BUMBLEBEE (*BOMBUS TERRESTRIS*) MOVEMENT IN AN INTENSIVE FARM LANDSCAPE

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SUMMARY

Eight commercially reared nests containing the short-tongued bumblebee species *Bombus terrestris* were placed around the perimeter of a seed crop of lucerne, *Medicago sativa*. Bee foraging distance and direction data from each nest were collected following marking of the bees with fluorescent powders. Bees observed within the crop foraged from full flowering onwards, travelling a modal distance of 17.5 m. Fewer than 3% of the bees travelled further than 100 m within the crop. Because of the nests' different positionings around the crop edge, all bees were not presented with equal flight opportunity within the crop. However, the data recorded help interpret pollination potential of bumblebees.

Keywords: bumblebee, movement, lucerne

INTRODUCTION

New Zealand's legume seed industry can develop through more efficient production, decreasing the dependence on imported seed (Dunbier and Wynn-Williams 1983). Insufficient pollination has led to sub-optimal seed yields, and bumblebees have been identified as good potential pollinators of lucerne (Read and Donovan 1989). New Zealand has a species-poor native bee fauna and pollination of legume crops by native bees is also poor. Among other species, bumblebees have been introduced to New Zealand but there is insufficient knowledge to optimise their use as pollinators. Previous New Zealand work involving a long-tongued bumblebee, *Bombus hortorum* L. has resulted in models predicting ideal bee stocking rate for red clover crops, based on data on the foraging behaviour of individuals (Macfarlane and van den Ende 1990). However, the spatial aspects of bumblebee foraging behaviour have largely been ignored. The aim of this current work was to quantify bumblebee (*Bombus terrestris* L.) pollination potential in relation to how far they travel from the nest to forage.

METHODS

Eight commercially reared colonies containing *Bombus terrestris* L. were obtained from Bee Pacific Ltd (Christchurch) and were placed along the sides of a 16 x 150 m lucerne seed crop, allowing even spacing between nests, in early February 1994. Stocking rates for bumblebees in lucerne have not been established, so this rate was chosen to achieve high reobservation rates, and to observe between-nest interactions. Because the colonies were intended for glasshouse use, shelters to protect them against light, heat, wind and excessive moisture were constructed using wooden honey bee frames. These were further shaded with 0.5 m^2 polythene sheets, painted silver and held at an angle in wooden frames above the nests, facing north. Bees were automatically marked for visual observation as they were leaving the nest using a "marker tunnel" assembled from a plastic drink bottle. This was painted black and its cut-off base attached to the only exit hole in the wooden honeybee frame. The bottle's neck rested on an alighting pad. Inside the horizontal bottle, a layer of corrugated cardboard was dusted with one of the eight different-coloured fluorescent powders. A cosmetics brush protruded vertically into the bottle behind its neck; the brush also had powder on it. In this way, all bees leaving the nest were marked on their ventral and dorsal surfaces.

The field was divided into a grid, each cell of which measured 4 x 4 m, with the exception of one row in which the cells measured 4 x 2 m. Observations were made by walking transects up and down the cell edges, observing 2 metres on either side of the line. In this way, bumblebee foraging in the whole grid and hence the whole crop was assessed. An observation time of 30 s per grid cell meant that one observation of the whole crop took 1 h 15 mins. There is a trough in bumblebee activity around mid-day (Alford 1975). This decline in activity is considered to be due to unfavourably high temperatures, and the presence of honeybees in the crop (Donovan pers comm). A bumblebee's ability to regulate its own body temperature permits it to forage early morning and late evening when there is little competition from other flower visiting insects. Overheating is probably a serious problem. Bumblebees often show a lull in flower visiting activity in the hottest part of a sunny day. Also nectar is often scarce in the middle of the day (Prys-Jones and Corbet 1987). To maximise reobservation rates in our study, observation sessions were carried out late to mid-morning and late afternoon where possible.

Data were recorded as points on a scale map of the crop. Vector distance and direction data were established from known nest positions on the field map. Flight distances were summarised by frequency distributions. A time-lapse video was set up outside one nest entrance to record bee 'traffic' over one day. This was used to estimate re-observation rates of marked bees. The maximum number of bees foraging away from the nest at a given re-observation session were estimated by calculating how many bees were out of the videoed nest at reobservation times. This was extrapolated to give an estimation of total foragers assuming equal numbers of bees in each nest.

RESULTS

Before the lucerne reached full flowering, individual bumblebees were found up to 650 m outside the crop on weed species, although regular transects surveying crop surroundings were not part of the re-observation design.

From full flowering onwards, bumblebees utilised the lucerne crop. A total of 197 marked bees was recorded within the crop during 19 observation sessions, which were carried out over a five-week period from early February to early March. Re-observation rates estimated from the time-lapse video information indicated that the proportion of foraging bees actually observed in the crop ranged from less than 1% to 20%. Most foraging activity in this experiment occurred in the late afternoon, peaking at 17.00 h as shown in Fig. 1. Different maximum flight distances resulted for bees from each nest (Table 1). A frequency distribution (Fig. 2) of pooled results for all bees re-observed within the crop shows that most bumblebees travelled relatively short distances to forage within the crop. At least 61% or more bees foraged within 50 m of the nest inside the crop (Table 1). The highest frequency of flight distances was in the 15 to 19 m class . Fewer than 3% of bees travelled 100 m or further within the crop (Fig.2).

TABLE 1: Bumblebee flight distance characteristics for the eight nests bordering a lucerne crop.

Nest	1	2	3	4	5	6	7	8
Maximum distance travelled (m)	101	64.4	84.4	90.4	79	82.6	74.6	83.2
% bees travelling < 50 m	73.67	80	83.34	95.23	84.77	82.35	61.53	89.64
Total number of bees re-observed for each nest	19	10	12	21	46	34	26	29

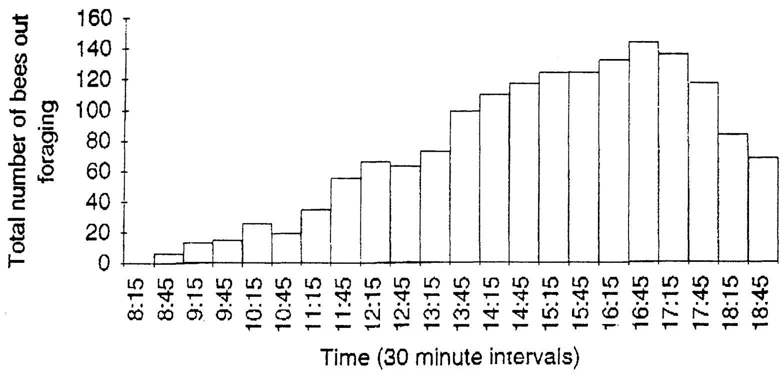

Figure 1: Bumblebee foraging activity over a day in a lucerne crop.

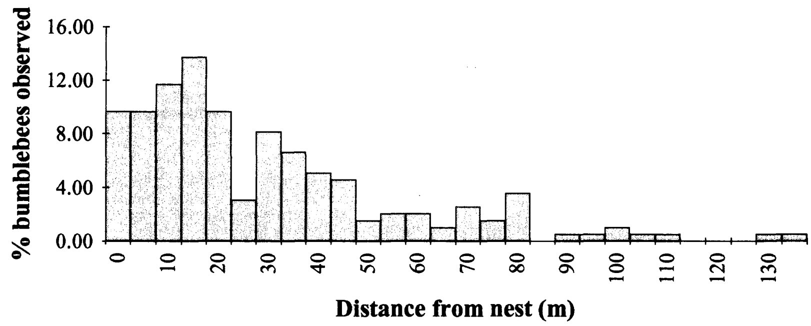

Figure 2: Frequency distribution of flight distances for bumblebees observed within the flowering lucerne crop.

DISCUSSION

Optimal foraging theory assumes that individuals strive to maximise gains while minimising costs (Heinrich 1979). One aspect of this theory involves energy costs and rewards. The pollen and nectar energy a bee earns, either for itself or the colony, or both, must not be outweighed by the flight energy cost of gaining that reward. Before the crop seemed profitable to the bees, ie. when local resources were limited, a 650 m forage flight must have been warranted by a high nectar reward from the weeds found at that distance. When the lucerne forage resource became less limited at full flowering, more bees remained loyal to the crop. Within the crop itself, most bees foraged relatively close to their nests. Free reported finding *Bombus agrorum* individuals no further than 18.4 m from the home nest within a crop of red clover Butler (1951). The highest frequency of bee flight distances in this experiment was in the 15 to 20 m class (Fig. 2), which supports Butler's claim. His methodologies were not reported.

Bumblebees are not territorial and will forage closely in each other's presence (Donovan, pers comm). In this study bees from different nests were observed foraging closely within the same crop grid cells which supports this theory. The number of re-observations was so low for some nests that the maximum flight distances indicated in Table 1 are likely to be unreliable. Each nest started with approximately 40 workers, but over the season these developed at different rates. When the nests had died, hatched worker brood cells were counted and ranged from 171 in the smallest nest to 714 in the largest one. The colony supplier (Bee Pacific Ltd) commented that this range in colony size is normal for nests from a reared system. The suppliers have found that the nests which spend the shortest time in the rearing room produce larger colonies and at a faster rate when taken to a crop / glasshouse. The larger nests in this study were also the nests which had spent the shortest time in the rearing room. However, total cells counted at the end of the season does not mean all those bees were alive simultaneously. In addition to birth and death rates, only a certain percentage of bees leave the nest to forage. Re-observation rates could be more accurately estimated by recording nest traffic more often throughout the re-observation period.

The crop was relatively uniform in terms of stem and flower density, so differences in the flight distances within the crop were unlikely to be a result of environmental factors in the crop.

In conclusion, of the bumblebees re-observed within the lucerne crop, most foraged near the nest. The field's shape and size and the positioning of the bumblebee nests limited maximum potential flight distances achievable by bees within the crop. Colony size varied markedly in the reared nests and it would seem that nests with less time in the rearing chamber produce more workers after introduction to the crop. This was found to be a contributing factor to the resulting different flight distance distributions between nests. Overall reobservation rates of marked bees within the crop were poor.

The next step will be to choose an appropriate tool for the spatial analysis of bee re-observations to estimate activity zones of each bee nest in relation to crop factors and to calculate an overall "crop coverage" by bees.

Bumblebee foraging efficiency in more typical, larger paddocks needs to be assessed using similar methods to those described here. Advantages to crop seed production need to be quantified and compared with controls. Management recommendations for the use of commercially reared bumblebee nests, and for enhancing existing natural bumblebee populations must be based on the spatial and temporal restraints acting on bumblebee foraging behaviour.

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REFERENCES

Alford, D.V., 1975. Pp 83-92 Foraging. *In*: Bumblebees.Davis Poynter, London.

Butler, C.G. 1951. Bee Department publication. Rothamsted Experimental Station, pp 108-113.

Dunbier, M.W., Wynn-Williams, R.B. and Purves, R.G., 1983. Lucerne seed production in New Zealand - Achievements and potential. *Proc. NZ Grassl. Assoc.*: 30-35.

Heinrich, B., 1979. Foraging optimisation by individual initiative. Pp 123-147. *In*: Bumblebee Economics, Harvard University Press, London, England, 245pp.

Macfarlane, R.P. and van den Ende, H.J., 1990. A summation of the factors influencing red clover (*Trifolium pratense*) seed yield in New Zealand. DSIR Internal Report.

Prys-Jones, O.E and Corbet, S.A., 1987. Foraging Behaviour in Bumblebees. Naturalists Handbook 6. Richmond publishing Co. Ltd, Slough England. Pp 35-53.

Read, P.E., Donovan, B.J. and Griffin, R.P., 1989. Use of bumblebees, *Bombus terrestris*, as pollinators of kiwifruit and lucerne in New Zealand. *NZ Ent.*: 19-23.