honeys were proven to be contaminated following additional analysis in New Zealand.

Japanese authorities were eventually persuaded to allow residue testing to be done in New Zealand prior to shipment, and in 1983 negotiations were completed which waived the need for antibiotic testing as it

was illegal to feed OTC to honey bees under the Apiaries Act 1969. This is the current situation and although samples of New Zealand honey are occasionally checked by Japanese authorities no cases of OTC contamination have been proved.

The developing organic market places the onus on the producer not to use any drug or chemical, whether gazetted or not, in the production, harvesting and processing of his honey and the protection of honey combs during storage. Part of the organic certification process requires the honey to be analysed for OTC as well as other pesticides.

If New Zealand gazetted the use of OTC for control of AFB or EFB then residues would be a major concern to all honey exporters. The Japanese honey export certificate would have to be renegotiated and exporters would probably have to have every consignment tested for OTC at their expense.

The same would apply to producers of organic honey. Because AFB and EFB would eventually spread to every hive, and become a contaminant in retail honey, it is hard to imagine how beekeepers could maintain disease free hives and still meet their organic protocols and price expectations. The developing market for organic honey is regarded by some beekeepers as very important if New Zealand wishes to maintain access into Europe for our premium priced honeys.

It could be possible to set tolerance levels for antibiotics in honey but drug feeding would destroy the 'clean green' image that honey marketers are keen to promote. The Japanese market has a zero tolerance level for OTC in honey. It is likely the New Zealand Health Department would also set a zero residue level but in the event no level was established then an automatic limit of 0.1ppm would apply.

Concern has been expressed in the past about human pathogens developing resistance through continual exposure to low levels of antibiotics eaten in our food eg poultry and pigment and even pip fruit. No evidence has been presented to document these claims but the Pesticide Board deregistered OTC some years ago, in an attempt to limit the use of antibiotics. The antibiotic was used to control fireblight on pipfruit. The subject still remains an emotive one.

If issues of drug feeding, and especially honey contamination, were made public for whatever reason then local sales of honey would be depressed and export opportunities threatened. In New Zealand honey sales have been adversely affected in the past because of publicity about toxic honey and possible 245T contamination.

In Canada honey sales from the praraie provinces were stopped when residues of sulpha drugs were found. Sales of New Zealand honey have been threatened in Germany when levels of miticide were allegedly found.

In summary, the proper use of drugs as chemicals should not lead to residue problems but if contamination does occur the effect on current and forward sales of honey can be dramatic.

BENEFITS OF DRUG FEEDING

a) Reduced destruction costs

Most countries, states or provinces that allow feeding of antibiotics for AFB or EFB control usually recommend or require that any colonies showing signs of these diseases be destroyed, or at least infected frames be destroyed.

It is usually recommended that infected hives be quarantined, combs of pollen and honey be rotated so stores are used up, and any combs showing fresh breakdown be destroyed. If this regime is followed while chemotherapy is continued, then AFB can be controlled and even eradicated over several years (Murrell & MacDonald, 1986).

If New Zealand followed a similar protocol of destroying diseased frames only, then some savings would be made over the present practice of destroying the entire colony plus all frames and sterilising other hive parts. Whether the costs of destroying some frames, quarantining infected hives and feeding drugs was less than destroying diseased bees, brood and stores and sterilising equipment has not been investigated.

b) Reduced inspection costs

The real cost benefit of drug feeding is in reducing the time spent inspecting hives for AFB or EFB. This would apply particularly to hives managed for pollination where bees, brood and stores are frequently interchanged, and where hives are shifted and exposed to enhanced levels of drifting, floral contamination and other diseased hives.

However, this only applies if drugs are fed routinely to **all** hives as a preventative.

c) Reduced disease audit costs

If OTC is fed on a routine basis, to all hives by all beekeepers, then the level of apiary audit inspections could be reduced. Such audits are currently carried out by MAF and beekeepers holding an inspectors warrant issued by MAF. Current inspection levels are 8% of apiaries with 10% as a negotiated target. However, experience in Canada, the USA and Australia suggests that significant levels of AFB will occur despite extensive drug feeding and a government organised or sponsored inspection program is still worth while.

ACCESSIBILITY OF ANTIBIOTICS

In North America and Tasmania OTC is freely available for controlling AFB. In the UK and mainland Australia OTC is only available for EFB control and a prior diagnosis is required before the drug can be prescribed. Prescriptions are usually issued only by a veterinarian or state apiculturist once the laboratory diagnosis (or personal visit) has confirmed the presence of EFB. At the moment the costs of

the laboratory testing in the UK and Australia are paid for by the government, but a move to user pays is being discussed.

In New Zealand, antibiotics are generally only available from a veterinarian and the animals for which the prescription is written must be under the care of the veterinarian. The exceptions are some forms of penicillin and OTC premixed in animal feedstuffs eg poultry and pig meal.

If OTC was to be made available for treating AFB in New Zealand decisions would need to be made on whether it was to be fed routinely to every hive every year as a preventative, or only fed to those hives showing symptoms of AFB or EFB.

a) **Preventative Feeding:**

In this case it would probably be desirable to have OTC registered as a Schedule II drug and sold (without prescription) already mixed with a suitable carrier.

b) **On demand feeding**

If OTC was to be restricted for use in diseased hives only then a prescription from a vet or an apicultural officer may be required. Proof of the disease status of the hive(s) may be required (as in the UK and Australia) and this would involve an apiary visit or a laboratory test. The cost of this service would have to be met by the industry under current government policy.

COSTS OF OTC FEEDING

Current costs (September 1989) for Pfizer product are shown in Table I. No generic OTC is available in New Zealand.

Table I Terramycin cost per dose of 1 g per hive

	% active ingredient	$ cost per/g of active ingredient		
		Wholesale	50% markup	100% markup
TM50	5	0.82	1.23	1.64
TM10	1	0.68	1.02	1.36
TM100	10	0.28	0.42	0.56

In applying a cost benefit analysis to OTC feeding other costs need to be allowed for:

* Cost of lab analyses to determine whether EFB is present and/or AFB is absent.
* Cost of prescription from MAF or Vet.
* Cost of carrier eg castor sugar, icing sugar or sugar syrup, plus delivery cost to get the drug in the hive.

* More than one one dose/hive/year may be required especially for AFB. Pfizer recommend 3 feeds at 4-5 day intervals in spring or autumn. It is not advisable to feed more than 1 g of active ingredient per application because of toxic side effects of OTC to larvae.

  Similarly for EFB the 1 gm per hive dose may be administered over more than one application (eg Victoria recommends 0.3 g/hive administered weekly over 3 weeks although NSW recommends 1 g/hive given at one application).

* Hives still need to be examined for the presence of AFB or EFB although perhaps not as frequently or rigorously as under a no drug feeding regime.

LEGAL IMPLICATIONS OF OTC FEEDING

a) **Legislation: Apiaries Act**

The use of OTC is currently controlled by Section 25 of the Apiaries Act, whereby drugs can only be used if so gazetted by the Minister. The gazette notice would also stipulate under what conditions the drug was to be used.

Future control and monitoring of drugs used in beekeeping will be empowered in the Agricultural Compounds Bill, the Biological Security Bill and the Primary Products Bill. In any case, application to use OTC for feeding to bees must be made by the industry to the Minister of Agriculture.

b) **Registration: Animal Remedies Act**

Any application to use OTC in New Zealand for controlling bee diseases must be made by the proprietor to the Animal Remedies Board and/or Pesticide Board. (This board, along with the Pesticides Board, may be combined as the Hazards Control Commission).

Once the proprietor has established the product will do what is claimed on its label, and where the board/commission is satisfied there is sufficient information on its toxicity, residues and environmental effects, the board can grant a product registration.

The sort of information required by the board with an application for registration includes:

Names and quantities of the active ingredients in the product
Details of the formulation
Methods of analysis
Chemical and physical properties
Toxicity data
Efficacy data
Residue data
Effects on the environment
Safe methods for disposal of containers

A Product label should contain:

Name and address of the proprietor
Trade name for the product
Its registration number
The amount of active ingredient per litre or per kilogram of product
Use claims for the product
How to use the product
Precautions to be observed when using the product

Where the remedy is highly toxic or where it could have some adverse environmental effects, the board can require that it be used only by persons approved by the board eg veterinarians.

The board can also declare directions to be mandatory ie, that users must only apply the remedy as directed on the label.

There is provision for experimental use in the case of an emergency eg where the drug was required to attempt to eradicate an exotic disease such as EFB.

c) **Residues**

With increased levels of feeding of OTC residues are bound to occur. Issues dealing with residues and 'fitness' for sale will be addressed in the Primary Products Bill, but the implications of residues need to be well understood by the industry.

d) **Exotic Pest and Disease Response**

Under the new Biological Security Bill, MAF and the beekeeping industry, will be required to develop a management plan(s) to eradicate and/or control exotic diseases. These plans ensure systems are in place to survey for exotics and respond when they are found.

Control concepts are based on the declaration of an infected place (outbreak apiary) an infected area (say 3-5 km radius of infected place) and a disease control area (may be a county, province, north island etc). Protocols would be required for each exotic disease as to the appropriate eradication or control methods, compensation, movement control and so on.

FURTHER RESEARCH REQUIRED

No research work has been done in New Zealand on AFB for many years. Current work being undertaken in Australia may provide answers to some of the questions on AFB and EFB control.

One project is being undertaken by the Department of Agriculture and Rural Affairs, Victoria whose aim is to investigate the control of AFB by a variety of treatments. These include:

* Repeated treatments of OTC
* Removal of brood combs showing AFB and
* A combination of OTC treatment and removal of brood combs.

This project is due for completion in mid 1992. The second project which is being undertaken by NSW Agriculture and Fisheries involves the development of techniques for the prevention and control of AFB. The aims of this project are:

* To determine whether there are any detectable strain variations of *B larvae* and whether variants can cause differences in disease expression.

* To determine the current latent *B. larvae* status of hives in NSW commercial apiaries, and to determine the value of examining preprocessed honey samples from packing plants as a means of tracing infection sources.

* To determine how long latent *B. larvae* infections persist in commercial, and in artificially infected hives so as to predict the disease outcome of such infections.

Laboratory and culture techniques for determining the presence of AFB in honey have been improved over the years. However, improved techniques are needed for other bee products especially pollen where other organisms present in pollen can obscure the AFB colonies. Pollen that is being trapped for artificial pollination must be certified AFB free before being sprayed onto kiwifruit flowers. The development of an ELISA technique would be very useful for a quick diagnosis of honey and other bee products especially in the field .

The efficiency of other antibiotics, eg Tylosin, should be examined so there is an alternative should resistance develop to OTC.

NBA SURVEY OF EMERGENCY RESPONSE PROCEDURES

A questionnaire was sent to all branches and a group of selected beekeepers seeking their views on who should plan for and manage an outbreak of an exotic disease, what control strategies are appropriate and their opinions on the implications for some of these strategies. The questions asked are in Appendix I.

Only 13 responses out of 37 were received and in general the replies showed a great range of opinion, often conflicting and often inconsistent. For example many respondents were opposed to using drugs to control AFB and EFB but thought it was acceptable to feed chemicals for *Varroa*.

There were no original suggestions presented that MAF or the NBA executive were not already considering, but at least some NBA members are now thinking of the issues to be addressed. If any program to control or eradicate an exotic disease is to be successful, it must have the co-operation of the beekeepers. The beekeeping industry must have an active part in designing the strategies and agree on the implications and costs of any methods employed.

EUROPEAN FOULBROOD (EFB)

This exotic disease of honey bee larvae is caused by a non-spore forming bacterium *Melissococcus pluton*. Unlike AFB bacteria EFB bacteria multiply rapidly in the gut of young bee larvae where they compete for larval food and cause death by starvation. (Bailey, 1981). Any disruption to the gut lining caused by the bacteria will also allow viruses, such as Kashmir Bee Virus, to enter the blood stream (Anderson, 1985) and exert toxic effects.

Although EFB is not a spore former it can exist for several years on hive equipment and bee products (Bailey, 1981).

EUROPEAN FOULBROOD AND DRUG FEEDING

Much of what has been said about AFB and antibiotic feeding also applies to EFB. Although EFB is caused by a non-spore forming bacterium it is very resistant and can spread rapidly. The Australian (except Tasmania) recommendation for controlling EFB is to:

* Have the disease properly identified by an accredited laboratory.
* Apply for a permit, from a veterinarian or state apiculturist, to purchase OTC.
* Apply 1 g (active ingredient) of soluble OTC as a syrup spray or as a dust to the broodnest observing withholding periods.
* Feed every hive in the apiary whether EFB is obvious in each hive or not..

Hornitzky (1990) reports that EFB can exist in latent forms just like AFB and is not always cured by OTC treatment. The issue of natural resistance to EFB by bees in Australia has not been clearly demonstrated although Mraz (1978) claims to have developed a resistant line that eliminated EFB as a serious problem. in apiaries he managed in Mexico and in the USA.

If EFB became established in New Zealand its effects on hives would be dramatic enough that beekeepers, especially those involved in pollination, would demand the right to feed OTC. The implications of using OTC to try and eliminate the exotic EFB (before it became established) or the routine use of OTC to control either EFB or AFB or both, needs to be considered by the beekeeping industry.

CONCLUSIONS

There is no evidence that OTC can be relied on to cure AFB or EFB. However, the antibiotic can suppress symptoms of both diseases and so lead to their spread through the practice of exchanging bees, brood and honey between hives. In North America OTC is used on a routine preventative basis with

attendant problems of drug residues, AFB spores in honey, and possibly development of resistant strains of foulbrood bacteria.

The best cost benefits can be demonstrated to the beekeeper under a preventative feeding regime. where inspection costs are lower and destruction of infected colonies may be reduced. Also, government inspection audits may be less than in New Zealand, at least in some states. In Australia and the UK (and in New Zealand) the trend is to restrict the availability of antibiotics rather than to liberalise their use.

Any application to use OTC on a routine or preventative basis in New Zealand, whether hives showed foulbrood or not, is likely to be strongly opposed by government bodies, consumers and a significant number of beekeepers.

Thus, New Zealand beekeepers could find themselves in a similar situation to mainland Australia where OTC is available only on prescription from apicultural officers or veterinarians. Drugs can only be used for EFB control and before a prescription can be issued, a positive diagnosis has to be made for AFB or EFB. If a similar situation arose in New Zealand then the cost of the EFB diagnosis, and prescription issuing fee would most likely be born by the beekeepers.

Government has a role in monitoring hives for EFB, designing a response (in consultation with the industry) for EFB and funding these activities until such time as EFB is eradicated or declared endemic. The beekeeping industry has the responsibility of controlling AFB and deciding whether government has a place in this. If the industry wishes government to continue a hive auditing role then it will have to pay for these services. The effect of a reduced or non-government role in disease monitoring on its ability to issue zoosanitary export certificates also needs to be assessed.

In addition the beekeeping industry needs to address a number of other issues regarding responses to EFB and control options for EFB and AFB particularly the use of chemotherapy. Principles adopted for foulbrood should also apply to the use of chemicals for other diseases such as exotic mites. In summary these issues include:

* Ensuring that the Agricultural Compounds Bill, Biological Security Bill and Primary Products Bill have the controls over the use of drugs that the industry wants.

* Ensuring that gazette and registration procedures for relevant drugs or chemicals are in place in advance to allow the emergency or long term use of these compounds to control or eradicate EFB, tracheal mites, the external Asian mite and *Varroa*.

* Negotiating what controls over the use of OTC are acceptable to the industry.

* Rationalising the use of OTC by beekeepers while others attempt to operate drug free hives and produce organic honey.

* Developing a policy on, and setting possible tolerances for residues, in bees, bee products and equipment.

* Assisting MAF to prepare contingency plans to control or eradicate exotic diseases.

* Promoting, and possibly funding, research projects that would help with identifying AFB and EFB in bees and bee products, and strategies to control these diseases.

* Reassessing the possibility of establishing a compensation fund from levies, or an insurance scheme, to cover the costs of an outbreak of an exotic disease.

REFERENCES:

Anderson, D 1985: Viruses of New Zealand honey bees. New Zealand Beekeeper No. 188: 8-10

Mraz, C: 1978 European foulbrood disease in Australia. Australasian Beekeeper 79(11): 229-232: 213-214

Bailey, L 1981: Honey Bee Pathology. Academic Press 124 P

Bambrick, J F; Rothenbuhler, W C: 1961 Resistance to American foulbrood in honey bees IV. The relationship between larval age at inoculation and mortality in a resistant and susceptible line. Journal of Insect Pathology 3: 381-390

Gilliam, M; Taber, S; Argauer, R: 1979 Degradation of Terramycin in Honey. American Bee Journal 19: 720-723

Gilliam, M; Argauer, R 1981 Terramycin residues in surplus and brood nest honey after medication of honey bee colonies by three different methods. Gleanings in Bee Culture 109: 545-546.

Glinski, Z; Rzedzicki, J: 1977 Evaluation of the sensitivity of *Bacillus larvae* to antibiotics and sulfonamides isolated in Poland in 1962-1971 Polskie Archiwum Weterynaryjne 20(1): 9-16.

Gochnauer, T A: 1981 The distribution of *Bacillus larvae* spores in the environs of colonies infected with American foulbrood disease. American Bee Journal 121 (5): 332-335.

Hansen, H: 1984 The incidence of the foulbrood bacterium *Bacillus larvae* in honeys retailed in Denmark. Danish Journal of Plant and Soil Science 88: 329-336.

Haseman, L 1961: How long can spores of American foulbrood live? American Bee Journal 101: 298-299.

Hoopingarner, R; Nelson K: 1988 American foulbrood cleanup rate using three Terramycin treatments. American Bee Journal 128(2): 120-121.

Hopkins, I: 1916 Forty-two years of Beekeeping in New Zealand 1874-1916. Reprint NZ Farmer.

Hornitzky, M: 1988 The detection of *Bacillus larvae* (American foulbrood) in adult honey bees. Proc. Second Australian and International Bee Congress: 83-84.

Hornitzky, M: 1990 Honey bee diseases in Australia, 1990. Overview Australasian Beekeeper: 92(1): 20-28.

Hornitzky, MAZ; Karlovskis, S; Hallstrom, A L: 1988 Oxytetracycline activity in honey bee larvae following hive treatement with various oxytetracycline preparations.
Journal of Apicultural Research 4(27): 239-244.

Johansson, T S R; Johansson, M P: 1971. Antibiotic resistance. American Bee Journal 111(2): 56-57, 60.

Katznelson, H; Jamieson, C A: 1953. Recent developments in the control of American foulbrood and nosema with antibiotics. American Bee Journal 93(10): 404-405.

Katznelson, H; Jamieson, C A: 1955. Further studies on the chemotherapy of diseases of the honey bee. Gleanings in Bee Culture 83(5): 275-277.

Knox, D A; Shimanuki, H; Caron, D M: 1975 Ethylene oxide plus oxytetracycline for the control of American foulbrood in honey bees. Journal of Economic Entomology 69:606-608.

Leighton, T: 1982(a) Field Studies on the effectiveness of alternative antibiotics compared to oxytetracycline. Final Report California Department of Food and Agriculture Project # 1504.

Leighton, T: 1982 (b) Effectiveness and optimal selection of antibiotics for control of American foulbrood disease. Final Report California Department of Food and Agriculture. Project # 5828.

Morse, R A: 1978. Honey Bee Pests, Predators and Diseases. Cornell University Press 430 P.

Murrell, D C; MacDonald, D N: 1986. The Prairie Beekeeping Manual. Alberta Agriculture: 97 P.

Oka, H; Ikai, Y; Kawamura, N; Uno, K; Yamada, M; Harada, K-I Uchiyama, M; Asukabe, H; Mori, Y; Suzuki, M: 1987 Improvement of chemical analysis of antibiotics IX. A simple method for residual tetracyclines analysis in honey using a tandem cartridge clean-up system. Journal of Chromatography: 389, 417-426.

Oldroyd, B P; Goodman, R D; Hornitzky, M A Z; Chandler, D:1988. The effect on American foulbrood of standard oxytetracycline treatments for the control of European foulbrood of honey bees (*Apis mellibera*). Australian Journal of Agricultural Research 40: 691-697.

Rendall, G F: 1981. Antibiotic risk to bees. The Veterinary record. February 28: 194

Rothenbuhler, W C: 1964 Behavior genetics of pest cleaning in honey bees IV. Responses of F1 and backcross generations to disease-killed brood. American Zoologist 4:111-123.

Thompson, V C; Rothenbuhler, W C: 1957 Resistance to American foulbrood in honey bees. II Differential protection of adults of different genetic lines. Journal of Economic Entomology 50: 731-737.

Wilson, W T; Elliot, J R; Hitchcock, J D: 1971 Low recurrence of American foulbrood in honey bee colonies previously treated with drugs. American Bee Journal: 111(11): 430-431.

Wilson, W T; Elliot, J R; Hitchcock, J D: 1973 Treatment of American foulbrood with antibiotic extender patties and antibiotic paper packs. American Bee Journal 113:344, 341-344.

APPENDIX I NBA EMERGENCY RESPONSE QUESTIONNAIRE

1 A decision-making group of some sort will have to be in place to actually manage the situation when an exotic disease is found. Which group(s) should be represented on such a committee AS OF RIGHT and because of particular responsibilities or expertise in the area?

2 Can you name any other group(s) who might provide valuable input to such a committee as a member, while perhaps not having direct representation or voting rights?

3 Would you rank the following pests/diseases/undesirable genetic material introductions by their seriousness for New Zealand beekeeping in the short term (1-3 years)? Acarine (Trachael) mite, *Tropilaelaps* (Asian) mite, *Varroa* mite, Africanised honey bee, European foulbrood.

4 Would you rank them now by their seriousness to New Zealand beekeeping over a longer term (5-15 years)?

5 What is your attitude to the feeding of chemicals or drugs to PREVENT bee diseases such as AFB, EFB, other pests/diseases not yet here?

6 What is your attitude to the feeding of antibiotic drugs to TREAT OUTBREAKS of bee diseases such as: EFB, *Varroa* mites, AFB.

7 Describe a situation when allowing antibiotic drug feeding might be a valid decision as part of the treatment of an exotic pest or disease outbreak?

8 Can you name any sectional group of the industry that might require 'favoured' treatment at the possible expense of the beekeeping industry and its clients? If so, please describe.

9 Describe a situation where you would feel the restriction of bee movements between the North Island and South Island would be warranted.

10 Describe a situation where you would feel the restriction of honey and other bee products between North and South Islands would be warranted. Who would control such product movement and how would it be managed?

11 If some or all of your bees were destroyed as part of the treatment of an exotic pest/disease outbreak, what percentage of financial value would you expect to be compensated? By whom? Can you describe other possible methods/sources of compensation?

12 a) Describe how you as a beekeeper would expect each of the following situations to be managed. Try to take into account the possible failure of some of your solutions and outline a contingency plan. Describe how the decisions you outline would affect your business and those of your fellow beekeepers.

b) European foulbrood is discovered on the Canterbury Plains in hives owned by a hobbyist.

c) Acarine (tracheal) mites are discovered in hives in Northland.

d) Bees from a South Auckland bee hive are discovered to have Africanised honey bee genes.

e) Hives that had been placed into the honeydew areas in Canterbury are later found to have Varroa mites.

Appendix II American foulbrood Disease Levels in New Zealand from 1970-1990 (MAF)

Year ending 31 May	Apiaries		Hives	
	No. of Apiaries	% Diseased	No. of Hives	% Diseased
1970	13,703	2.7	195,874	0.4
1971	14,345	2.8	200,774	0.4
1972	14,865	3.3	204,359	0.5
1973	15,384	2.3	207,944	0.4
1974	15,390	2.6	206,068	0.4
1975	15,396	2.8	204,191	0.4
1976	15,830	3.0	205,714	0.6
1977	16,263	2.8	207,237	0.5
1978	17,273	3.1	210,978	0.6
1979	18,438	3.9	226,870	0.8
1980	19,450	3.7	233,810	0.7
1981	20,159	3.5	238,097	0.7
1982	21,019	3.4	253,605	0.6
1983	23,644	3.5	269,043	0.6
1984	23,960	2.8	277,005	0.5
1985	26,018	*	309,428	*
1986	26,866	3.9	328,961	0.9
1987	27,620	4.4	340,433	1.1
1988	27,177	5.5	335,702	1.4
1989	27,082	5.6	330,338	1.1
1990	25,786	7.0	318,203	1.2

* not available