BEHAVIOUR AND EFFECTIVENESS OF BEES IN POLLINATING LEGUMES

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Abstract

One honeybee or bumblebee working on each square metre of white clover or red clover gave adequate pollination. This could be obtained with one hive of honeybees to each three hectares of flowering clover. Lucerne seeding averaged only 10% of the potential maximum in open fields with honey- or bumblebees. In cages where honeybees were forced to gather pollen, this was raised to 30% but it was not possible to increase seed set significantly in the fields.

INTRODUCTION

IN ASSOCIATION WITH T. Palmer-Jones of the Wallaceville Animal Research Centre, the writer has studied the pollination requirements of several crops (Palmer- Jones et al. 1962; Palmer-Jones and Forster, 1965, 1966, 1971).

Although the association between bees and white clover *(Trifolium repens)* is accepted, there was little known about the finer points of white clover pollination so some investigations were carried out.

Cages were used to control bee densities and to give the two extremes of bee coverage-no bees at all, and complete saturation. The normal bee population was supplemented with an extra $2\frac{1}{2}$ hives/ha on one crop. Other comparable seed crops with average bee coverage as supplied by commercial apiaries were used as controls.

Further comparisons were made in the Mackenzie Country where at that time there were very few apiaries and enclosures were erected to keep stock off plots to allow clover to seed.

Counts were made of flowers and the number of honey- and bumblebees on the crops. It was only close to the main range in the high country that bumblebees were a factor in white clover pollination. Quite short distances away there were at times very few.

When crops had seeded, ripe heads were collected and closely analysed. The number of florets setting seed was decided entirely by the number of bees working the crops. Number of seeds per

pod, number of shrivelled seed, and percentage germination did not seem to be associated with bee visitation,

Caged clover with no bees had no seed at all. Fifty bees/ha gave 5% florets setting seed with a gradual rise to nearly 10 000 bees/ha and nearly every floret seeding. Even the extremely high artificially induced concentration of 35 000 bees/ha gave only 97%. Thus, with one bee working on each square metre of clover, ample pollination should occur. One hive for 3 ha of flowering clover will achieve this. The effect of building up bee concentration at one point was spread over about a radius of 1½ km.

The pollination requirements of red clover *(T. pratense)* have received much attention over the years. There does appear to be an accepted natural affinity between bumblebees and red clover. This has created a strong impression that it is bumblebees and maybe bumblebees alone that effectively pollinated red clover.

It is a fact that the tongue of the honeybee is seldom more than 7 mm long and red clover florets are about 10 mm deep. But, as Snodgrass (1925) ' points out, several appendages of the bee's head combine to form the proboscis and it is the proboscis that is inserted into the flower.

Observations in 1954-5 had shown honeybees to be doing 76 to 89% of the pollination of Montgomery red clover near. Timaru (Forster and Hadfield, 1958).

Later detailed work was undertaken to gauge the relative effectiveness of honeybees and bumblebees on red clover and big cages were set up near Geraldine with hives of bees enclosed. Small cages were used to keep bees out.

Small cages were also set up at Five Forks in North Otago. Some of these cages were kept stocked with long-tongued and some with short-tongued bumblebees.

As well as cage studies, detailed observations were made on crops in South Canterbury, the Mackenzie Country, also in North Otago and South Otago.

More than half the bumblebees working red clover were the short-tongued *Bombus terrestris*. Most of these punctured the sides of the florets and thus achieved no pollination. In cages where short-tongued bumblebees were confined, however, 20% of the florets set seed. This is more than their working methods in the field would lead one to expect so perhaps *B. terrestris* has been under-rated as a red clover pollinator.

It has been stated that any floret mutilated by a bumblebee piercing the side will not set seed even if pollinated before or after the side was bitten out. In some interesting work carried

out by L. Corkill (unpublished data) short-tongued bumblebees were confined on red clover and were replaced later by long-tongued bumblebees. Seed set was checked against clover worked by long-tongued bumblebees only. Results showed that seed set was reduced by *72%* where short-tongued bumblebees had previously worked the flowers.

Assessments were made of the speed at which various types of bees work. On an average, honeybees took three seconds per floret, while the average for bumblebees was 2.6 seconds.

In the small cages with no bees, it was soon apparent that no seed was setting. The clover in these cages stayed in a state of full flower typical of unpollinated blooms.

In cages with short-tongued bumblebees, 20% of the florets set seed, honeybees in cages gave 68%, while in the crop 73% was achieved. On all the crops worked, the highest seed set was 82%, and this crop was worked by both honey- and bumblebees. The fact that more seed was obtained in some crops in the open than in cages with bees confined may seem to indicate that pollination is not a vital factor. The reason why the clover in the cages with a maximum amount of pollination available did not give a maximum of seed production is possibly because with each crop, once pollination reaches a certain level, other factors become more important.

The crops broken up into five groups according to seed set and ranked from highest to lowest, with honey- and bumblebee counts alongside, are shown in Fig. 1. Honeybee counts do follow the pattern of seed set fairly closely, while bumblebee counts bear only a slight relationship.

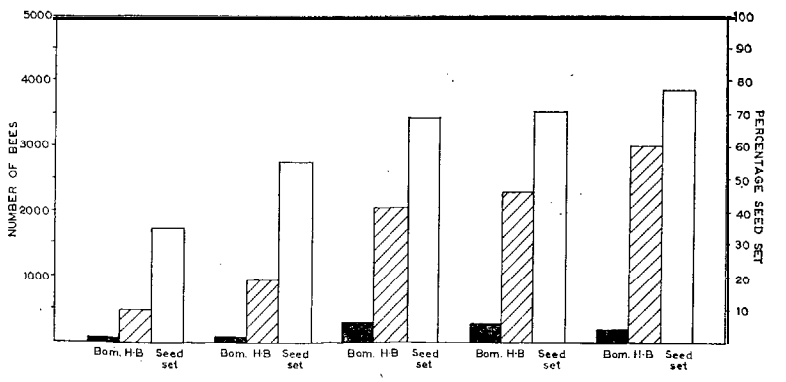

FIG. *1: Red clover pollination.*

One crop at Tokarahi was of particular interest. This was country appearing reasonably favourable for bumblebees-i.e., broken terrain with cover for nests, early nectar and pollen from willows and brass&as. There was not a solitary bumblebee on this crop. However, there was quite a good honeybee coverage, 11 000/ha, and 78% of the florets set seed. This one example clearly illustrates the honeybee's ability to pollinate red clover.

Lucerne pollination is a vexed problem. All are aware that lucerne seed yields in New Zealand are comparatively low. Lucerne has an enclosed flower held shut under tension, something like a cocked rifle. When the tension is released, the flower snaps shut. Stamens and stigma strike hard against the standard petal and stay there. This process has evolved to implant pollen on the insect that has done the tripping and at the same time for the stigma to pick up pollen the insect has carried from a flower previously visited.

Honeybees and long-tongued bumblebees are able to gather nectar without tripping lucerne flowers. Actually the impact of the tripped flower can strike in an unpleasant manner and an insect can be trapped for several seconds.

Insects gathering pollen must trip lucerne flowers but in New Zealand ample alternative sources are usually available from which pollen can be gathered more readily.

A survey was made of 32 crops ranging from Blenheim to Ranfurly. Honeybees were present on all crops in large numbers at between 2250 and 16 250/ha, except at Tara Hills where there were only 250/ha. However, honeybees appeared to trip only occasional flowers more or less by accident.

-There- were- some high bumblebee counts, up to 4250/ha at Tara Hills. That was exceptionally high and from there counts ranged down rather steeply to no bumblebees at all on thirteen crops. Pollination ranged from 5 to 15%. Both of these crops, the highest and the lowest seed set, happened to have no bumblebees on them at all, but both had relatively high honeybee counts of about 7500/ha. The high bumblebee count gave 12% seed set. This was higher than the average of 10%, but not as high as the 15% obtained with honeybees only. Overall honeybees seemed as effective as bumblebees as pollinators of lucerne.

In intensive studies at Blenheim two large cages were used to confine bees on flowering lucerne with the hive in one cage being deprived of stored pollen. Small cages were used for special treatments on other plots.

In the big cages where bees were confined, many more worked the flowers for nectar and some gathered pollen too. This gave about four times as many florets tripped as on the outside field and resulted in four times as many seed-pods.

With no bees, no flowers were tripped and no seed formed. In the open field with normal honeybee coverage but no bumblebees, 1.1 % of the florets were tripped and 5% set seed. In cage A with a hive of bees that had pollen, 4.4% of the florets were tripped and 25% set seed, while in cage I3 with a hive kept short of pollen there were 4.8% florets tripped and. 30% seed set. There is, thus a clear pattern of insect tripping determining the level of seed set.

The small cages were then lifted and flowers marked according to various procedures. Of hand-tripped flowers that had no bee visits, 17% set seed, showing that lucerne is self-fertile to only a small degree. Hand-tripped flowers followed by a visit from a bee had 2 1% seed set. Of flowers hand-tripped after a bee had visited them without tripping, 22% set seed. Flowers visited by bees with no tripping, either by the bee or by hand, gave 6% seed set, and with no bee visit and no hand tripping just a trace. Bee visitation in any circumstances does seem to have a beneficial effect.

A study was made of the effects of self-fertilization by automatic or mechanical tripping. It had been shown that only 17% of florets so tripped set seed. It was found further that the average number of seeds per pod from selfing was 1.4 compared with 4.4 for cross-pollination. Of these seeds from self-pollination, only 22% germinated compared with 60% from cross-pollination. Combining these two factors means that ten times as many plants are obtained from cross-pollination as from selfing.

To induce bees to gather pollen from lucerne hives were stripped of pollen and pollen traps put on to keep them from getting much pollen into the hive. No lucerne pollen was identified in the traps and there was no increase in tripping in the field.

Next successive waves of hives were moved up on to flowering lucerne with the idea of having bees that had not already learned to work lucerne' without tripping or had not become fixed on other flowers. This was coupled with intensive observations of bee activity in the field and in several control crops.

Thousands of bees working on lucerne flowers were closely studied. A small percentage had small loads of lucerne pollen, and a few, very few, with larger loads deliberately and methodically tripped flowers, while some accidentally tripped occasional

florets, An average of 4.5% of the honeybees achieved some pollination on the control crops. Where waves of fresh hives were brought up, 7.6% of the honeybees did some pollination and this gave 4.1% florets tripped in the crop. The seed set was 15.6%. That is higher than average, but the same has occurred under ordinary field conditions.

On another set of lucerne crops, 125 honeybees were closely followed in succession. Five of these were deliberate pollen gatherers and 19 tripped single florets. While under observation, the 125 bees visited some 4000 florets in about 5¼ hours. Thirty or 1.6% of the florets visited were tripped by the bees. These florets would be visited several times by bees during their attractive period and this would multiply the tripped florets up to a level which would easily account for the seed set obtained.

It would seem, then, that seed set in lucerne is only a fraction of the potential, largely through a lack of suitable pollinators. The seed that is set is mainly the result of honeybee visits to flowers. Short-tongued bumblebees should, on the face of it,, be much more effective but in many lucerne-growing areas they are not present. Where they are numerous, lucerne seed set shows no worthwhile increase.

The moving up of successive waves of honeybees did slightly increase seed set but the advantage was not sufficiently clear-cut to warrant the expense. No answer to the problem can be suggested.

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