Ministry of
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Proceedings of:

MAF beekeepers' seminar

Nelson, 26 July 1983

Edited by: A G Matheson

MAF

Nelson

PROCEEDINGS OF A MAF BEEKEEPERS SEMINAR

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Themes - *pollen*

pollination

biological control

Edited by: A G Matheson
Apicultural Advisory Officer
Ministry of Agriculture
& Fisheries
Nelson

C O N T E N T S page

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MAF = Ministry of Agriculture and Fisheries

DSIR = Department of Scientific and Industrial Research

SEMINAR OPENING Murray Reid

Thank you Andrew, good morning ladies and gentlemen. It takes a lot of work to organise a seminar like this, and most of the responsibility has rested with Andrew Matheson who was just addressing you.

Andrew has only just come back from a period overseas where he was working for the United Nations on a beekecping feasibility study in Jamaica. While he was away John Smith and myself kept the pot boiling as far as the seminar arrangements were concerned. In fact we did a little more than that, we changed half the programme around for Andrew, but never mind.

What happened in the meantime, while Andrew was away was that we became aware that there were some more developments happening in the field of biological control, carried out or proposed by DSIR scientists. As this is possibly going to affect some of you in one way or another, we thought it very opportune that you should be made aware of what was going on or proposed.

So we are pleased to involve the DSIR group in our seminar today, and they will be talking on various aspects of the work proposed, both in weed control and wasp control. The original theme that was proposed for the seminar was pollen; its production, processing and marketing; and pollination. You will see from our programme we still have retained some of those aspects.

What I would like to do now very briefly is introduce the rest of my colleagues from the apiary section that are here, just so that you do know who they are.

We start in the deep south with Cliff van Eaton. Cliff is a Canadian who joined our section last October, and comes with a lot of experience in bee breeding, genetics, and artificial insemination, and he will be a very valued and respected member of our team. So welcome to New Zealand Cliff, I'm sure most of you will make Cliff feel welcome, I know the Southland beekeepers certainly have in the time he has been here.

Next up the line is Kerry Simpson from Oamaru. Kerry is an Apicultural Advisory Officer, as is Cliff. Kerry joined the section after becoming, I guess disillusioned is the word, with teaching. He was a secondary school teacher, and his last appointment was as head of the science department at Otorahanga in the Waikato. Kerry had an interest in bees, and in fact I was chatting him up to be a part time apiary inspector but he decided, no that was not good enough, he had to join the section as a full member. Kerry just recently has been in charge of a bilateral aid programme to the Tuvalu Islands in the Pacific. He has had one trip there already and taken some bees over, and will shortly be going back again.

Our next member from our team here is John Smith, Apicultural Advisory Officer, Christchurch. John has many talents, and apart from being a video kid he has also been responsible for putting the apiary computer programme together. Some of our team that have access to the microcomputers have already put your apiary registrations on computer, and your annual list of apiary registrations may arrive in that form this year. This will not happen everywhere, but some districts will be on that system.

And lastly the Apicultural Advisory Officer from Nelson, is Andrew Matheson. Andrew is also from the Waikato, a resident from Hamilton, and has been in the MAF six or seven years. Andrew, as I have mentioned, is involved with the United Nations project in Jamaica. It was a feasibility study so I don't suggest that he will get to go back on a continuing basis, but he had a very valuable contribution to make to that study.

So we have got a diverse range of people working in the apiary section. Some of the other work that we do has been put up on the display board outside in the foyer, which I am sure you will all take advantage of seeing.

That experience and range has been brought together in this seminar today, with help from our colleagues in the DSIR and the beekeeping fraternity. I hope you enjoy the seminar and you get some valuable information from it, and I have great pleasure in formally declaring it open.

HIGH COUNTRY WHITE CLOVER POLLINATION, BROKEN RIVER 1981-1983

Dan Pearson

In recent years there has been substantial investment directed to improvement of hill and high country pastures. Part of this investment has been for introduction of exotic pasture species, of which clover is possibly the most important as it improves the nitrogen status of the soil and hence productivity overall. Self-perpetuating pastures, which are the aim of this investment programme, will only occur if the clover produces enough seed to ensure that it will re-establish. The object of this study has been to investigate the positive and negative effects of insects on white clover seed production in high country areas.

Methods

The observations on which this report is based were made during the summer seasons of 1981/82 and 1982/83 on the Flock Hill Station, at Broken River alongside Highway 73, between Porter's Pass and Arthur's Pass. The area is at 43° 11' 30" S and 171° 43' 50"E and an elevation of 760 m (2500 feet). The plot is on a flat terrace and the locality is subjected to NW storms at about weekly intervals through the summer.

There are two sites on the other side of Broken River, about 900 to 1000 metres from the plot, where bees are located during the summer. In the 1981/82 season there were 18 hives at the nearer site and 15 in the other; in the last season only the nearer site was used with 15 hives being placed there. In the 1981/82 season the hives were placed on 17 December (Day 179) and in the 1982/83 season they were placed on 12 December (Day 174).

Different series of measurements were taken in the two seasons. In both seasons I set out a transect about 100 m long, and at weekly intervals counted white clover inflorescences contained in 0.25 m^2 quadrats at 1 m intervals along it. This gave me a picture of the distribution of flowering - i.e. the beginning, end and the peak - through the season. This distribution of flowering also allowed me to make an estimate of the total numbers of flowers per hectare over the season.

In the first season I was unsure of which pollinators would be present and how many there would be, so I didn't know what method would be best for recording their activity. The first method I tried was to mark out a large quadrat (square) on the ground, count the flowers in it, and then count the bees that came into it and record the number of flowers they visited. This wasted a lot of time. It was quite cool at the beginning of the season and there were few bees present. On the worst day, with a 16 m^2 quadrat containing over 1000 flowers, I watched for 5.25 hours and didn't see a single bee. As the season became warmer and the bees more numerous it became more difficult to keep track of the number of flowers individual bees visited. I changed to recording the times at which individuals entered and left the quadrat. I estimated the number of flowers visited by following individual bees and used a stop-watch to determine how many flowers they visited per minute.

When pollinator numbers increased even further I reduced the quadrat size to 8 m^2, then gave it up altogether because I simply couldn't keep track of the bees. I then started searching an area of about 1 m wide as I walked along the transect, and counted all the pollinators I could see over a period of 5 minutes. This past summer I used this transect search combined with counting the numbers of flowers available on each inflorescence, timing the visiting rate of individual pollinators, and counting the numbers of inflorescences per m^2 along the transect. These figures will allow me to estimate the probability of an individual flower being visited by a pollinator. These data have not yet been analysed.

To determine seed set and causes of loss of clover seeds I tagged individual inflorescences each week through both seasons. Each week I also tied off flowers which had already been pollinated on tagged heads. These flowers gave me a record of pollinator and pest insect activity for each week through the season.

Inflorescences were harvested when the seeds were fully matured; I considered them to be ready when the stems were hard and dry. In the laboratory they were taken apart and each ovary inspected for seeds and damage. Damage was classified by cause - lack of pollination, clover case-bearer, bugs, leaf roller caterpillars, and seed abortion. This last category included seeds which had started to expand then stopped, through to seeds which looked normal but were a muddy colour and had no internal structure. Damage attributable to each of these causes was calculated by multiplying the average number of seeds per ovary for the head by the number of ovaries affected and subtracting the number of unaffected seeds in affected ovaries.

Weather information was taken from the meteorological station kept by the Forest Research Institute at Craigieburn Forest. The station is 3 or 4 km away and about 140 m higher.

Results

The major influence on pest and pollinator insects in the Craigieburn area during these seasons was the weather. In the first season my trips coincided with the weekly NW storms so I had the impression it rained all the time. The second season was mostly fine so the season seemed better, but in fact it was much cooler (Fig. 1). (The date system I've used for my graphs is the number of days after the winter solstice; I think this is an appropriate time for the beginning and end of a biological or growing year. Using this system 1 Dec. is Day 163 and 1 Jan. is Day 194.) Figure 1 shows the accumulation of day-degrees above 5°C at 15 cm in the soil, calculated by subtracting 5°C from the weekly mean soil temperature. The 5°C threshold is appropriate for white clover because it is close to the minimum temperature at which growth will occur. Both lines start on Day 163, although events before then determine the time of the onset of flowering of the clover. By the end of the 1983 season the accumulation was about 200°C short of the heat the area had received in the previous summer.

Figure 2 shows the weekly mean soil day-degrees for individual weeks of both seasons. In 15 of the 17 summer weeks the mean was higher in 1982 than in 1983; from mid-December to the end of January temperatures were consistently much lower. Air temperatures show a similar pattern for the two seasons but the difference at the end of the season is about 250°C. The weekly mean air day-degrees also show only two weeks in which the temperature was higher in 1983; one of them was only marginally so.

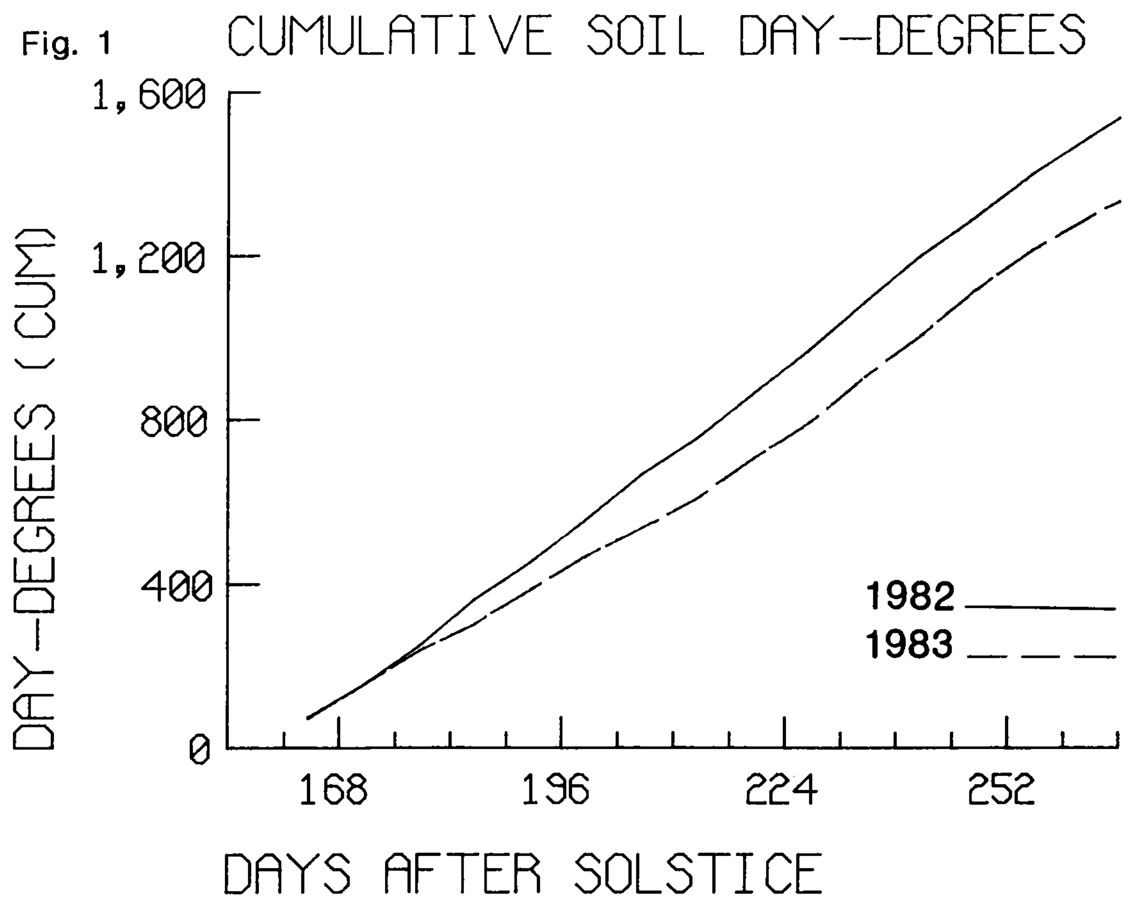
The effect of these temperatures appears as differences in the amount and timing of flowering in the two seasons as is illustrated in Figure 3. In 1982 the peak flowering was reached on Day 199 (6 January) while in 1983 the peak occurred on Day 206. Although the peaks of the two seasons were one week apart, the start of the seasons were separated by more than two weeks. Pollinators are probably not attracted to a resource of less than 5 flowers per square metre. I used this as a lower threshold and it was reached on Day 164 in 1982, while in 1983 it was not reached until Day 181, more than two weeks later. These dates are marked by solid vertical rules in Figures 4 and 5. There were also fewer flowers during 1983, with a total of 168/m^2 over the season compared to 229 in 1982, a reduction of 27%. Warmer conditions at the end of the 1983 season also produced a large flush of flowering at a time when the chances of successful seed development were lower. In 1983 this flush comprised 25% of the flowers produced over the season, while in 1982 only 6% of the flowers were produced in the comparable period.

The hives were placed at the sites on the other side of Broken River on Day 179 (17 Dec.) in 1982 and on Day 174 in 1983. The dates are marked by asterisks in Figures 4 and 5. At these times there were 23 and 2 flowers per square metre, respectively. Enough flowers to attract pollinators became available on Day 164 in 1982, two weeks before the hives were placed, and in 1983 on Day 181, 10 days after they were placed. I recorded losses due to lack of pollination in the two seasons (Figs 4 and 5). In 1982 the loss was around 65% - 85% during the first three weeks but dropped dramatically to about 5% in the fourth week, after the hives were placed. In 1983 there was no pollination in the first week but there were not enough flowers to attract pollinators. Lack of pollination remained as the major cause of seed loss through the 1983 summer, at 20% - 60%. I think this was the result of honey bee activity being limited by cool weather.

Figures 4 and 5 also compare weekly losses due to lack of pollination with the next largest loss factor in each of the two seasons. In the 1983 season the next largest factor is what I term abortion; I believe it is a result of cold weather conditions acting directly on pollen or on the fertilization process. Seeds begin to develop, indicating pollination has occurred, but development stops at various stages along the way. In 1982 the second largest loss factor was clover casebearer.

Figure 6 comprises two pie-charts depicting the fate of potential seed in the two seasons. In both years about 1/4 of the potential output would be classed as good seed which would actually reach the ground. Lack of pollination accounts for 36% of the loss of potential production in 1982 and 41% in 1983. The largest difference in the two years is in loss to clover casebearers, nearly 15% in 1982 but less than 3% in 1983. Losses due to weather and abortion were both greater in 1983 than in 1982; in both years losses to other factors were insignificant. Each year about 27% of the potential seed was classed as good and would be available to produce new plants. In 1982 good seed amounted to about 14 kg of seed per hectare; in 1983 this quantity would be reduced to about 1 kg per hectare.

Fig. 1


CUMULATIVE SOIL DAY-DEGREES
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1,200
800
400
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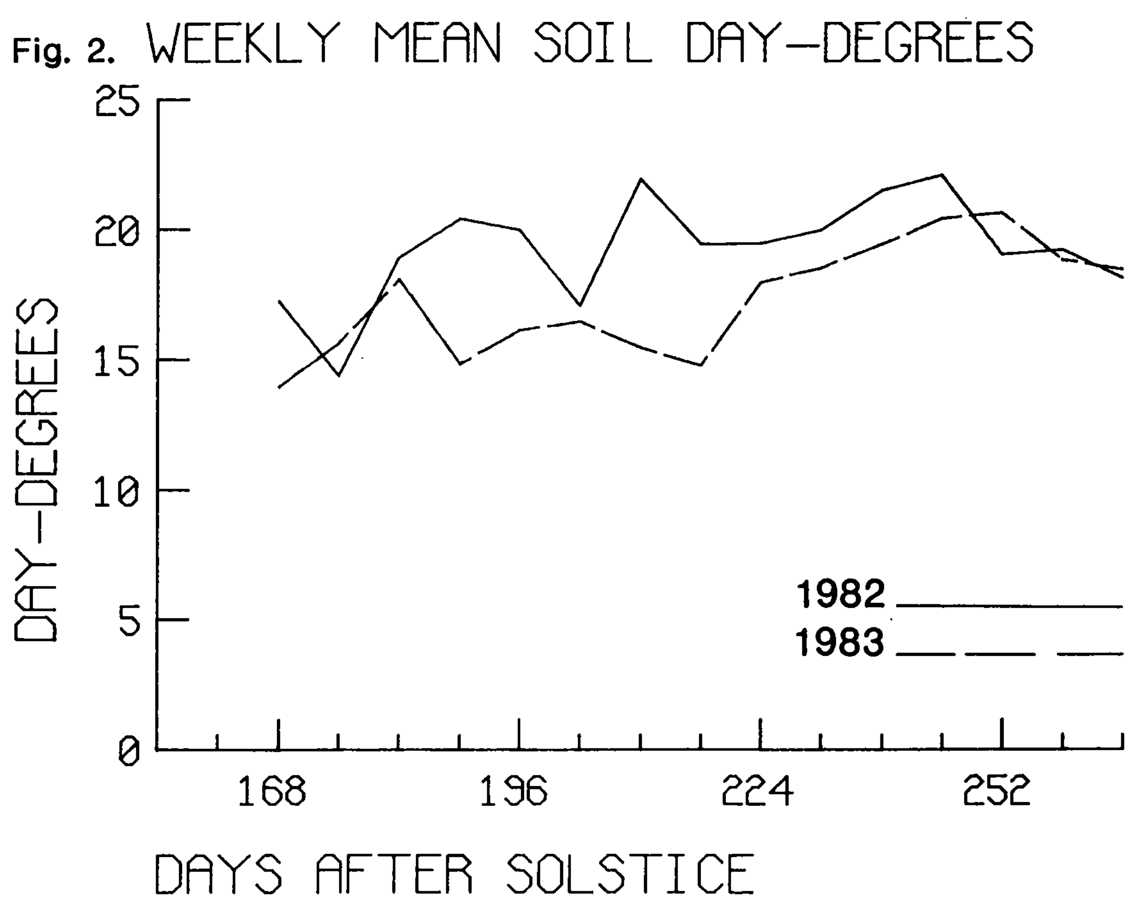
DAY-DEGREES (CUM)
168
196
224
252
DAYS AFTER SOLSTICE
1982
1983

Fig. 2.


WEEKLY MEAN SOIL DAY-DEGREES
25
20
15
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DAY-DEGREES
168
196
224
252
DAYS AFTER SOLSTICE
1982
1983

Fig. 3. CLOVER FLOWERING 1982 1983

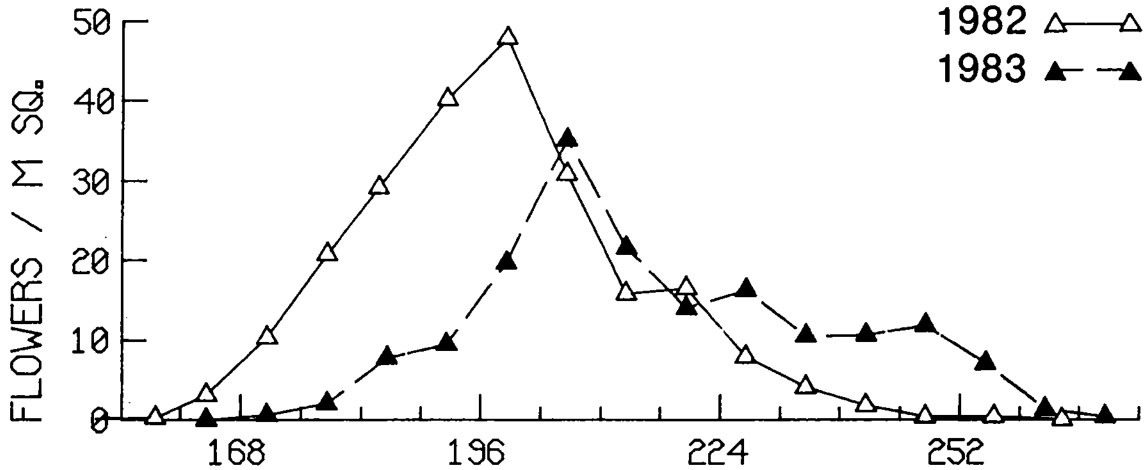


Fig. 4. 1982 LOSSES

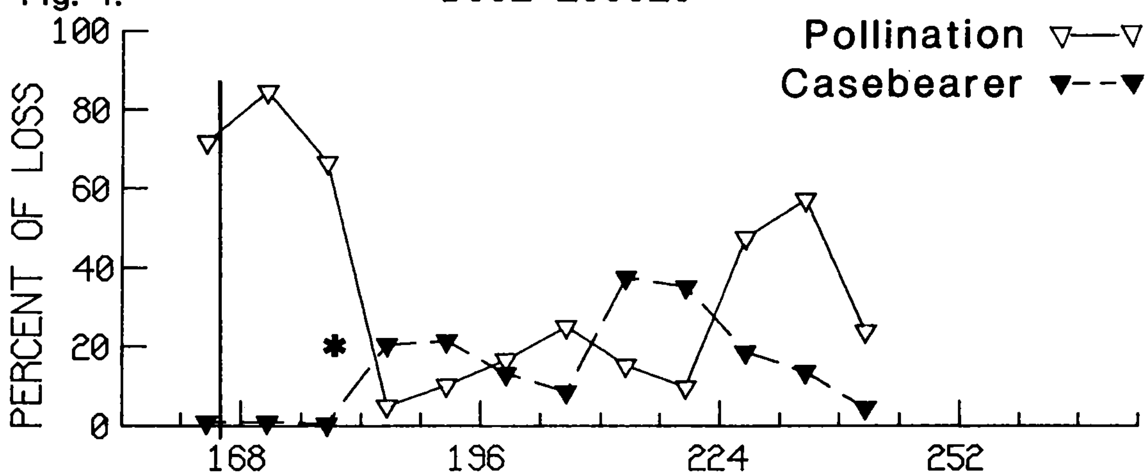


Fig. 5. 1983 LOSSES

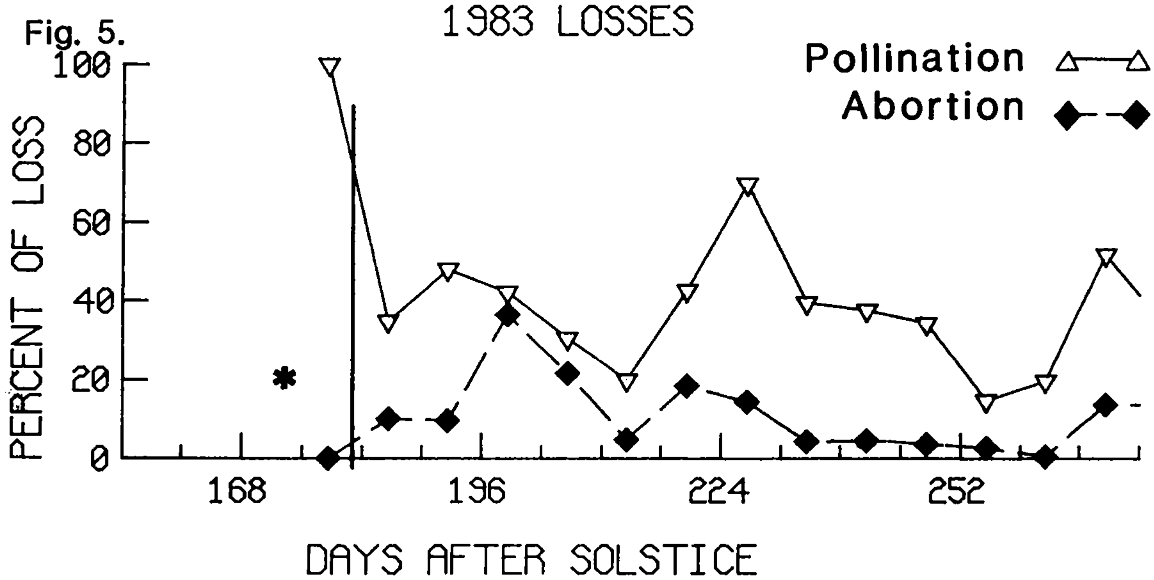
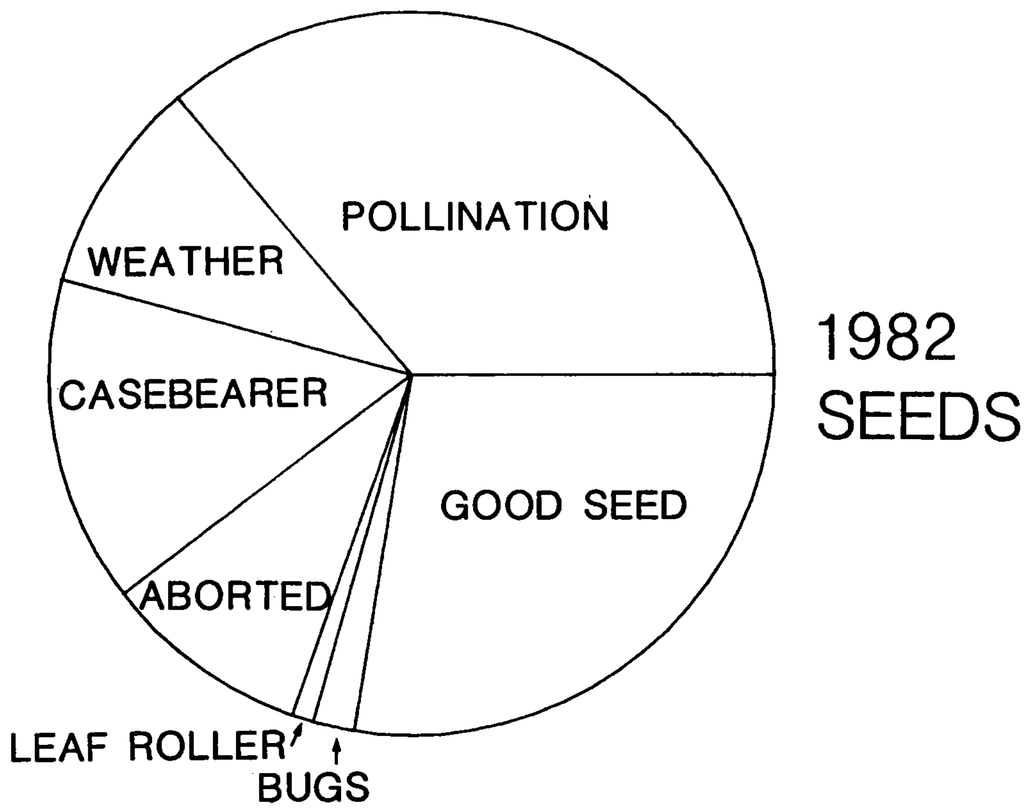
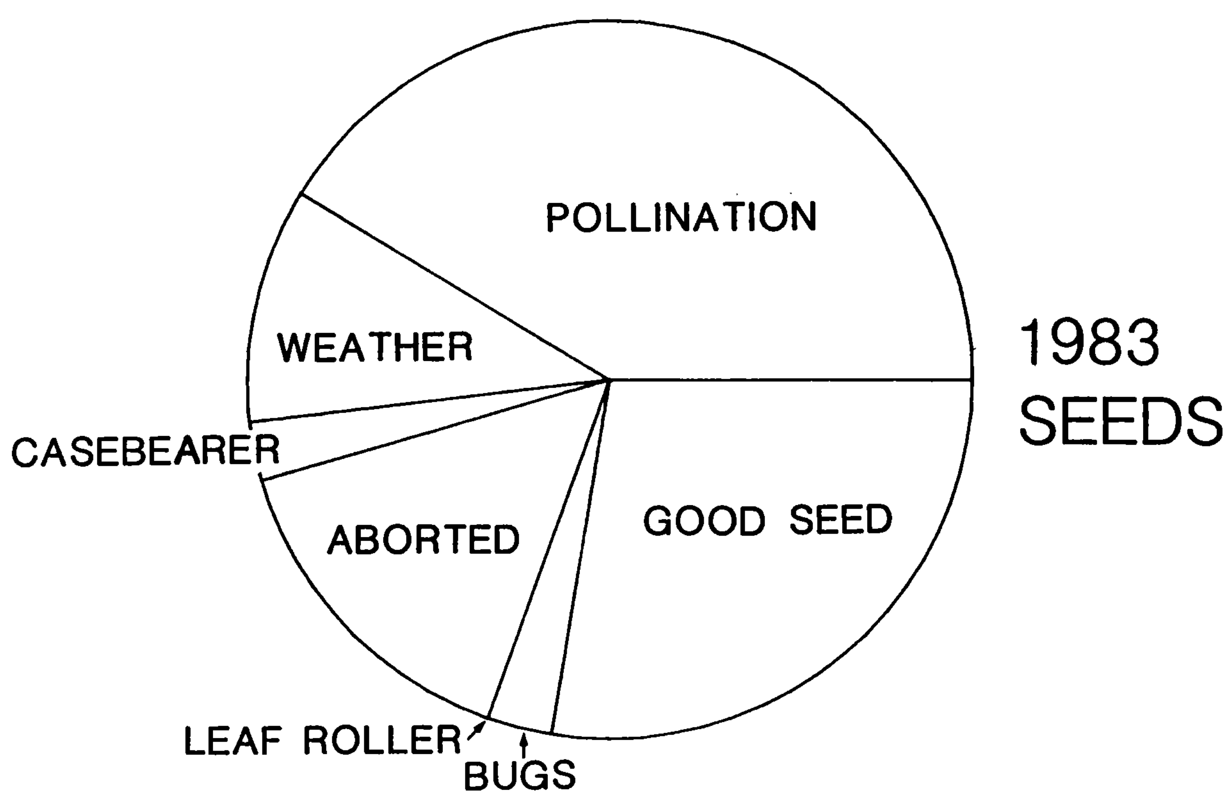


Fig. 6.


POLLINATION
WEATHER
CASEBEARER
ABORTED
GOOD SEED
LEAF ROLLER
BUGS
1982
SEEDS


POLLINATION
WEATHER
CASEBEARER
ABORTED
GOOD SEED
LEAF ROLLER
BUGS
1983
SEEDS

ARTIFICIAL POLLINATION: PROGRESS AND FUTURE DIRECTIONS

M.E. Hopping and N.J.A. Hacking

Introduction

Pollination is perhaps the most important event in the production of a kiwifruit crop, because every flower on the vine is capable of developing into an exportable fruit. Fruit weight, however, depends on seed number. For fruit of minimum export weight, 700-800 seeds are required, while more than 1100 seeds are needed if the fruit is to reach 39-36 tray count weights (Hopping & Hacking, 1983).

Seed number per fruit is dictated by the number of pollen grains transferred from male to female flowers during pollination. Under ideal conditions 2000 pollen grains are needed to obtain 1200-1400 seeds, but we have good evidence from field studies that up to 12 000 pollen grains must be transferred to obtain this number of seeds.

Wind pollination occurs in kiwifruit orchards, but insufficient pollen is transferred and the fruit fail to reach export weight. Effective pollen transfer in orchards results from insect pollination, notably by honey bees which are brought into orchards during flowering (Palmer-Jones & Clinch, 1974). However, both male and female kiwifruit flowers lack nectar and are thus unattractive to bees. Further, weather conditions can influence bee activity markedly and in years when cold, wet, or windy weather coincides with flowering, significantly fewer export weight fruit are harvested (Table 1).

Our research aim is to develop an alternative pollination system to that of wind and insects. This system entails collecting pollen from male flowers, suspending this pollen in a defined spray medium, and then spraying the pollen suspension onto open flowers to maximise seed numbers and exportable fruit. This paper will summarise our progress with artificial pollination, and will comment on the pollination services that will be required in the future.

Pollen collection from male vines

Pollen for our trial work has been obtained from male vines inter-planted in commercial orchards. In future, we would anticipate that all-male orchards would be planted for the sole purpose of pollen production. The procedure that we have developed for pollen collection is outlined in Fig 1. Individual male flowers contain up to 9.5 mg of pollen, and provided that they are picked immediately before petal unfolding most of this pollen can be extracted. Harvested flower buds are passed through revolving cutter bars in a specially designed mill, to detach anthers from other flower parts. Anthers are separated from flower debris by a rotary screen placed at the mill outlet. Anthers are then dried slowly in forced-draught driers to facilitate pollen release. Anther drying is the rate-limiting step in the process, but we have found that rapid anther drying in a rotary drier decreased pollen viability substantially. Once dried, the anthers are tumbled in a rotary drum to release pollen. Pollen is removed from the drum in an air stream and is collected quantitatively by cyclone separators.

Pollen storage

Pollen from the cyclone separators can be used directly, or stored for at least two years without loss of viability. For short term storage (up to 3 weeks) we recommend storing pollen in air-tight containers at -18°C (domestic freezer temperature). For storage up to one year, pollen should be stored in a modified atmosphere (20% RH) at -18°C (or lower temperatures). For storage times longer than one year, lower storage temperatures (-90°C or lower) are needed.

Pollen suspension medium

If pollen is mixed with water and agitated to form a suspension, most of the pollen dies within a few seconds because of osmotic shock. To overcome this problem, an inexpensive mixture of chemicals (called CBCA) has been developed (Hopping & Simpson, 1982). The CBCA mixture is dissolved in the water before adding pollen. Pollen suspended in CBCA retains full viability for up to 3 hours. CBCA is also formulated to protect pollen from desiccation, as spray droplets dry on the stigmatic surfaces of the flower. However, success in pollen spraying depends largely on how the pollen:CBCA suspension is prepared and dispersed:

(a) Water contaminated by zinc, ferric, or aluminium ions will reduce pollen viability (Hopping & Simpson, 1982);

(b) Pollen should exceed 10% moisture content before mixing with CBCA (Hopping & Hacking, 1983);

(c) Pollen suspensions should be mixed and delivered to sprayer nozzles by compressed air, rather than centrifugal, piston or diaphragm pumps (Hopping & Hacking, 1983);

(d) Pollen suspensions should be applied to open flowers within 60-90 minutes of mixing.

Application of pollen suspensions

Field trials in the Bay of Plenty during 1978-1981 established that when flowers were sprayed by hand with pollen:CBCA suspensions, seed numbers were increased and fruit were heavier at harvest (Hopping & Jerram, 1980; Hopping, 1982). Although much was learnt about kiwifruit pollination during this period, the major problem that remained unsolved was a practical means of applying pollen over entire orchards (Hopping & Hacking, 1983).

A. Pollen sprays applied with hand-held nozzles:

It is likely that pollen derived from a pollen orchard would cost kiwifruit growers between $1.50 and $2.00 per gram. Efficient pollen application is therefore critical to keep pollination costs within practicable limits. Results from the 1981/82 season show that handoperated spray nozzles minimise pollen wastage (Hopping & Hacking, 1983). At 1.0 g pollen per litre CBCA, sufficient pollen was deposited to produce fruit containing about 500 seeds. Thus, two spray applications and no bees, or one spray application plus low bee numbers, would result in at least 1000 seeds per fruit, and most fruit would reach export weight.

A pressurised sprayer was built in November 1982 and fitted with 8 hand-held spray nozzles (spraying systems TG0.5). For vines on the pergola system 8 people were spaced on a line in front of the sprayer and preceded the sprayer down pergola row spaces. As operators walked forward, open flowers above their heads were sprayed with pollen in CBCA suspension (1.0 g per litre).

A block of 0.2 ha of mature vines growing at Katikati was sprayed twice (50 and 90% flowers open) and some outside rows with delayed flowering were sprayed a third time. A total of 75 g of pollen was applied in 20 man-hours of spraying time. All but two of the male vines in this block were Tomuri with less than 100 flowers on each. No beehives were used, although considerable bee movement occurred from adjacent blocks with added hives.

The first pollen spray application increased the number of fruit reaching exportable weight by 21.7% (Table 2), a similar increase to that achieved by hand-pollinating flowers by brushing male flowers over female flowers. The second and third pollen sprays, which were applied to later-opening flowers, had no effect on fruit weight. Over the whole block the percentage of fruit at harvest that reached 42-33 tray count weights were: unsprayed, 53.4; sprayed with pollen, 68.9; and hand-pollinated with dry pollen, 73.5.

Although the increased crop from this trial will more than repay costs incurred during spray pollination, the comparatively small increase overall in exportable fruit suggests that further development with this technique is not warranted. It is clear from this and other trials in 1982/83 that each spray pollination event must deliver sufficient pollen to obtain a fully-seeded fruit. Repeat spraying with less than optimum amounts of pollen (as with hand-held spray nozzles) does not give additive results.

B. Pollen sprays applied with mechanical sprayers:

We believe that artificial pollination has little future unless the technique can be refined to a simple spray operation where one man can spray-pollinate at least 7.0 ha of vines in one day. A boom sprayer fitted with conventional T-jets and a pressure tank for pollen suspension formation and delivery was built and tested in 1981/82. Fruit that resulted from sprayed flowers (no wind or insect pollination) contained around 300 seeds and weighed 60 g (Hopping & Hacking, 1983). Further improvements could not be obtained without using excessive amounts of pollen. In late 1982 an electrostatic charging device became available which applied 80 000 volts to the spray cloud from T-jets. In theory, charged pollen:spray droplets should be attracted to point charges on stigmatic tips and thus improved pollen deposition.

A number of vines trained on the pergola system in a Te Puke orchard were enclosed in a Sarlon shade cloth tent to prevent insect (but not wind) pollination. Open flowers were pollinated once with dry pollen or with pollen suspensions applied by dipping, hand-held nozzles, or boom sprayer (Table 3). Fruit set and fruit weight following pollination by dry pollen or with pollen suspensions applied by dipping gave comparable results (Table 3). Thus pollen viability was not impaired by CBCA treatment. Pollen sprays applied with the boom sprayer gave poor results and fruit weight was less than that achieved the previous year. Electrostatic charging improved sprayer performance to the level achieved by hand-spraying with the same nozzles as were used in the Katikati trial. Although all spray pollination treatments fell short of the potential demonstrated by hand-pollination, the substantial improvement that resulted from electrostatic charging indicates that further benefits could be expected from this spraying system.

Future sprayer developments

Recently, laboratory studies have shown that the electrostatic charge distribution on the pollen spray clouds produced by T-jets was non-uniform, and only the centre part of the spray pattern achieved a useful charge. This finding explains, in part, problems experienced with field studies in 1982/83 (Table 3). Further work with T-jets mounted on a boom sprayer is unlikely to improve pollen deposition.

A new sprayer based on controlled droplet application (CDA) coupled with electrostatic charging has been built. Laboratory tests have shown that this sprayer has the advantage of low-volume spraying, accurate droplet sizing, uniform electrostatic charge distribution and enhanced droplet deposition. A full-scale effort is now underway to develop and evaluate a prototype CDA sprayer before flowering begins in 1983.

Kiwifruit pollination in the future

It is clear from Table 1 that wind and insects do not successfully pollinate kiwifruit every year. An alternative pollination system is required irrespective of a projected shortage of beehives after 1985 (Martin, 1982). We have developed a technique to collect pollen and a means of maintaining its viability in a spraying system. If an effective application system can be developed over the next year, we suggest that pollination could be maximised by a combination of insect and artificial pollination:

(i) introduce 2-3 hives of bees at 15-20% flowering to pollinate early-opening flowers;

(ii) spraying pollen at this stage of flowering will be too wasteful (unless spot spraying by hand-held nozzles can be perfected;

(iii) artificially pollinate at 40-60% flowering. Pollen application to be less than 150 g pollen per ha;

(iv) artificially pollinate a second time at 90-100% flowering, again using less than 150 g pollen per ha.

Whatever the outcome of our research into the artificial pollination of kiwifruit, there will be a continuing need for a pollination service by the beekeeping industry.

ACKNOWLEDGEMENTS

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TABLE 1:

Meteorological conditions at Te Puke during flowering in 1979 to 1982, and the percentage of kiwifruit that reached exportable weight. All fruit data came from the one orchard.

Year	Meteorological conditions during flowering				% fruit reaching export weight
	Temperature °C Max	Temperature °C Min	% days with rain	Remarks	
1979	22.0	10.7	22		85.0
1980	18.0	8.7	88	Wet cold season	59.6
1981	20.6	12.2	70		83.4
1982	20.1	10.1	44	Excessive wind	57.1

TABLE 2:

The percentage of exportable weight fruit (> 72 g) following pollination by wind and honey bees, or by pollen sprays (1.0 g pollen per litre CBCA) applied by hand-held nozzles.

Stage of flowering	Pollination treatment	% fruit exceeding 72 g
50-60% flowers open	Unsprayed	71.0
	Sprayed	92.7
90-100% flowers open	Unsprayed	68.5
	Sprayed	70.0
100% flowers open	Unsprayed	79.7
	Sprayed	83.7
	Hand pollination (dry pollen)	94.5

TABLE 3:

Fruit set, fruit weight, and percentage of exportable weight fruit ($>$72 g) following a single pollination with dry pollen, or with pollen in CBCA suspension (1.0 g per litre).

Pollination	Fruit set (%)	Fruit Weight (g)	% fruit exceeding 72 g
Hand pollination (dry pollen)	92.9	82.4	84.8
Flowers dipped in pollen suspension	94.0	86.6	74.4
Hand-held spray nozzle, TG 0.5	95.4	62.5	31.8
Boom sprayer, 730385 T-jet	66.6	44.3	3.0
Boom sprayer, 73085 T-jet, electrostatic charging of spray droplets	80.0	59.0	30.0

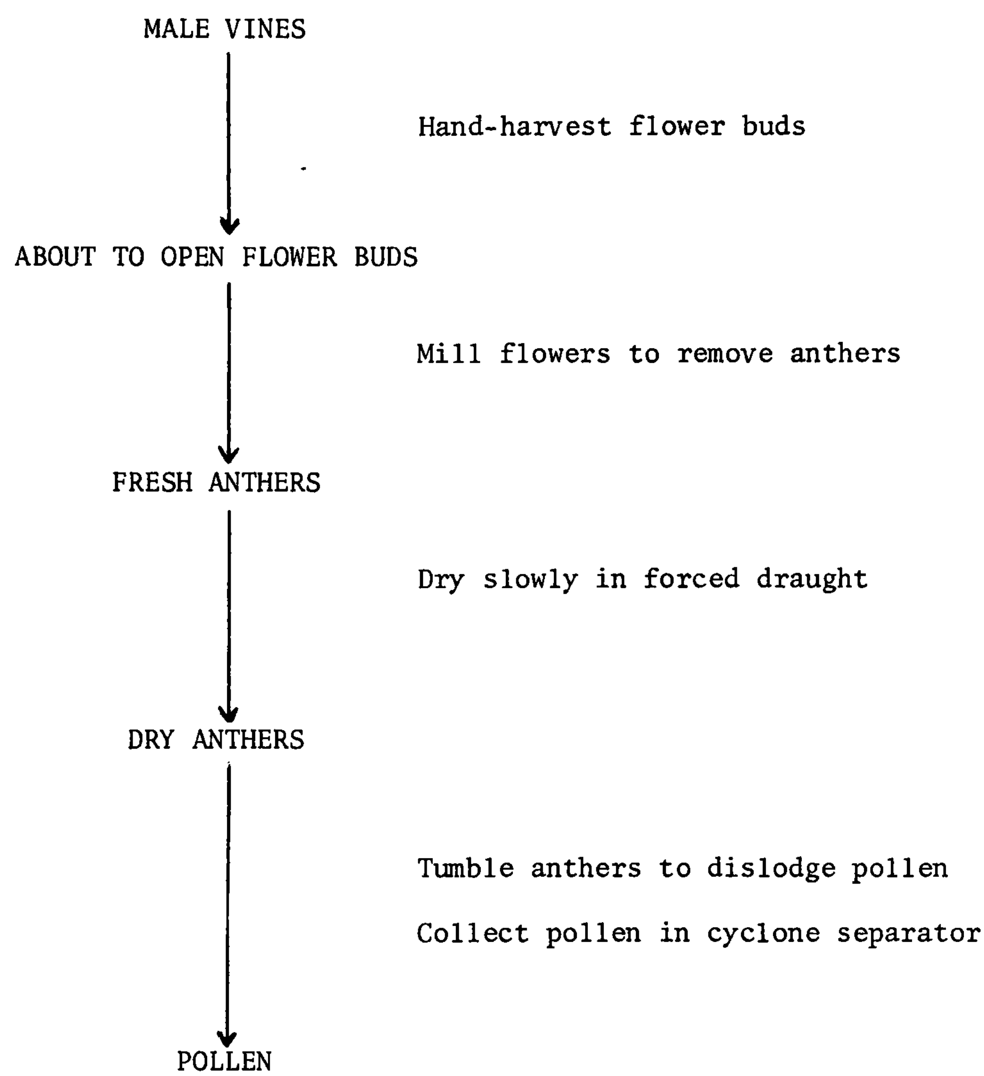

FIGURE 1: Flow diagram of the procedure for extracting pollen

KIWIFRUIT POLLINATION

Barry Donovan

PART A

The kiwifruit flower/insect survey

The insect visitors to kiwifruit flowers were surveyed from 1980 to 1982. The aim was to determine which species most commonly visited the flowers, with the ultimate objective of determining which species were the most important pollinators. During 1980, 9 teams of 2 people (Entomology Division staff, assisted by several MAF personnel) collected all insects present on kiwifruit flowers throughout the period of bloom in selected orchards from Northland to Nelson. Sampling techniques were standardised so that results from each orchard could be compared. The teams surveyed continuously during every alternate 2 hours from 5.00 am until 11.00 pm. Most orchards were surveyed up to 5 times so that the period from early bloom to late bloom was evenly covered. In addition to catching insects, the teams recorded the time that individual insects spent on flowers, their contact with stigmas, and their movement between male and female flowers. Insects were also captured on flowers of other plant species within the vicinity of the surveyed orchards.

In the laboratory the number of viable (male) and non-viable (female) pollen grains carried by the captured insects is being determined. These data are being integrated with data obtained from the field.

Following a preliminary assessment of the 1980 survey, the scope of the surveys was modified in 1981 and 1982. During these latter two years bees were the focus of attention because their behaviour and the number of male pollen grains carried by them indicated that they were the most important pollinators.

Fifty-four orchards were surveyed in 1980 and 1981 and 19 of these were surveyed in 1982. During the survey the opportunity was taken to record other data that appeared to be of importance.

Preliminary results

More than 6000 specimens were captured. Many are yet to be identified to species, but at least 150 species are represented, of which a few are mites and spiders. The insects can be divided into large groups, and of these bees were the most common group captured during 1980 (Table 1).

Honey bees and thrips were greatly under-represented in the samples. Because beehives were hired into many orchards, the number of bees was expected to be high, so a limit of 40 bees per 2 hour period (which was not always met) was set. The small size of thrips made them difficult to collect.

Table 1: Main insect groups captured during 1980.

Insect Group	% of total insects
Bees	31
Nematocera (gnats, midges)	21
Hover flies	8.5
Other flies	13
Thrips	9
Beetles	6
Moths	3
All other	8.5

The insects which appeared to possess the potential to be important pollinators, i.e. the large, hairy insects which might have carried much male pollen to stigmas, were all bees, flies or moths (Table 2).

Table 2: Total number of large, hairy insects taken from all orchards during 1980, and the percentage of orchards at which they occurred.

Major group	Species	No. of specimens	% of orchards at which present
Bees	*Apis mellifera*, honey bee	592	95
	Bombus (3 spp.), bumble bees	143	60
	Colletidae, Halictidae (7 spp.), native bees	138	49
Flies	*Melanostoma fasciatum*, small hover fly	107	61
	Melangyna novaezelandiae, large hover fly	90	63
	Other Syrphinae, hover flies	27	34
	Dilophus nigrostigma, bicoloured swamp fly	66	29
	Odontomyia (3 spp.), soldier flies	39	20
	Muscidae, house flies, etc.	29	29
	Sylvicola (2 spp.), outhouse flies	19	22
Moths	*Crambus* spp., grass moths	35	37

Six criteria were thought to be important for evaluating the comparative status of the various insects as pollinators. These were:-

1. Abundance
2. Rate of flower visitation
3. Movement between flowers
4. Stigmatic contact
5. Number of male pollen grains carried
6. Effect of competing bloom.

1. Abundance

Honey bees occurred in 95% of orchards, and were 4 times as numerous as the next most common group of insects, the bumble bees.

The number of honey bees frequently bore little positive relationship to the proximity of managed beehives. For example, at one orchard where the nearest apiary was 1 km away, on one day there were 2-4 honey bees per female vine at any one time during weather suitable for bee activity. Another orchard about 15 km away, which was stocked with 8 hives/ha, had only 1 honey bee per 2 female vines at any one time on the same day.

Although bumble bees were present in 60% of orchards, their numbers were usually low. Their loud buzzing and large size resulted in the capture of a high percentage of individuals encountered.

Native bees occurred in almost half the orchards surveyed in 1980. About 80% of the specimens belonged to 4 species of *Leioproctus* and the remainder to the genera *Lasioglossum* and *Hylaeus*. *Leioproctus* are almost entirely black, and most females are nearly as large as and resemble black honey bees (males are smaller). *Lasioglossum* and *Hylaeus* are also basically black, but are much smaller than honey bees.

The fast flight and wariness of native bees, and particularly *Leioproctus*, sometimes made capture on flowers rather difficult. Where they did occur numbers ranged from very few to hundreds per hectare. At Manutuke near Gisborne, where exceptionally high numbers were present, I took the opportunity during a survey rest period to capture 100 *Leioproctus* on and over one male vine as quickly as possible: this took 80 minutes. Discussions with growers indicated that the numbers of native bees could vary both between and within seasons: sometimes few occurred until late in the flowering period, while sometimes few occurred at all. Occasionally there were so many present that a low hum was evident throughout an orchard.

Two species of hover flies were present in a similar number of orchards as were bumble bees, but other flies and moths occurred in a third or less of orchards.

2. Rate of flower visitation

All bee species occurred on both male and female flowers. From observations made by survey teams during 1981 and 1982, the average time spent on flowers ranged from about 9 seconds for bumble bee queens to 74 seconds for Leioproctus. Honey bees averaged 14.5 seconds for male flowers and 17.8 seconds for female flowers. Large hover flies took an average of over 190 seconds to visit a flower.

3. Movement between flower sexes

The movement of Leioproctus was difficult to observe because of their rapid flight, but 7.7% of queen bumble bees and 20.3% of honey bees moved from one sex of flower to the other. Most of the flies, thrips, beetles and moths moved slowly, if at all, from flower to flower.

The sex of pollen carried by an insect is to a large extent a record of the sex of flowers from which the pollen was collected. Of examined bees randomly collected from both sexes of flowers, 87% of honey bees had pollen from both male and female flowers, of the bumble bees 56%, and the Leioproctus 60%. Most of these bees, therefore, had probably visited both male and female flowers.

4. Stigmatic contact

Female kiwifruit flowers have up to 40 stigmas. Bumble bee queens were observed to contact an average of 20.1 stigmas, honey bees 9.2, Leioproctus 7.7, Hylaeus 2.6 and Lasioglossum 0.3. Few other insects contacted stigmas, although thrips were sometimes numerous on stigmas.

5. Number of male pollen grains carried

Bumble bees, Leioproctus, and honey bees collected from female flowers averaged 20-90 000 male pollen grains on their bodies (pollen pellets excluded), but within each species the range varied from none to half a million. The small native bees and large hover flies averaged 100-5 000 male pollen grains, while most other species averaged just a few (e.g. thrips) to about 50. Two to 6 times more male pollen grains were carried by bees collected off male flowers, with the maximum being 8 million carried by a queen bumble bee.

6. Competing bloom

In general honey bees appeared to visit flowers of other plant species more frequently than did other bees (however see Part B). Leioproctus and Hylaeus, which are solitary in that each female provisions her own cells with both pollen and nectar, presumably must visit other flowers for nectar. Many of these other flowers, for example cabbage tree and pohutukawa, were often difficult to collect from because of the height of flowers above the ground.

To summarise, integration of the survey and laboratory data available to date for the groups of insects, their relative occurrence in orchards, their flower visitation, stigmatic contact and ability to carry male pollen grains, suggests that bees were by far the most important pollinators of kiwifruit.

Individually, because of their large size, their ability to carry huge numbers of male pollen grains, and their high degree of stigmatic contact, bumble bee queens and workers were probably most important, followed by honey bees and Leioproctus, and then Lasioglossum and Hylaeus.

Collectively, however, honey bees were of paramount importance, mainly because they enormously outnumbered all other bees. A major factor contributing to their importance is their manageability: bumble bees and native bees cannot be supplied when and where needed and in the numbers required.

PART B

Model of the number of bees needed for pollination

When considering kiwifruit pollination, three factors stand out:-

1. the species is dioecious, that is flowers are either male or female, and the sexes occur on separate plants;

2. the flowers are nectarless;

3. there are very few flowers per hectare compared to many other crops which need pollination.

1. The occurrence of male and female flowers on separate plants means that pollen has to be transported often many metres in order to reach the stigmas of female flowers. From 2000-3000 male pollen grains are needed per female flower for fruits of export size to grow (Hopping, 1981). The agencies that may effect this transport are insects and wind.

2. For insects to visit flowers a reward must be offered by the flowers. Most flowers produce excess quantities of pollen, so that some can be utilised by insects without detriment to the reproductive potential of the plant. Additionally, most flowers produce nectar to attract insects. Kiwifruit, however, is nectarless, but both male and female flowers produce large volumes of pollen. The pollen from female flowers is non-viable, and appears to function as an attractant to insects.

The strategy of offering large volumes of pollen as a reward for insect visitors, instead of a combination of pollen and nectar, is well documented for various groups of plants. For example our native Pennantia, which is not closely related to kiwifruit, exhibits the same pollination syndrome. This strategy can be very successful, but because bees also require nectar it is only so if nectar is available from other flowers.

3. A stand of lucerne may have about 100 million flowers per hectare, but the same area of kiwifruit has only about 200 000 female flowers open at one time, and perhaps a similar number of male flowers. A few simple calculations can lead to some interesting considerations.

If one honey bee visits on average about 3 flowers a minute (including flying time), then in say 6 hours (which observations suggest might be about an average foraging time for a bee in one day when working with kiwifruit) a bee could visit about 1 000 flowers. If at maximum bloom there are 200 000 female flowers per hectare, then only 200 bees would be needed at one time (or about 1 bee per 1.7 female vines) for 6 hours for all flowers to average one visit. If about an equal number of bees were visiting male flowers, (as observations indicate there may be) then on one hectare there would need to be 400 bees for 6 hours. If there were 5 fine days during the 8 days when a flower is receptive to pollen, then at 400 bees per hectare each flower should average about 5 visits. Based upon data from the survey, most of these bees should have visited male flowers, so presumably most flowers will average several visits from bees that are carrying 20 - 90 000 male grains.

A crucial and as yet unknown factor is how many visits from a bee are necessary on average to pollinate a flower, that is, to transfer 2 000 - 3 000 male pollen grains to the stigmas of one flower. If a few visits are sufficient, then very few bees appear to be needed per hectare.

Another way of looking at these data is that the low number of flowers per hectare means that compared to most other crops such as lucerne, white clover, or fruit trees, few foraging bees per hectare can be catered for. If each female vine can provide forage for an estimated average maximum of about 4 bees, and male vines about 10 bees (because a male vine usually carries far more flowers at one time than does a female vine), then a hectare of kiwifruit can carry no more than about 2 000 bees. As a typical hive at mid-late November would have up to 5 000 pollen foragers, a stocking rate of 8 hives/ha would require most pollen foragers to fly beyond the orchard in order to locate flowers that were not already being exploited.

However these data are average data. Long periods of inclement weather mean that during fine spells many more bees are needed at the same time.

Intensive research which is now in progress into numerous aspects of kiwifruit pollination such as the role of wind as a pollinator, the importance and management of bumble and native bees, number of insect visits needed for pollination, and the possibility of mechanical pollination, should answer many questions within the next several years. In the meantime, however, pollination by honey bees seems to be of paramount importance for the production of export fruits.

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PREPARING POLLEN FOR MARKET

Adrian Tasman

Pollen markets

In order to prepare pollen for a market we must first identify the type of market the pollen is intended for, and that particular market's requirements. As there are different commercial pollen markets so there are different market requirements. We could, I suppose, split up the pollen market into six categories, each with its own particularities and requirements.

1. Plant breeding.
2. Fruit pollination.
3. Extraction of certain components.
4. Pollen supplement for bees.
5. Feeding to domestic animals.
6. Human consumption (on its own or mixed with honey or royal jelly).

For the first three markets, plant breeding, fruit pollination, and the extracting of certain components, pollen of specific plant origin is required. This is of course quite obvious. It would be most unlikely, impossible in my opinion anyway, that in plant breeding we would like to cross a dandelion with an oak tree, or in fruit pollination pollinate for instance kiwifruit with the pollen of a banana tree.

For those first two markets we need not only pollen of specific origin but also obviously the pollen grain must be viable. Storage of viable pollen is a complicated and involved process and I will not bore you with that aspect right now.

It seems to me that most, if not all, of you are more interested in general pollen markets and probably mainly in the human consumption one. All the same I think I should mention that, for instance, pollen from lupin stored at -180°C (and that is a very cold temperature obtained by liquid gases) should remain unchanged and live for about one million years. Different types of pollen require different treatments to remain viable, which is one reason why pollen is such a fascinating and challenging subject.

The extraction of certain components is in the main for the pharmaceutical industry, as an example the collection of select species of pollen from particular grasses and the ragweed Ambrosia is necessary for the study and treatment of hayfever.

General pollen harvesting and marketing is therefore likely to be in the three final commercial pollen applications, producing pollen for supplement to bees, producing pollen for feeding to domestic animals, and last but not least, pollen production for human consumption.

The domestic animal market has, I believe, potential. Experiments with laboratory rats established that pollen and pollen extracts can serve as biostimulants in feeding rations. This work suggested to agronomists associated with large hybrid corn (Zea mays) breeding programmes in Romania, a possible use for the 50 kg/ha of pollen removed in detasseling corn plants. Through by-product recovery and active collection, about 10 000 kg of pollen was harvested in 1970. Feeding experiments suggested that under some circumstances it may be feasible to harvest and use such pollen in animal feeds.

In piglet diets pollen was found to be beneficial. Pollen added to the diet of calves resulted in significant weight gains. Probably the most significant animal feeding benefits demonstrated with Zea mays pollen involved egg production in hens. When the feed ration included pollen, egg laying increased 17% in the first 60 days and the egg yolks had a more intense and desirable yellow colour. Meat chicken showed weight gains in both sexes when pollen was added to their diets; females consistently gained more than males. (Maybe there is a moral here but it eludes me.)

Whether or not it is economic to add pollen to commercial feeding rations is open to question, but I think that we should perhaps look to the somewhat more sophisticated market of the fanciers. I am thinking of the pigeon, canary, budgie and cockatoo type of market. If racing pigeons fed on pollen supplement fly faster, and more prize canaries or cockatoos can be bred per year (and I am reliably informed that some cockatoos have a price tag of $600 each) then pollen supplement in that sort of market must surely have a place.

Pollen for human consumption

As there are ten golden rules in the preparation of pollen for market, any market but certainly for the human consumption market, I might as well spell them out here and now.

Rule 1. Quality control.
Rule 2. Quality control.
Rule 3. Quality control.
Rule 4. - yes, you have guessed it, Quality control.
If there were twenty five golden rules then all twenty five would be quality control, because without top quality pollen we will have no market, and without a market all our work and effort in collecting and packaging is an absolute waste of time.

How do we set out then, with the collection of pollen to achieve and maintain a top quality pollen product? From the outset the beekeeper's management should ensure that the collected bulk pollen be protected from excessive sunlight, moisture intake, insect infestation, and extraneous material.

I would suggest a clear apiary site for a start, so that the bees do not have a partly or wholly overgrown entrance. This is so that when the worker bee comes in the pollen trap it does not brush against grass or other obstructions which may well harbour moisture, or dust from the road, industrial waste particles, or a combination of pollutants which will attach to the pollen pellets carried on the hind legs of the worker bee as it struggles through and past those obstacles to reach the entrance of the hive.

Further we will have to consider the type of pollen trap in use. The pollen trap we are using and are familiar with in our set up is a commercial trap bought from a large bee equipment manufacturers in Christchurch of which you see a sample here.

We have made a small alteration to the trap to facilitate, if you deem it necessary, a change of entrance to the bee hive. In the original set up you had to lift the complete hive off the trap if you wanted to stop trapping pollen. This is all right if you have a couple of hives with pollen traps, but when you operate several hundred hives with traps underneath them then the process becomes somewhat tiresome! So you see a very simple and quick operation: now I trap - now I don't. The bees adjust very rapidly, almost without disorientation, to the entrance change.

The critisism I have of this trap is that it not only collects pollen pellets from the worker bee's hind legs, but also the debris direct from the hive above and this can contaminate the pollen below. If the hardboard panel restricts honey bee ventilation and the ripening of honey is open to conjecture - our experience, in the field, is that it does not affect the ventilation process to any great extent. Another drone escape wouldn't do any harm.

I know of a trap developed in France where the pollen trap is sited inside the top of the hive, using a top entrance; in this particular trap the pollen is usefully dried by the rising warmth of the hive. The higher pollen yields claimed for such a trap were further improved by making an additional hole at the back of the hive, to serve as a drone exit and for waste removal by the bees, and for extra ventilation. Another, and I understand, a very effective pollen trap was designed by Mr Stan Chambers of Western Australia which handles the debris problem rather well.

The initial placement of traps on hives within an apiary will cause some disorientation and drifting. However the honey bee adapts to the trapping mechanism usually within four days. The pollen quantity collected in the first week is nearly always small due, no doubt, to the adjustment the bees have to make. Depletion of pollen stores in the hive due to consumption will make the bees keen pollen collectors after the first week of instalment of the trap.

The same principles for honey production apply to pollen collection - the stronger the hive the greater the harvest. The trap we are using lets enough pollen through to ensure continued bee production and colony build up and maintenance.

A small number of workers will make use of the drone hole, but it is amazing how few. What I noticed, however, is that the more experienced field bees make much smaller pollen loads with which they squeeze through the grid. Also if one examines the grid closely you will notice that not all squares are equal in size, and it does not take long for the smart ones to find the bigger squares to wriggle through with their pollen loads either wholly or partially intact. The young field bees arrive at the hive with beautiful big pollen pellets, the older and wiser ones know better.

The feeding of sugar syrup will increase the quantity of pollen collected by the bees. I suppose this is natural enough because the need to search and collect nectar is eliminated by the availability of the sugar syrup - so more field bees are available for pollen collection.

Strong hives placed on a good pollen producing site (and I think of, for instance, a place with plenty of willow trees close by with a good spread of different types of willow trees, from early flowering to late flowering willows) can produce in favourable conditions 10 kg or more.

In some areas where there is a lot of pollen available a pollen trap is a double blessing. The trap prevents too much pollen storage in the hive, with the effect of permitting expansion of egg laying over, what might be without trapping of pollen a number of heavily laden pollen storage combs.

A pollen trap will not prevent swarming, the old queen will find her way through the drone hole and half your hive is away. A sudden collapse in quantity intake of pollen is immediately apparent. A quick check of the hive will tell you what the reason is. If it is swarming, then the virgin will also find the drone hole on her way out - but you are really lucky if she will find the drone hole again on her way back in. So you change the entrance to no collecting, to aid the virgin with her entrance problems, also of course that hive will not collect pollen of sufficient quantity anyway due to the swarming that took place.

I know that I strayed somewhat from the subject of my talk but I thought it worthwhile to share with you these practical observations in relation to the pollen trap. Oh yes, that reminds me, if at all practical place the drawer of the pollen trap at the back of the hive so that when you collect pollen from the hives you don't disturb the bees at the entrance of the hive concerned. In damp weather the drawers tend to jam at times and it is so much better to have your tug-of-war with the jolly thing well away from the hive entrance.

Once the pollen is scraped off the bees' hind legs and dropped in the drawer it is essential that air can circulate around and through the pollen pellets, in order to reduce the moisture content and mould build-up. Food processing reference papers indicate that one aim of control of solid content of foodstuffs is to ensure adequate keeping qualities; microbiological and chemical changes in food are a function of water activity. Thus it is important to establish a moisture content which is safe for pollen storage. This moisture content is in the area of 8 - 10%.

It is therefore of the utmost importance that the pollen traps are emptied at least twice a week, preferably three times a week, and then the pollen immediately frozen in your deep freeze.

We have learned that problems with most food poisoning organisms can be solved at low temperatures, and that bacterial growth does not occur below -10°C. There is apparently no record of yeast growth below -12°C, or fungi below -18°C. Drs T S K and M P Johansson suggest freezing of pollen for a period of 24 - 48 hours before storing at room temperature, to destroy eggs and larvae of any insects and mites in the pollen that might otherwise damage it. With all this information in mind we deep freeze all our pollen for at least 48 hours.

Then we dry it in a poultry egg incubator, which is thermostatically controlled at a temperature of 38°C. The drying takes 2 - 3 days, depending which way the wind blows. If it is a sou'wester you can bet your bottom dollar it will take a full three days to reduce the moisture content to below 10%, if a nor'wester blows we do it in two days or even less.

A further useful point in controlled drying is in the protection of pollen nutrients, which otherwise will get lost due to drying the pollen at a too high a temperature. I believe pollen should never be dried at a temperature exceeding 45°C.

The dehydration of undesirable foreign bodies makes them more easily removable as well. The cleaning of the pollen is done, by us, with the aid of a small seed cleaner. This is done preferably on warm sunny days, as pollen has the characteristic that it will absorb moisture from the air quite rapidly, and as soon as your moisture content rises above 10% it will lose its holding quality and the pollen will be unfit for marketing.

A byproduct with the small seed cleaner is pollen dust. We do not mix the pollen dust with the pollen pellets, because if we did the finished article would not look so attractive. We can sell the pollen dust separately for feeding back to bees. Also sometimes pharmaceutical companies require pollen dust, and they too can then be supplied without having to grind the pollen pellets into dust.

The pollen, after it is cleaned, is packed in airtight containers. During this process any foreign material spotted is removed by hand, a tedious job but in my opinion very necessary - remember the ten golden rules, quality control, quality control, quality control.

It is here, I think, I must mention the problem of mice droppings. For heavens sake make absolutely sure that your pollen traps are mice proof. Pollen is highly attractive to mice, and their droppings are about the same size as the pollen pellets. The small seed cleaner will not separate the pollen pellets from the mice droppings, that job will have to be done by hand. The best way is to pour the contaminated pollen onto a white bed sheet. The darker mice droppings stand out somewhat better then, but, oh boy, what a rotten job. One big pain in the neck, I assure you. We absolutely refuse to buy any pollen offered to us contaminated with mice droppings. I have had one commercial pollen trapper telling me, when he offered to sell to us pollen mixed with mice droppings, that I shouldn't worry about it, mice droppings were, so he said, nothing else than a bit of harmless vitamin B12! Well you tell that to your client!

After the pollen is packed in airtight containers, we freeze it for the second time for 48 hours to make absolutely sure that our quality remains tops. We have one European buyer who laments that our pollen is almost twice the price than he can buy elsewhere, but he continues to buy our pollen. Why? Because our quality is such that it is worth his while.

The quality of pollen, a unique natural product, can be maintained by utilising temperature and moisture control. Therefore I cannot see any reason to suggest to you the use of fumigants. The effects of such chemical treatment can only, in my opinion, distract from the uniqueness of this product.

Packaging of pollen should be carried out with as little human handling as possible. In fact pollen should be poured rather than handled and this procedure is to be encouraged throughout all operations from the point of hives right through to the final packaging stage. The final product must be sealed in airtight containers as explained earlier. Full protection in plastic is apparently only possible in a plastic/ nylon combination film. Selection of flexible film for this purpose is a matter for the film packaging supplier to advise on. A similar situation exists for pouch packs for retail shelf packaging, and where supply is to small retail outlets.

For exporting pollen, New Zealand is in a happy situation with the non-occurrence of some diseases causing troubles overseas, such as European foulbrood. While it is believed that the continuing demand for pollen will increase with the further development of varying uses, it is most important that quality control of our New Zealand pollen product is of the highest standard.

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THE IMPLICATIONS OF BIOLOGICAL WEED CONTROL FOR NEW ZEALAND BEEKEEPING

Richard Hill

Introduction

One of the major concerns of the beekeeping industry today is the continuing net loss of bee forage plants from the New Zealand countryside. There are a number of reasons for this decline, but two result directly from agricultural management practices: many farmers physically remove important sources of pollen and nectar such as scrub or gorse-hedges, only to replace them with nectar-free forest trees or wire fences. Farmers also use a number of herbicides to control pasture weeds, and these reduce the floral diversity of the New Zealand countryside by killing non-target broad-leafed plants. Clovers remain the most important nectar source for bees in this country, and the impact of herbicides on pasture clover content is well documented (e.g. Edmonds *et al*., 1982). This concern was highlighted by two remits to the National Beekeepers' Association conference in 1982, which requested the agriculture industry to reduce the herbicide load on New Zealand pastures (*New Zealand Beekeeper*, June 1982).

Beekeepers perceive biological control of pasture weeds as a new threat to existing pollen and nectar sources in New Zealand. Criticism centres mainly on the current DSIR programme aimed at the control of nodding thistle, but includes a new project on gorse control which we hope to expand next year (Hill, 1983). In this paper I hope to show that our biological weed control programmes are not totally incompatible with the aims and interests of the New Zealand beekeeping industry. I will describe the philosophy behind biological weed control, and then consider in detail the projects aimed at nodding thistle and gorse.

Biological Control: Theory and Practice

A weed is a plant which when taken from its natural habitat without its herbivores and diseases and placed in a favourable environment, where it reproduces and develops with sufficient vigour to interfere with the activities of man. The emphasis in this definition lies in the removal of a plant's natural restraints, and by introducing those insects and diseases into New Zealand our job is to restore the natural balance which exists in a plant's native habitat.

Control of a weed normally means eradication of the plant from a limited area by the use of herbicides or some other management procedure. As a result weeds are often absent from treated areas, but very abundant elsewhere. Biological control, on the other hand, aims to lower the vigour and density of the weed throughout its range to such an extent that it is no longer regarded as a serious problem. Many plants in the New Zealand countryside are extremely common, but are not regarded as weeds. We would hope to reduce the density of our target weeds so that they can be regarded in the same light.

In the first stage of a biological control programme the species of insect or disease which cause damage to the weed in its native habitat are identified, and assessed for their ability to damage the plant. Likely candidates are then rigorously tested to prove that they do not attack any important plant species which the agents will encounter in their new environment, other than the target weed. This work is always carried out in the native range of the weed and normally takes at least 5 years. Only then are chosen control agents introduced into New Zealand for final safety checks under strict quarantine. A number of insects are then reared in quarantine and released. This phase also takes at least 5 years. If the control agent establishes here, it is normally a further 5-10 years before it becomes widespread, and possibly longer before it reaches sufficiently high numbers to cause damage to the weed.

As an illustration of how biological weed control works, let us consider the most famous and successful project undertaken to date. In 1920 two species of prickly pear cactus occupied 25 million hectares of Queensland rangeland. Most descriptions of this project simply say that the prickly pear moth *Cactoblastis cactorum* was introduced, and prickly pear quickly disappeared. In fact, as with all such work, this was a slow and complicated project. Exploration for potential control agents began in North and South America in 1912. In the following 20 years, 150 insect species were tested and 52 were selected for introduction to Australia. Of these, 19 were successfully reared and released in large numbers, but only 9 (including the moth) established successfully. The project ended in 1939, 27 years after the initial research, with prickly pear under sufficient control so that farming and grazing could be resumed on the affected land. In the following 44 years the weeds have remained in balance with their natural enemies at a low population density. This is not to say that any of the prickly pears are necessarily rare or even uncommon in Queensland. They are probably still amongst the commonest introduced plants in the State, occurring throughout the landscape at 1-15 plants per hectare.

This example illustrates three important features of biological weed control:

1. Such control is a long and gradual process. The most successful project undertaken so far took 27 years to complete.

2. Biological control can never result in the total eradication of a weed, it can only lower its density.

3. Successful control results in decreased awareness of the weed so that it is no longer regarded as a problem.

Nodding thistle

Nodding thistle is regarded as a valuable source of nectar, especially in areas subject to summer drought. A letter published in the *New Zealand Beekeeper* in March 1983 asked what economic cost/benefit analysis was carried out before Entomology Division of DSIR began its nodding thistle control programme. No reliable cost/benefit analysis of nodding thistle control has ever been carried out, nor has any estimate of its value to the New Zealand economy as a nectar source. Both studies would be lengthy, difficult, and extremely expensive. Though the economic effects of nodding thistle control have not been defined precisely, this weed can cause many serious problems for farmers, including reduced pasture production and accessibility, and a reduction in the values of wool, hay, and seed crops.

It is much simpler to estimate the current control costs borne by the New Zealand economy. Based on the subsidy paid to farmers for noxious weed control by the Noxious Plants Council in 1979/80, the rules governing the subsidy scheme, prevailing costs in 1979/80, and current control costs, it is possible to estimate the current cost of nodding thistle control in New Zealand. This calculation gives a figure of $6.2 million (Table 1), which includes the value of the herbicide applied and the costs of applying 25% of that herbicide by helicopter. This figure probably under-estimates the true cost of nodding thistle control, because it does not include application costs for the remaining 75% of herbicide, or unsubsidised herbicide use. Even this estimate of nodding thistle control costs approaches 50% of the value of New Zealand's annual surplus honey crop.

Our control programme began in 1973, and two insects, the crown-root weevil (Trichosirocalus horridus) and the receptacle weevil (Rhinocyllus conicus), have been introduced. The crown-root weevil has not yet established, but the receptacle weevil can now be found almost throughout New Zealand. This weevil lays eggs on nodding thistle buds, and hatched larvae feed in the receptacle. This results in seed abortion. The seed production of nodding thistle in New Zealand has consequently been severely reduced, though the impact of this on the density of thistles is not known yet. Approximately 5% of flowers which are heavily infested drop to the ground, but otherwise the weevil does not appear to affect nectar production.

What do we hope to achieve by the establishment of these insects in New Zealand? In line with the definition of control which was given earlier, successful control will be achieved when lowered thistle densities maintain themselves in equilibrium with the natural enemies which we have introduced. A parallel can be drawn between nodding thistle, which has certain characteristics which make it a serious noxious weed, and scotch thistle which only merits spasmodic control measures. If the vigour and reproductive capacity of nodding thistle could be reduced to that of scotch thistle, then it could be said that control had been achieved.

Table 1 shows that approximately 148 000 hectares of New Zealand pasture were sprayed for nodding thistle control in 1979/80. Though the impact of such herbicides on pasture quality is only poorly known (Edmunds et al., 1982), it has been established that most cause debilitation of clovers, which sometimes disappear from pastures entirely. Whatever the beekeepers' concern regarding nodding thistle, clover remains New Zealand's single largest nectar-source for honey production. A direct result of biological control of nodding thistle would be a large reduction in the use of pasture herbicides, and better clover production.

Gorse

Gorse is a serious impediment to the development of potentially productive farmland, and causes many hectares of improved pasture to revert to scrub every year. Our research into the prospects for controlling gorse biologically stems from a new emphasis on hill and high-country agricultural research recently initiated by the National Research Advisory Council. It is estimated that gorse can be found on 700 000 hectares in New Zealand, and that improvement of just 10% of this land could yield $24 million in animal production annually. Recently some uses have been suggested for gorse, and its value as an important early spring pollen source for bees cannot be disputed. As in the case of nodding thistle, a reliable analysis of the full costs and benefits of gorse control would be extremely complex, and no such analysis has been carried out. The current annual costs of gorse control can be estimated, however, again using Noxious Plants Council subsidy figures (Table 1). Assuming standard application rates, 35 000 hectares of gorse were sprayed in 1979/80. If this area is sprayed annually, and 75% of herbicide is applied by air, then the current annual cost of gorse control exceeds $14 million. This figure is also an under-estimate, since 25% of application costs are not accounted for, nor is unsubsidised herbicide application.

Gorse is the single most important problem facing the forestry industry in establishing new plantations. Typical site preparation costs are now over $600 per hectare, and include the costs of two or sometimes three applications of hormone herbicides for brushweed control. At least one of these applications can be directly attributed to gorse control, and at current planting rates this treatment alone costs over $5 million per annum. Gorse control is therefore costing the New Zealand economy at least $19 million per annum.

I hope that I have been able to show the economic importance of gorse, but how do we intend to achieve biological control, and what degree of control do we regard as sufficient? Gorse is an extremely common plant in Western Europe, and occupies thousands of hectares of heathland in the south of Britain. It is neither highly invasive nor vigorous, growing only approximately 15 cm per year. We believe that this lack of vigour can be attributed in part to the activity of herbivores, especially insects. We hope to introduce the most selective of these insects to New Zealand in an attempt to restore the natural balance which exists in Britain, and at present we have 4 insect species in mind. Two of these are undergoing final safety tests, and given favourable results from these tests we will release both species next year. It is impossible to predict how great an impact these introduced species will have in New Zealand, but like prickly pear in Queensland, gorse will never become rare, and will probably remain one of New Zealand's most abundant plants. It will be at least 5 years before control agents can be spread widely in New Zealand, and a further 5 to 10 years at least before any noticeable effect on gorse can be achieved.

Discussion

There is no doubt that many noxious weeds, especially nodding thistle and gorse, cause substantial losses in agricultural production in New Zealand. Control of such weeds is necessary to maintain the quality of existing pastures, and to develop potentially valuable scrublands.

Most current control procedures, especially fire and herbicides, have a severe impact not only on the target weed, but on other plants. Beekeepers suffer particularly from the impact of many herbicides on clovers and wayside flowering plants. The biological method of weed control possesses certain characteristics which give it distinct advantages over the more destructive methods, especially with regard to beekeeping.

1. Biological weed control takes a long time to establish. Programmes beginning now will not show measurable effects for many years, but if biological control is established it should provide stable weed densities from year to year.

2. Biological control can never result in the eradication of a weed, only a reduction in its vigour and density. Even when excellent control is achieved, as in the prickly pear example, the target weed is still common.

3. Successful biological control leads to decreased concern over the target weed and less application of alternative control procedures which can damage non-target plants.

In attempting to conserve noxious weeds beekeepers are at odds, not only with those of us involved in biological control, but with those interested in all forms of weed control. This includes the powerful pastoral agricultural industry whose influence guides our research. While the beekeeping industry places so much reliance on gazetted noxious weeds this conflict will continue. Since both industries stand to benefit greatly from increased beekeeping activity in New Zealand, both should concentrate on replacing noxious weeds as nectar and pollen sources by planting with species chosen from the vast array of appropriate flowering trees and shrubs now available for this purpose. In the meantime costly noxious weeds will remain legitimate targets for biological weed control research.

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	Value of herbicide applied 1979/80 ($)	Herbicide cost/ha 1979/80 ($)	Treated area 1979/80 (ha)	Herbicide cost/ha 1983 ($)	Estimated herbicide value 1983 ($)	Estimated cost of aerial application ($)	Estimated annual cost to economy 1983 ($)
Nodding thistle	1 841 000	12.44	148 000	17.04	2 522 000	3 700 000 (25% of total area)	6 222 000
Gorse	6 831 000	190.74	35 800	316.80	11 345 000	2 685 000 (75% of total area)	14 030 000

Table 1: Estimated cost of nodding thistle and gorse control to New Zealand agriculture. The value of herbicide applied in 1979/80 is based on subsidy figures only. The area treated annually is assumed to be constant. Only a proportion of application costs are included.

BIOLOGICAL CONTROL OF WASPS

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The problem. The German wasp, *Vespula germanica* (F.), established in New Zealand by accident, probably in 1943, near the Te Rapa Air Force base just north of Hamilton. Within about 20 years most of the vegetated areas of New Zealand were colonised, and throughout much of the country wasps had become pestiferous. Since wasps soon began attacking beehives, beekeepers were among the first to notice the new insect. Bees were killed, and honey and brood was removed. A survey of the cost of wasps to beekeeping which was conducted by Walton and Reid in 1974 indicated that the loss was $140,000 annually.

Additionally, newspapers have reported that high wasp numbers have caused schools to be closed, some timber milling and scrub clearing operations have had to be terminated, and much fruit has been destroyed. Many people exhibit vespiphobia, a fear of wasps and wasp stings.

Wasp life cycle

Normally a fertilized queen wasp begins constructing a nest during spring or early summer. She selects a dry, wind-proof canopy such as an abandoned mouse or rat nest, or a space within or under a decaying tree stump. A firm ceiling support such as a plant root from which to suspend the nest is essential. A queen wasp will construct up to 60 cells, within each of which she raises one worker wasp. Worker wasps begin emerging after a month, and immediately begin to take over the activities of foraging, nest construction and brood feeding from the queen.

During summer the nest grows rapidly, so that by autumn it is usually larger than the volume of a beehive super. At this point the nest begins producing drones and new queens. Unlike bees, wasp queens are raised in cells which are just like those in which worker wasps are raised except that they are larger. Wasp drones may be raised in either worker or queen cells. Many thousands of individuals of both sexes are usually produced.

On sunny days drones and new queens leave the nest and mate. With the onset of winter the fertilised queens hibernate in dry, secluded hibernaculae such as under loose bark on trees or between boards in stacks of timber.

Under normal circumstances most New Zealand nests and all European nests die by mid winter. However, if the New Zealand winter is mild and food such as honey dew, flies or honey bees is available through the winter, some nests can survive for at least two years. A nest that survives a winter normally reverts to producing workers as soon as the days begin to lengthen, although some drones and new queens may continue to be produced. Such a nest begins the spring with an enormous population advantage over a nest just initiated by a queen. It is these overwintered nests, which can grow to one or more cubic metres during their second summer, that cause many problems to beekeepers.

Reasons for abundance of wasps in New Zealand

German wasps belong to the group of insects commonly known in the northern hemisphere as "yellowjackets" and "hornets". The total number of species of these paper nest-building wasps is about 58. England has 7 species, and North America 19. New Zealand was entirely without yellowjackets or hornets before the German wasp became established.

The German wasp in New Zealand was therefore without competition from other similar wasp species. Additionally, studies of hundreds of nests by several researchers have failed to find any enemies of wasps here. Northern hemisphere nests, on the other hand, harbour numerous species of insects, mites and nematodes. These can reduce the rate of nest growth and so their ultimate size and wasp population. Sometimes nests can be killed by wasp enemies.

Wasp enemies

Perhaps wasp numbers could be reduced if an effective enemy of wasps could be introduced? Through published information and correspondence with researchers in the northern hemisphere, possible candidate wasp enemies were reduced to two species, one a beetle and the other a parasitic ichneumonid wasp. Both species attach and destroy German wasp brood.

The rate of attack by beetles upon wasp cells proved to be very low, so only the ichneumonid *Sphecophaga vesparum* was perservered with. Female *S. vesparum* are about 5-10 mm long, and very closely resemble many parasites of some New Zealand caterpillars. After entering a wasp nest and somehow evading attack from worker wasps, the female parasite lays from one to four eggs through the cap of a newly sealed brood cell onto the larva or early pupa within. Eggs hatch after several days. The small parasite larvae then crawl towards the abdomen of their host where feeding begins. At least the abdomen of the host is destroyed, and sometimes the thorax and head also.

Mature parasite larvae spin one of two kinds of cocoons. About 95% are thick-walled and distinctly yellow. Within these cocoons parasite larvae usually pass the winter, and adult parasites emerge the following summer. The other kind of cocoon is thin-walled and white. New adult females emerge from these as soon as 11 days after the egg is laid. These "summer" adults are very active. They run rapidly throughout the wasp nest, laying in as many suitable cells as possible. Larvae of these summer generation females produce yellow and white cocoons in about the same ratio as before. With this type of life cycle one invading parasite can give rise to sufficient parasites to virtually destroy a large wasp nest within a few months.

Attempted introduction of *Sphecophaga vesparum*

During 1979, 798 yellow cocoons were imported from Washington State, U.S.A.

Parasites were bred for several generations upon larvae of the German wasp within the insect quarantine facility at DSIR Lincoln. During 1980 six New Zealand-grown parasites were released into two field boxes which contained wasp nests, but the nests were not attacked.

From 1980-1981 8,493 yellow cocoons were imported from Europe. The cocoons were collected by personnel of the Commonwealth Institute of Biological Control Station at Delemont, Switzerland. A series of six tests was conducted to determine whether or not parasite would attack honey bee larvae. (Table 1.)

Table 1: Details of honey bee - *Sphecophaga vesparum* tests.

Test number	Test Conditions	*Sphecophaga* released	Result
1	Honey bee brood covered with bees	22	No attack
2	Honey bee and German wasp brood, no adults	18	13 parasite cocoons in wasp comb
3	Honey bee brood, no bees	2	No attack
4	Honey bee brood, a few nurse bees at top of comb	30	2 parasite cocoons on 2 drone cells at bottom of frame
5	Defended nucleus hive, parasites released into cage fixed to hive entrance	4	(Parasites dismembered (in cage by worker bees, (no attack on brood, no (attempt by parasites (to enter hive
6	" "	23	

Tests 1 - 4 were conducted within screened containers about the size of a beehive super. The cage used in Tests 5 - 6 was about one third of a cubic metre, and was connected by a 300 mm long wire mesh tunnel to the entrance of the nucleus beehive.

The results of these tests, and the fact that the parasite has never attacked honey bees anywhere in the world, indicate that New Zealand honey bees would not be attacked. The Director of Entomology Division, DSIR, has therefore authorised the release of parasites that have been bred for one generation in quarantine. Our present effort is directed towards breeding more parasites so that the probability of field establishment will be increased.

Occurrence of Vespula vulgaris (L.) in New Zealand

Earlier this year entomologists ascertained that another species of wasp, known in the northern hemisphere as the common wasp, is established in the Dunedin and Wellington-Lower Hutt areas. The size and colouration of the three castes of V. vulgaris is very similar to that of the corresponding castes of V. germanica. However V. vulgaris workers and queens have an anchor-shaped black mark on the face, versus a black line or row of dots in V. germanica, and the abdomen of drone V. vulgaris is usually darker than that of V. germanica. Nests of V. vulgaris are coloured a mottled light brown, whereas nests of V. germanica are grey. The life cycle of the two species is very similar, although overwintering nests of V. vulgaris are as yet unknown.

Studies in Europe indicate that V. vulgaris is usually 2-3 times as common as V. germanica. Four nests of V. vulgaris which were collected in Dunedin during autumn were larger than the average size of autumn nests from Europe and North America, and from two to 23 times as many queens were produced. Factors that influence the biology of the common wasp in New Zealand therefore appear to be very favourable.

The common wasp probably established here during the late 1970s. As the species tolerates a wide range of habitats overseas, we can expect most of New Zealand to be occupied within the foreseeable future. There are also indications that V. vulgaris may become more common than V. germanica, but whether the total number of wasps will increase or remain about the same through displacement of V. germanica by V. vulgaris remains to be seen. Beech forests where honeydew is plentiful may support large numbers of V. vulgaris, but availability of nest sites will also be important.

The possible status of the common wasp as an enemy of honey bees will be of major concern to beekeepers. Nuclei have been robbed in autumn in England, and dead worker wasps have been found among hive debris in the United States. Worker V. vulgaris have taken foraging honey bees in the field in England (3 records), Russia, and Connecticut (north-eastern USA). These reports suggest that beekeepers here can expect their bees to be attacked, but I estimate that the severity of attack may not reach the extreme levels sometimes experienced with V. germanica.

Control measures for V. vulgaris are the same as those for V. germanica - destruction of nests. However one benefit from the establishment of the common wasp is that the parasite for V. germanica is much more effective against V. vulgaris, so the prospects for successfully establishing the parasite and for maximising its efficacy are enhanced. If the parasite does establish, an overall reduction of both the numbers of wasps and the average size of their nests could be expected, but many years would elapse before this would occur. Until then existing measures for wasp control must continue to be employed.

A COMMUNITY TREE-PLANTING PROGRAMME HELPS TO PROVIDE SHELTER, BEE FORAGE AND EMPLOYMENT

Lindsay Jeffs

Introduction

Beekeepers and people working in the employment agencies share one major difference from the general community - they are both in a growth industry.

Beekeeping is the highest agricultural growth sector in New Zealand, with the number of hives increasing at 4.2% per annum over the last 5 years (Appendix 1). The number of people registered as unemployed or on special work programmes rose by 62 408 over the last 5 years, until at 30th June 1983 it stood at 112 724 - an annual increase of 24.8% (Appendix 2).

Yet both groups face problems. For beekeepers the problems are:

1. The seasonal fluctuation of the honey crop.

2. The lack of real growth in the industry's honey production at a time when the number of beekeepers and hives has increased. This has caused a decline in returns per hive without even considering other cost factors such as inflation, fuel price, etc (Appendix 1.4).

3. The erosion of the country's pollen and nectar resource.

For people in the employment agencies the problems are:

1. The sheer number of unemployed people. In New Zealand we now face the situation where our real unemployment level represents 10.1% of the workforce - a figure which places us alongside the USA (10.8%), EEC (13%), and the OECD nations' average of 8.5%. A special feature of the unemployment pattern in New Zealand is that two-thirds of the registered unemployed are under the age of 25.

   It is now true to say that the fear of unemployment has invaded the majority of New Zealand households, and the public opinion polls (July 1983) show that New Zealanders view unemployment as the major problem facing the country at the present time.

2. The need to assist people to cope with unemployment and its associated socio-economic problems.

3. The need to create worthwhile "special work programmes" to assist people who are temporarily or permanently unemployed.

4. The provision of relevant job training to assist people obtain future employment.

5. The rapid technological and social change occurring within society.

Beekeepers in the South Canterbury region and the YMCA in Timaru have combined in an attempt to solve the problems that each organisation faces, by using a Government-sponsored employment programme to produce pollen and nectar tree stocks.

Background

The South Canterbury honey industry is based on approximately 15 000 hives, and about 30 full time beekeepers and a number of part-timers. The total return from the sale of honey and wax is some $912,000 (60,000 kg honey). The limitations on production are the region's pollen and nectar resource and climatic factors.

South Canterbury beekeepers, like most of their counterparts in other districts, have suffered from modern agricultural developments aimed at increasing agricultural production. Rough spots on farms; weeds, such as thistles and buttercup, growing within established crops, pastures, and on road frontages, have been suppressed through the use of chemical and now biological control. Miles of gorse hedgerows, established by our forebears for stock enclosures and shelter, have been ripped out and replaced by wire fences. The richer the farming area the more pronounced such tendencies seem to be - due no doubt to the tax advantages farm improvements enjoy, plus the effect of such government incentives as the stock retention scheme, SMP's (supplementary minimum prices), and subsidised noxious weed control.

However, farmers have not been the only group involved in the intensification of land use. "Weed" species and "wild" areas on roadsides and riverbeds have been removed by local councils or catchment boards, with a consequent loss of pollen and nectar producing weed species such as broom, dandelion, and blackberry.

Government bodies such as the New Zealand Forest Service have encouraged the planting of single species in shelter and woodlot forests on marginal land. Until today, we are faced with individuals and organisations considering land use from a single-use perspective.

The effect of such processes has been to the detriment of the beekeeper, as traditional sources of bee forage are eliminated. In the Canterbury Plains area the loss of earlier flowering plants has caused pollen shortages in the early spring, and affected the hives' ability to raise healthy young bees in the spring. The length of the honey flow has also been shortened by the loss of weed species such as thistles, the nectar of which is compatible with the predominant white clover honey that is collected.

These tendencies cause beekeeping in the South Canterbury area to be less predictable, and increase the costs involved. Beekeepers are forced to expend time, effort, and money, to compensate for the loss of bee forage. To adjust to the spring nectar, and in particular, pollen shortage, beekeepers either supply pollen supplements or move their hives near riverbeds unaltered by weed control techniques, where such plants as willows can provide the pollen required. To adjust to the decrease in the diversity of the main honey flow flora, beekeepers need to shift their hives more frequently and to improve their management and handling efficiency to remain competitive.

Any of these techniques involve expense to the beekeeper, which is reflected in both the profitability of the industry and the price of honey. In a poor year, for example, when beekeepers may be forced to provide pollen supplements, this could cost for the South Canterbury region $300,000 (15,000 hives at $20 per hive).

In an area such as South Canterbury the above problems are further exacerbated by the region's pronounced tendency to periodic drought associated with strong, dry winds of north-westerly direction.

Drought conditions affect the availability of water and soil nutrients essential to plant life. Such conditions thus reduce the ability of plants to produce pollen and nectar by affecting the plants' growth habit, flower initiation, length of flowering, disease susceptibility, wind damage, etc.

In addition, climatic factors affect the ability of the bees to forage for food. Dr Eva Crane (1) suggests that most foraging is done within 1 or 2 km of the hive, although it is not unusual for bees to travel up to 4-5 km to pollen sources. Bees apparently do not fly to collect nectar if the temperature is less than about 12°C or the wind speed is greater than 25 km/hr. Also plants cannot yield nectar unless the temperature is high enough, for example, limes 15°C, white clover 23°C.

Thus moves such as the planting of trees to modify the negative affects of our climate, by reducing soil loss, wind speed and evaporation, are welcomed by beekeepers. However, single purpose shelter such as trimmed pine hedges do not enhance the pollen and nectar resource of the region.

Beekeeper initiatives

To overcome these problems beekeepers in the South Canterbury region have taken a number of positive steps. For example:

As individuals
- by meeting and talking with groups to increase public awareness of the problems the industry faces.
- by recommending to farmers, horticulturists, and nurseries various plants that are suitable for bee forage.
- by negotiations with local nurseries to provide plants to match farmers' orders.
- by taking various plants on their trucks to drop-off to farmers as a means of payment, goodwill, or marketing.
- by designing and planting their own properties as bee forage areas as an example of what can be done.

- by becoming involved in community projects, which have a direct or indirect bearing on the quantity and quality of the local pollen and nectar source.

  One such example is Fred Bartum's involvement in the programme to refurbish the Pleasant Point Domain. This domain is characterised by large-scale block plantings of various exotic trees at about the turn of the century. Many of these trees are now dead, dying, or diseased, due to age, the effect of several gales, and neglect.

  By the use of a YMCA Work Skills Development Project team (WSDP), many of the spent trees have been removed and thousands of multi-purpose trees planted, watered, and tended. This project, which has been going for approximately 15 months, is a long-term one which hopefully will see the Pleasant Point Domain return to its former glory, whilst benefiting both passive and active users of the facilities. By having an input into such a project, the local beekeeper can ensure that a number of plants with bee forage potential are included, and also assist in the creation of work opportunities for the local people.

As a group

- working with the local MAF Apicultural Advisory Officer to produce lists of suitable multi-purpose (shelter, amenity, erosion control, and bee forage) plants for the local area.

- making contact with organisations such as the Farm Forestry and NZ Tree Crops Associations, whose interests overlap, to host joint field days.

- becoming involved in the local and regional planning process by discussing their requirements for multi-purpose land use with local councils, ad hoc bodies (catchment boards, etc), and government departments (Forest Service and Lands & Survey) on a formal or informal basis.

- jointly hosting field days with the local catchment authority so that each group gets to know the other's needs. Such field days have been held with the South Canterbury Catchment Board, which administers the region's water and soil resources and is involved in the prevention of water and wind erosion of soil through river control and wind control techniques. A number of local soil conservators who work with farmers or other organisations to revegetate bare soil prone to erosion by using shelterbelts, berm land protection and hillside erosion control, have a broad vision and a keen interest in the use of multi-purpose trees fulfilling functions other than pure control of soil erosion.

The Timaru project

From the liaison between the South Canterbury Catchment Board, MAF, beekeepers, and the YMCA, developed a community project that could fulfil the objectives of all parties.

This Work Skill Development Programme (WSDP) project aims to establish an experimental nursery producing multi-purpose pollen and nectar shrubs and trees which are suitable for planting in the South Canterbury region. The objectives of the project are as follows:

1. The training of young people in basic nursery skills, tree planting, and maintenance.
2. Expansion of the pollen and nectar resources to assist the honey industry in South Canterbury.
3. Expansion of shelter on farms.
4. Control of soil erosion.
5. Provision of amenity planting.
6. Enhancement of the landscape.

What is a WSDP?

A Work Skills Development Project is a Department of Labour funded scheme whose aim "..... is to encourage public sector employing authorities and community organisations to provide supervised employment and training for job seekers who, because of their limited work capabilities, cannot be considered for placement in subsidised or unsubsidised private sector jobs." (2)

The sponsoring body applies for the right to run a specific project and, if approved, appoints a supervisor who may be recruited for up to 2 years through either the Department of Labour or through outside sources. The Department will reimburse the wages of approved supervisors and trainees who it has selected as having needs for this type of training.

A labour-related overhead allowance is also granted to meet ACC levies, necessary personal equipment, minor tools, machinery hire, and transport. For certain projects a grant may be available to cover the costs of special materials used on a project. The sponsoring organisation provides the training which is of a sub-apprenticeship or work skills nature, designed to assist the individuals to make the transition into unsubsidised work as quickly as possible. In addition, limited training may be given in pre-employment courses, life-skills, and personality development. The trainees, depending upon local interpretation, may be on the scheme for up to six or twelve months.

Planning requirements

These projects are not created without considerable thought and forward planning prior to submitting a proposal to the Department of Labour. It is necessary to:

1. Find a suitable sponsoring organisation.

2. Be prepared for the inevitable delays. When working with plant material such delays, whatever the cause, can disrupt growing schedules for up to 12 months.

3. Locate a site for the experimental nursery that is centrally located, of suitable soil type, in which temporary facilities such as sheds can be placed. Such a site was found in Timaru by the MWD on a vacant section on the proposed motorway.

4. Obtain support from organisations other than the local beekeepers who might be affected by the project, for example; the local Catchment Board, the Parks and Reserves Department of the local City Council from which cutting material and training might be obtained, the Advisory Services Division of MAF, the Lands & Survey Department, the local technical institute, and local nurseries.

5. Find a supervisor with a particular interest in the project who could also be responsible for the detailed planning and establishment of a nursery, provide instruction in basic nursery techniques, liaise with interested parties, and determine which species would be suitable for cultivation.

6. Prepare a carefully worded case to submit to the Department of Labour for approval. Such a case should have clearly stated goals and objectives, and a work programme which is within the constraints of available capital, expertise and labour.

What has been achieved?

In our case, we submitted a proposal to the Department of Labour for approval in November 1982, and received formal notification of agreement in January 1983. Since that date to mid-July 1983, considerable progress has been made towards meeting our original objectives and our immediate goal of establishing, by the spring, a nursery capable of producing substantial stocks of pollen and nectar tree stocks.

1. A supervisor and six trainees have been appointed to the project.

2. Contact (personal or written) has been made with people throughout New Zealand known to have expressed interest in this field, whether in the public or private sector.

3. An amenity block and propagating shed has been erected on the site, while existing chook-houses have been converted to storage sheds.

4. A shadehouse, cold frames, raised seed beds, bulk material storage bins, compost bins, and open ground beds have been built or prepared at the site.

5. Seeds and cutting material for propagation have been collected from various South Canterbury resources, such as the botanical gardens, private farms and houses, public buildings, the MAF, and Catchment Board research stations. We have also been fortunate in obtaining some material from the MWD stations at Palmerston North and Alexandra, plus DSIR, Lincoln. Most of this material is now growing, either at the site or at the homes of various trainees whose parents have allowed us to use their facilities of glasshouses or tunnel houses with 'hot beds'. Careful records have been kept of the source of plant material and the propagation methods used, to enhance the trainees' work experience and to determine suitable cultivars for the South Canterbury conditions.

6. A number of local nurseries have been approached and have given their support to the project, either verbally or by providing training days or materials.

7. Preparation for the next 6 months' planting is now well advanced. Orders for seeds have been placed with suppliers both within New Zealand and overseas, sources of suitable plants have been located, and plans for building our own tunnel house finalised. Agreement has been reached with the Timaru City Council Parks and Reserves Department to use land at their new nursery site at Washdyke, for planting certain open ground stocks (such as willows) which will be obtained from the South Canterbury Catchment Board's nursery.

8. A joint committee has been established with the beekeepers, Catchment Board officers, and the MAF Apicultural Advisory Officer to monitor and provide assistance to the project. A number of beekeepers, through their local association, have generously donated several hundred dollars for equipment.

9. A system of distributing the tree stocks produced has been devised. As our project is a work skills programme the plants cannot be sold, so when they become available for planting (some this year but the majority from 1984 onwards) they will be made available to beekeepers, who will arrange their distribution to farmers, catchment boards, local bodies, or government departments, to include in existing and planned shelter belts and amenity areas.

   Emphasis will be placed on distributing the tree stocks in areas of known pollen and nectar shortage. The actual planting will be done either by the work skills trainees or by the recipients of the plants. However, careful records will be kept of all tree stocks disposed of, and regular checks will be made to ensure weed control and to monitor tree mortality and growth. From these records it is hoped that species recommendations, based on soil type, climatic factors, and husbandry, will be determined and incorporated into the region's tree planting programmes.

10. A species list acceptable to all parties has been produced.

Special criteria

Initially the species to be included in the project were to be multipurpose pollen and nectar-bearing trees and shrubs of up to 5 metres in height, that could be incorporated as under-planting in some of the 600 kilometres of permanently fenced windbreaks already established under the South Canterbury Catchment Board's Wind Erosion Control Scheme. Gradually the criteria have been enlarged to permit more scope for amenity and shelter planting, while maintaining the specific local requirements of species that:

1. Flower in early spring to early summer, and produce pollen as well as nectar.

2. Are hardy, wind, drought, and frost (-8°C) tolerant.

3. Produce a honey type compatible with the clover honey for which the region is known.

4. Will not be of nuisance value to landowners (e.g. hawthorn and broom).

In addition to the above selection criteria, MacFarlane (3) lists the following requirements for bee forage trees, most of which have been considered in determining suitable species for our project.

a. A high yield of honey per hectare.

b. The honey needs to have a good colour and taste.

c. The flowers must be attractive to pollinating bees.

d. The trees and shrubs should have maximum practical use and economic value for the landowners, because most farmers do not derive cash income from bees. Species should possess benefits in addition to honey and pollination, e.g. livestock fodder, timber production, windbreak, or shelter uses.

e. Bee forage plants should have minimal pest and disease problems themselves, and their flowers should not provide undue benefit to pest insects.

f. Trees should start to flower at a young age, reach their full nectar and pollen bearing potential as soon as possible, and continue to flower for a large number of years.

g. A long flowering period each season is preferred.

h. It is an advantage to have a regular seasonal flowering and nectar yield.

i. The time of flowering is important, because it should complement major alternative sources, to avoid undue competition for pollination in crops and to develop a sequence of bee forage.

j. Pollen must be attractive to bees and provide high nutritional value, so that brood rearing of pollinating bees is maximised.

k. The bee forage plant must be free from toxic materials to bees, livestock, or humans.

The list of trees which we are currently growing or intend to grow is given in Appendix 3. Please note that this list will not be suitable for all districts, due to climatic factors and local requirements. The choice of species and the number of each species to be propagated must reflect local beekeepers' needs.

Project constraints

From our experience so far we have identified several constraints to the running of a nursery operation within a work skills development project.

1. The technology used in the nursery needs to be rugged, simple, with a low capital cost, and utilising available labour and expertise.

   As a result the choice of species has to be influenced, not only by the selection criteria mentioned earlier, but by the plants' relative ease of propagation.

   Species that can be cultivated in unheated tunnel houses or preferably cold frames or open ground should be favoured, as unlike commercial nurseries a work skills nursery can only operate during normal business hours.

2. The capital required, especially in the initial 'establishment' phase, often exceeds that available from Government funding. The community, and especially the section of the community which stands to benefit most from the project, thus needs to invest capital into the project. Without community support, such projects will not succeed.

3. The work skills trainees have little work knowledge and skills in plant propagation techniques. Frequently, due to personal reasons and the selection criteria used, they may possess little interest in the project. This can make motivation difficult.

4. The wage rate offered may make it difficult to secure and retain skilled supervisors, on whom the real success of the project depends.

5. The planning, administration, and organisational effort required greatly exceeds that involved in most work skills development projects and 'normal' business management.

Who will benefit?

The project is an exciting challenge with positive advantages to many sections of the community.

1. Agricultural producers (farmers and horticulturists)

Bees are necessary to agriculture as pollinators. Modern agriculture, especially horticultural diversification, has increased the demand for pollination services to achieve fruit and seed set; but pastoral farming relies for the long term persistence of clover in pasture by pollination.

Feral, or wild, colonies of honey bees, bumble bees, and native bees are too few in number to provide this service, and their number is predicted to decrease as agriculture expands into the present marginal lands. Wallingford (4) has suggested that there are two main directions commercial beekeeping can take to meet this demand:

1. Expansion of an area's pollen and nectar resource by planting desirable bee forage plants so that beekeeping for honey production remains economic.

2. Where honey production becomes unprofitable for lack of floral sources, beekeeping for pollination service fees alone may eventuate.

This latter approach is afflicted with difficulties, for example; access to orchard sites in the spring is often difficult and is labour intensive, the pollen and nectar production is often too small for maintenance of hive numbers and pollen supplements are required, research suggests that shifting hives can adversely affect the hive's ability to gather a later crop, and pesticide usage is a constant threat to the bees and beekeepers welfare - approximately 20% of Californian pollination service colonies are lost to agricultural chemical usage in each year.

Our project, therefore, takes the lower-risk first option of maintaining or expanding the area's ability to supply pollen and nectar.

Farmers will also benefit from improved agricultural production associated with the planting of windbelts, shelter copses, or agroforestry. Research indicates that pasture production can be increased significantly when soil and moisture losses are reduced by the use of trees.

The planting of trees also adds to land value. If multi-purpose trees are selected, farmers could benefit from the production of timber for commercial uses such as furniture making, posts, firewood, and animal fodder.

Properly planned, the increase in diversity of land use results in an enhanced landscape.

2. Ad hoc bodies and government departments

Planting areas such as windbreaks and woodlots, which have been jointly funded by farmers and agencies such as catchment boards and Forest Service, makes more efficient use of the land. Multiple use of land where stock have been excluded is sound land use, benefiting the farmer, the rural community and the nation, and provides for better use of taxpayers' and ratepayers' money.

3. The nursery industry

An essential part of the project is to identify the requirements for multi-purpose tree stocks that enlarge the pollen and nectar resources and thus stimulate demand for these species of plants. This will benefit local nurseries, who at the end of the project will have the opportunity to maintain supplies of tree stocks for this segment of the market, yet they will be spared the need to invest venture capital into the project. The experimental costs of the project, species identification, tree multiplication, tree planting, and record keeping, will be borne by the government and the community. When the principal parties feel confident to make recommendations on tree species, it is suggested that the beekeepers will place contract orders with local nurseries to supply the requirements.

4. The YMCA

The YMCA in Timaru achieves its goal of servicing the community by; assisting the unemployed to learn specific work skills; helping to create new job opportunities in areas such as nursery work, beekeeping, tree planting, and maybe farming; enhancing the landscape, which could in the long-term create tourist potential; and improving the general economic and social conditions of the South Canterbury region.

5. The beekeeping industry

Through the maintenance, and hopefully expansion, of the region's bee forage resources, coupled with a potential increase in available daily and seasonal bee forage time (due to the modification of the climatic extremes resulting from an increasingly tree-covered environment), the beekeeping industry will have its future stability and expansion ensured.

Conclusion

Beekeepers and employment agencies can attempt to address their problems as individuals, as a group, or in combination with other groups. As individual beekeepers it is possible to take various initiatives to conserve the pollen and nectar resources of your region and to assist in the creation of employment opportunities for your own children, by increasing hive numbers or by diversification. However, the long term bee forage resource will depend upon the attitudes and practices of farmers, councils, *ad hoc* bodies and government departments, while employment will depend upon the soundness of the nation's economy, government actions, and social and technological change. To influence these factors it is necessary to work with other organisations. No one group will have the financial or human resources necessary, but by using government incentives a start can be made.

From projects, such as this Timaru one, new developments in beekeeping seem possible. Instead of beekeepers being placed in a position only to react to adverse trends, they could take the initiative to determine the type, quality and quantity of a region's pollen and nectar supply. Can we see the day when beekeepers move towards managing their own pollen and nectar resource? The time for taking such initiatives is now. The financial, human, and other resources will probably never be more freely available.

Acknowledgements

Thanks for assistance in preparing this paper are due to Mr Kerry Simpson, MAF Apicultural Advisory Officer, and Mr David Stringer, Soil Conservator, South Canterbury Catchment Board.

Appendix 1 - New Zealand beekeeping statistics

Table 1 - Registered beekeepers by hive holding category

Category	1982	1981	1980	1979	1978	1977
1 to 50 hives	5568	5124	4792	4212	3737	3372
51 to 500 hives	347	323	301	274	232	217
500+ hives	137	131	124	121	123	120
Totals	6052	5578	5217	4607	4092	3709

Table 2 - Registered apiaries by hive holding category

Category	1982	1981	1980	1979	1978	1977
1 to 50 hives	7755	7197	6780	5895	5352	4589
51 to 500 hives	4490	3968	4230	4222	3782	3345
500+ hives	8774	8994	8440	8321	8139	8329
Totals	21019	20159	19450	18438	17273	16263

Table 3 - Registered hives by hive holding category

Category	1982	1981	1980	1979	1978	1977
1 to 50 hives	30249	28173	25809	23865	21136	19616
51 to 500 hives	60553	53569	57805	59849	50734	45583
500+ hives	162803	156355	150196	143516	139108	142038
Totals	253605	238097	233810	226870	210978	207237

Table 4 - Surplus honey crop (tonnes)

	1982	1981	1980	1979	1978	1977
North Island	4215	3251	2889			
South Island	2280	3680	4600			
New Zealand	6495	6931	7489	6474	8269	6078

Appendix 2 - New Zealand unemployment statistics

	1983	1982	1981	1980	1979	1978	1977
Registered unemployed	76868	48487	46928	33725	25363	24035	5844
Special work schemes	35856	31247	20418	19736	24953	18281	6873
Totals	112724	79734	67346	53461	50316	42316	12717

Appendix 3 - Species lists used in Timaru project

Scientific name	Common name	Maximum height (m)	Growth rate	Nectar and pollen value
A. Flowering period winter - early spring (June-September)				
Acacia baileyana	Cootamundra wattle	10	F	PN
Acacia boormanii	Snowy River wattle	5	F	PN
Acacia floribunda	sallow wattle	5	F	N
Acacia longifolia	golden wattle	5	F	P
Caragana arborescens	Himalayan pea tree	7	F	NP
Chamaecytisus palmensis	tree lucerne	5-7	F	PN
Erica lusitanica	Spanish heath	2	M	NP
Fushia excorticata	kotukutuku	3	M	N:P
Grevillea banksii	spider plant	7	F	NP
Grevillea rosmarinifolia	spider plant	2	F	NP
Ribes sanguinem	flowering currant	3-5	F	N:P
Rosemarinus sp.	rosemary	2	M	N:P
Salix caprea discolor	pussy willow	12	F	N:P
Sophora microphylla	kowhai	3	S	N:P
Sophora tetraptera	kowhai	7	S	N:P
B. Flowering period spring-early summer (October-November)				
Abelia grandiflora	abelia	2	F	NP
Aesculus hippocastanum	horse chestnut	30	M	NP
Buddleia salvifolia	buddleia	4	F	NP
Corokia cotoneaster	corokia, korokio	3	S-M	N
Corylus avellana	hazelnut	3	S-M	PN
Cotoneaster conspicuus	cotoneaster	2	F	NP
Cotoneaster horizontalis	cotoneaster	1	F	NP
Escallonia sp.	red escallonia	2	M	NP
Hebe parviflora	kokomuka taranga	3	F	N:P
Hebe salicifolia	koromiko	4	F	N:P
Hebe stricta	koromiko	3	F	N:P
Medicago arborea	tree medic	3	F	P
Pittosporum tenuifolium	kohuhu	7	M	NP
Pittosporum eugenioides	lemonwood	13	M	N:P
Plagianthus betulinus	ribbonwood	12	M	N

Salix fragilis	crack willow	20	F	N:P
Salix purpurea incana	bitter willow	3	F	N:P
Salix gatugensis	willow	5	F	N:P
Salix pentandra	willow	5	F	N:P
Sorbus aucuparia	rowan	4	M	P

C. Flowering period summer (December-February)

Ceanothus spp.	Californian lilac	2.5	M-F	NP
Cordyline australis	cabbage tree	5	F	NP
Eucalyptus albens	white box	25	F	N
Eucalyptus melliodora	yellow box	30	M-S	N
Eucalyptus pauciflora nivophila	snow gum	7	S	N
Hoheria angustifolia	narrow-leafed lacebark	12	F	N:P
Hoheria populnea	lacebark	13	M	N:P
Salix triandra "Semperflorens"	willow	4	F	N:P
Tilia spp.	lime	30	S	N

D. Flowering period winter (April-May)

Olearia paniculata	olearia	5	F	PN

KEY:

Growth rates: Fast, Medium, Slow

Nectar and pollen value:

N Nectar-producing source

P Pollen-producing source

NP Exploited by bees more as a nectar source than as a pollen source

PN Exploited by bees more as a pollen than as a nectar source

N:P Equally valuable for nectar and pollen.

References

1. Crane, E.E. 1973. Honey, a comprehensive survey. London, Heinemann, pp 13-20.

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3. MacFarlane, R.P. 1983. Pollination and bee forage: A viewpoint paper for submission on tree crops in the high country, pp 4-5. Unpublished report.

4. Wallingford, N. 1979. The nature of apiculture in a changing agriculture. New Zealand Beekeeper 40 (2): 15-16.

A wider bibliography is obtainable from the author.

CONCLUDING REMARKS

John Scott

Ladies and gentlemen, I'm the wind-up speaker, the mechanical man. My role is to present one view of the seminar, and that one view will be my own. My instructions are that I should be brief and I've got my briefs with me.

I anticipate that you would want me to express thanks to the speakers who have contributed so much to the success of the day. I think they have coped very well, as initially there were some problems with the venue, but I thank them sincerely for sharing their ideas, their experiences, and their research information with us.

Now if I could single out one particular man I would refer to Mr Adrian Tasman, and compliment him not only for his delivery but for his aids, and for the subject matter. I believe he earned his place amongst the professionals today.

That brings me to another aspect of my seminar that I would like to comment on. Perhaps I could emphasise at this stage that as the final speaker there is no opportunity for you (I hope I am right on this) to challenge, question or even discuss what I say. I don't doubt, and I certainly would welcome the opportunity later on, perhaps in the bar or wherever else, to clarify any points that I raise, or to argue, justify, and to hear your point of view.

But in connection with the subject matter of the seminar I always expect to get some sort of measure of the health and vigour of an organisation or a group from the programmes which they attract, and which they support.

Now in this case the heartbeat or the pulsebeat was, in my view, not very strong. There was no clear theme, there was no evidence of industry goals, there was almost an over-concern perhaps with the threats facing the industry. There was only one paper dealing with product development, and the last paper which certainly dealt with a matter which would be dear to the hearts of most people here.

Now I would ask; is the great leap forward for the beekeeping industry likely to come from these issues that we have talked about today? I challenge you with the statement, that if this industry is to maintain its importance and survive as an industry, it must be saying to research in a credible way; this is where we are heading, these are the problems that we've got to overcome. Then and only then, we can respond appropriately to those scientists or others who are paid from the public purse, and who say to us that their personal interests don't lie in contributing to New Zealand's economic future.

I believe you should be saying to the MAF advisory service "these are the critical issues with which we need your help".

Now I expect that both scientists and advisers are going to argue, to seek clarification or justification, but I believe they should do so with a respect which I think is lacking in so far as the industry is concerned at the moment.

In advocating that the National Beekeepers' Association take the lead in planning for their industry, I'm not singling out this group for criticism as the only ones who have abdicated their responsibilities in this area. I think horticulture and agriculture are full of such examples.

The meat industry, the largest primary industry in the country, is a classic. They have been selling meat for, it must be 101 years now, and it is only at this stage that the Meat Board is saying; we must be more concerned with what the market requires; we must ensure that this message gets back to the producer; we must in some way give him the incentive to produce the commodity that the market wants.

Now I don't speak to you as a person who is an expert in planning, as one who has already done what I'm suggesting your association should do. But I am committed as a member of MAF to a planning approach to the use of the Ministry resources. We are underway. I have certainly had the reservations and doubts about one's ability to look into the future and make any meaningful decisions, that you're probably having while I'm talking about this subject, but the alternative is less acceptable.

You may be interested that our major goal (and I am talking about Advisory Services Division of MAF now) as a result of our planning to date, is growth in export products.

I just wonder where the beekeeping industry ranks in this regard. From something I was reading in the plane flying over this morning, it would appear that the sale of records of New Zealand music may well already be threatening the beekeeping industry in terms of export earnings.

I think a seminar such as this must be entertaining, and I think it has succeeded in that because it has kept you in your seats right through a long day. It must be informative, and I believe there has been a lot of general information being passed over, so it has succeeded in those two areas.

But the most important result I would expect, look for, after a seminar is to see people taking home messages which they can apply to the benefit of their businesses. I think it is in that area that we have fallen down and if I'm correct, if we have fallen down, it is because the Association has not done its planning, or if it has it certainly has not made us party to its goals.

I will leave you with those thoughts.