INTRODUCTION OF NEW BEE SPECIES FOR POLLINATING LUCERNE

B. J. DONOVAN
Entomology Division, DSIR, Lincoln

Abstract

Yield of lucerne seed in New Zealand is very low-less than one-tenth that from areas of North America where pollinators are abundant, New Zealand lacks pollinators for lucerne and up to 90% of the florets are not tripped. Two species of bee are cultured in North America exclusively for lucerne pollination, the alkali bee, ***Nomia*** *melanderi* Cockerell, and the lucerne leafcutter bee, *Megachile pacifica* Panzer. Both species are now established in New Zealand and bee numbers are increasing. For the first time lucerne seed growers in New Zealand can begin to look forward to adequate pollination of their crops.

INTRODUCTION

LUCERNE *(Medicago sativa)* is an increasingly important constituent of New Zealand's agricultural economy. Iversen and Calder (1956) recorded that, in the lower rainfall areas of New Zealand, lucerne or pastures with lucerne as the dominant legume produce from 50 to 100% more dry matter per year than pastures based on clovers. Palmer (1966) stated that lucerne could be the most productive plant to grow on about 4 million ha, but calculated that present seed production is only sufficient to maintain about 204 000 ha.

LUCERNE SEED PRODUCTION IN NEW ZEALAND AND NORTH AMERICA

In the seasoas 1957 to 1971 in New Zealand, the area harvested for seed varied from 1707 ha to 5612 ha, with an average of 4072 ha, and yields per hectare have been between 49.4 kg and 107.2 kg with an average of 75.0 kg *(New Zealand Year Book).* Growers consider about 100 kg/ha to be a reasonable crop but occasionally yields of up to about 700 kg/ha have been recorded.

In North America, yields of over 1000 kg/ha can be consistently harvested in some areas, and in Washington State in 1950 and 1951, the average yield was 693 kg/ha (Menke, 1952). A yield of 2400 kg/ha has been recorded in Oregon (W. P. Stephen, pers. comm.).

What 'is the reason for the great disparity in seed yields between New Zealand and North America? It has been substantiated that seed set in lucerne depends upon florets being tripped (Hadfield and Calder, 1936) . Field studies by Palmer-Jones and Forster (1964) showed that pods available for harvesting in New Zealand averaged only 10% of the number possible for 32 fields. Although some tripped florets may fall off and so not develop into seed pods, it is evident that most florets are not being tripped. All honeybees observed were collecting nectar, but were doing so without tripping florets. Short-tongued bumblebees *(Bombus terrestris)* were tripping florets, and 50% were collecting pollen, but bumblebee numbers were low. It is clear that bumblebees are the main pollinators in New Zealand, but that up to 90% of florets are not being tripped because of low bumblebee numbers. Yields much above average are due to localized unusually high numbers of bumblebees, and/or tripping by honeybees which occurs in pollen dearths caused by drought or unavailability of alternative pollen sources.

NORTH AMERICAN LUCERNE POLLINATORS

In North America, two species of bee are cultured on a large scale specifically for lucerne pollination, the alkali' bee, *Nomia melanderi* Cockerell, and the lucerne leafcutter bee, *Megachile pacifica* Panzer. Both species are excellent pollinators of lucerne, and when present in sufficient numbers-about 7 000 to 10 000 females/ha-untripped florets are uncommon after several days of good weather suitable for bee flight. Researchers and growers have calculated that females of both species can trip enough florets in their lifetime to produce about 500 g of seed (Klostermeyer and Gerber, 1969; N. D. Waters, pers. comm.) .

Both species are solitary, but gregarious, that is, each female builds her own nest without any co-operation with other bees, but females tend to build nests adjacent to one another. Active flight is favoured by temperatures in excess of about 20°C. The total number of daylight hours above this temperature over the lucerne bloom period for successful leafcutter propagation in Canada must be at least 350 (Hobbs, 1973). Adult bees begin emerging from nests in early summer, reach peak numbers in mid-summer and die off a month or two later. Winter temperatures are not important because the species survive winter as fully-fed, hibernating quiescent larvae called prepupae.

Two species are cultured, because one species will often reach. greater populations in one area than the other. Alkali bees have

been cultured since about 1950, and leafcutter bees only since 1960, so a great deal is yet to be learned about the environmental requirements of both species.

ALKALI BEES

LIFE-CYCLE

This species is native to western North America, where it nests in salty soil, hence the name. The soil must be moist to be acceptable to bees, and salt helps retain moisture at an adequate level. After emergence in early summer, each female excavates a vertical tunnel down to about 10 to 30 cm and there rounds out a series of acorn-shaped cavities or cells 1.5 cm long and 0.8 cm in diameter. Pollen and nectar collected by the bee are stored in each cell, an egg laid, and the cells sealed with a plug of earth. A female bee can complete one cell a day if the weather is favourable and can complete about 24 cells in her life-time of about 6 weeks, but the usual number of cells is 20 (Bohart and Cross, 1955). Eggs hatch in 2 days into small larvae which consume all the pollen and nectar in 6 days. Within 3 days after this the larvae transform into the prepupal stage. In late spring when soil temperature is rising steadily, the prepupae begin to transform into pupae and then adult bees which emerge to repeat the cycle.

MANAGEMENT OF ALKALI BEES IN NORTH AMERICA

Observant growers in the late 1940s noticed a great increase in alkali bee populations as the area of lucerne saved for seed expanded, and a corresponding increase in seed/ha as alkali bee numbers increased. Salty moist areas of soil at the base of hills and along irrigation ditches, etc., were fenced off to protect bee populations, but enterprising growers soon sought to expand these nest sites and other growers in areas without natural nest sites wished to establish bees in their areas.

Large artificial nest sites are now made in the following manner. An area of desired size (up to 60 **x** 120 m but usually much smaller) is excavated to a depth of about 1 m, the bottom levelled, and the hole lined with plastic sheeting. Clean, round, river gravel from 2 to 4 cm in diameter is placed in the bottom 30 cm on the plastic, vertical pipes about 1.5 m long and 20 cm in diameter are stood on the gravel, and the hole is filled with a loamy silty soil. About 10 to 20 kg of NaCl are mixed into the top few centimetres of each square metre. Water is then run down the pipes to the gravel from where it slowly rises to the surface.

Properly constructed nest sites are very successful. Nest numbers per square metre can reach over 400, and there are usually enough bees nesting in about 20 m^2 to pollinate fully 1 ha of lucerne.

INTRODUCTION OF ALKALI BEES TO NEW ZEALAND

Palmer (1966) reported his attempts to establish alkali bees in New Zealand, but there was no indication of successful nesting, although bees later released by Palmer did construct nests at Earnscleugh in early 1969.

About 19 000 alkali bees have been released in New Zealand since 1964, and in Table 1 numbers of nests per year in prepared nest sites are presented.

TABLE 1: ALKALI BEE NESTS PER NEST SITE PER YEAR

	Nests			Jan.-Feb.		
Place	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*
Earnscleugh	*30*	50	*45*	*40*	*30*	*?*
Ida Valley	-	-	*18*	*8*	*3*	*0*
Lincoln	-	*5*	10 (a)	*0*		-
Grassmere	-	-	*0*	1	*0*	-
Seddon	-	-	*0*	*22*	0	-
Spring Creek	-	-	*70* (b)	*95*	220 (d)	925
Taumarunui	-		40 (c)	*20*	0	-
Total	*30*	*55*	*183*	*186*	*253*	*925*

Prepupae removed: (a) 23. (b) 230. (c) 103. (d) 50.

A dash (-) indicates that there was no possibility of nests that year because either bees had not been released at that nest site, or nests had not been constructed there the previous summer.

A zero (0) indicates that nests were not constructed but either bees were released at that nest site or nests had been constructed there the previous summer.

It is evident that alkali bees have probably died out in all sites except the Spring Creek site near Blenheim, where numbers have increased substantially. It has now been shown that both climate and soil in the Blenheim area are favourable to alkali bee propagation. Successful propagation in most other areas will depend primarily on the use of the right type of soil in nest sites. Alkali bees have not yet been observed on lucerne florets in New Zealand, but there can be no doubt that, when the population is much greater, lucerne will be pollinated.

LEAFCUTTER BEES

LIFE-CYCLE

This species arrived in the U.S.A. accidentally from eastern Europe or western Asia before 1937, and since then has greatly increased in numbers in western North America (Bohart, 1963). Newly emerged females search for holes about 10 cm long and 6 mm in diameter, usually in twigs or cracks in timber. After the removal of any debris, oval pieces of leaf are carried into the hole and 'stuck together to form cup-shaped cells up to 6 mm in diameter and 8 mm long. The bees store pollen and nectar in each cell, lay an egg, and seal the cell with circular pieces of leaf. The process is repeated at the rate of 1 or 2 cells a day until the hole contains about 10 cells. Female bees can make up to 35 cells in their lifetime of about 6 weeks (Klostermeyer and Gerber, 1969), but fewer cells are more common. Immature stages develop in a manner similar to that of alkali bees, except that, before entering the prepupal stage, leafcutter bee larvae spin a tough, fibrous cocoon about themselves. With the onset of warmer weather, prepupae transform into pupae and then adults which chew their way out of the nest and repeat the cycle.

MANAGEMENT OF LEAFCUTTER BEES IN NORTH AMERICA

In the late 1950s, several growers began drilling holes in barn timbers, etc., to increase nesting potential. Within several years, specially constructed shelters for nest holes in rolled corrugated cardboard, drilled boards and drinking straws were being placed in lucerne seed fields. A brisk trade in cells and nests developed, with cells selling for about 1 cent each.

Parasites and predators began to increase rapidly in the early 1960s, and management of leafcutters to maintain populations became more specialized. In Canada, grooved nest boards which could be taken apart at the end of the season for nest removal became widely used, and culture of bees has been most successful there (Hobbs, 1973).

INTRODUCTION OF LEAFCUTTER BEES TO NEW ZEALAND

Palmer (1966) advocated the introduction of leafcutter bees because they flew at lower temperatures than alkali bees and therefore would probably be more successful in New Zealand.

Leafcutter bees were first released in New Zealand in 1971 at Seddon. Nests were constructed, and the effect of bees on lucerne seed set in the area was immediately obvious. Plants that had

previously yielded only a few pods each (S. Orchard, pers. comm.) were covered in pods. Almost 394 000 bees have been released to date, but because of unusually adverse weather in Canterbury this past summer only 153 000 live prepupae are on hand. Increases in populations occurred at Blenheim and Seddon, however, but several moire seasons' work will be necessary before it can be determined whether or not the rate of increase is likely to be consistent.

DISCUSSION

Both alkali and leafcutter bees are now established in New Zealand. In one nest site alkali bee numbers have increased every year since release, but numbers are still low. The leafcutter bee population is much higher, and last summer for the first time an increase in a population was recorded. Efforts over the next several years at least will be directed primarily towards maximizing the rates of increase in the populations of both bee species. This will involve the development of management procedures best suited to New Zealand's variable weather conditions.

Later work will be concerned with numbers of bees needed for full pollination, and utilization of bees in areas where populations cannot maintain themselves. At this stage it is difficult to determine when bees will become generally available to growers, but if weather for the next few summers is favourable, interested growers should be able to obtain at least a few thousand leafcutter bees within several years. Release of alkali bees will take longer.

CONCLUSION

For the first time lucerne seed growers can begin to hope for adequate pollination of seed crops. Many insect pests of lucerne common in other countries are absent from New Zealand. Seed yields in good seasons should approach, if not exceed, average yields in North America.

REFERENCES

Bohart, G. E., 1963. Univ. *Utah* ***agric. exp. Sta.*** *Circ.,* ***144:*** 1-7.
Bohart, G. E.; Cross, E. A., 1955. *Ann.* ***ent.*** *Soc.* ***Am., 4%:*** 403-6.
Hadfield, J. W.; Calder, R. A., 1936. N.Z. *Jl* ***Sci.*** *Technol.,* ***17 (4) : 577-94.***
Hobbs, ***G.*** A., 1973. ***Can. Dept.*** *Agric. Publ.* ***1495: 1-30.***
Iversen, C. E.; Calder, J. W., 1956. *Proc.* ***N.Z.*** *Grassld* ***Ass., 1%: 78-88.***
Klostermeyer, E. C.; Gerber, H. S., 1969. ***Ann.*** *ent. Soc.* ***Am., 62 (6):*** 1321-5.
Menke, H. F., 1952. ***Am. Bee*** *J.,* ***92 (8): 334-5.***
Palmer, T. P., 1966. N.Z. *Jl* ***agric. Sci.,*** *1* ***(7):*** 21-4.
Palmer-Jones, T.; Forster, ***I.*** W., 1964. N.Z. *Jl* ***agric. Res., 8:*** 340-9.