FIELD PENETRATION OF BENEFICIAL INSECTS FROM HABITAT ISLANDS: HOVERFLY DISPERSAL FROM FLOWERING CROP STRIPS

G.L. LÖVEI¹, J.M. HICKMAN², D. MCDOUGALL¹
and S.D. WRATTEN³

¹AgResearch Flock House Agricultural Centre, Private Bag 1900, Bulls 5452,
New Zealand

²Department of Biology, University of Southampton, Bassett Crescent East,
Southampton, SO9 3TU, U.K.

³Department of Entomology & Animal Ecology, Lincoln University, P.O.Box 84,
Lincoln, New Zealand.

SUMMARY

Field penetration from habitat islands by beneficial arthropods was studied on a North Island organic farm. The 'habitat islands' were strips of flowering coriander (*Coriandrum sativum*) and tansy leaf (*Phacelia tanacetifolia*). The specific pollen of these plant species was used as a biological marker to determine how far the flower-visiting adults of the aphidophagous hoverfly *Melanostoma fasciatum* penetrated into the fields. Dissections demonstrated that this distance was at least 15 m in each direction from a central strip. Lack of coriander and tansy leaf pollen overlap in their guts indicated that hoverflies tended to move into the fields after visiting the flowers.

Keywords: natural enemies, habitat manipulation, dispersal, *Syrphidae*, pollen feeding

INTRODUCTION

The presence and maximum activity of beneficial arthropods in agricultural fields is highly desirable. They are important as natural enemies of pest arthropods and pollinators of crop plants, as well as a component of biodiversity. However, the yearly changes in the distribution and relative abundance of different crops as well as agricultural cultivation creates an environment which is fragmented, unstable and in many instances hostile to beneficial organisms. Manipulations which increase the suitability of cultivated habitats for these organisms could result in tangible benefits for farming and environmental management. Many beneficial species are highly mobile but depend on habitat or resource refuges to survive during times of adversity due to cultivation, spraying, or their biological needs. Simple manipulations like undisturbed habitat islands (Thomas *et al.* 1992) or nectar/pollen source provided by appropriate flowering plants (Powell 1986) can be very effective in increasing the local density of several types of beneficial arthropods. Beneficial arthropods can be retained near their desired site of action by strategically placed but small patches of such refuges (Powell 1986). By such manipulations the density, longevity, fecundity, and consequently, efficiency of several classes of natural enemies can be increased (Jervis *et al.* 1993).

Earlier work has demonstrated that tansy leaf (*Phacelia tanacetifolia*) is attractive to hoverflies (Lövei *et al.* 1993) and that local densities of hoverflies can be increased by planting central strips of suitable flowering crops (Lövei *et al.* 1992). In the present work, we used the pollen of coriander (*Coriandrum sativum*) and tansy leaf as natural biological markers to investigate the dispersal of *Melanostoma fasciatum*. The larvae of this species are aphidophagous and the species is potentially an important natural enemy of aphids.

Proc. 46th N.Z. Plant Protection Conf. 1993: 325-328

MATERIAL AND METHODS

Study site and collection methods

Hoverflies were collected in yellow pan traps in two paddocks on the organic farm at AgResearch Flock House, Bulls, North Island, between mid-December 1991 - January 1992. Both paddocks were planted with wheat and had 1.5 m wide central strips of tansy leaf and coriander ('novel crops' hereafter). Together these strips occupied half of the length of the paddocks; similar strips of quinoa and buckwheat made up the other half but were not studied in this experiment. The two wheat fields were 3.5 ha and 3.2 ha in size and were surrounded by other organically and conventionally managed pasture and crop paddocks. In paddock 1, the novel crops were neighbouring each other, and the strip length was 60 m. In paddock 2, they were separated by another crop (buckwheat), and the strip length was 100 m. Tansy leaf (at a rate of 14 kg/ha) was drilled on 11 October and coriander (40 kg/ha) on 17 October 1991, both at 1-2 cm depth with 15 cm between rows. The strips were maintained by hand weeding; the major crop was weeded by a mechanical Tyne weeder twice during October- November. No pesticide or fertilizer was applied. Each novel crop occupied about 0.4% of field 1, and 0.6% of field 2.

At equal distances from each other and from both ends of the strips, two parallel rows of trap-lines were established in each crop in each paddock, starting at the flowering strips and running at right angles to them (6 traps each side). The distances of the traps from the novel crops were 1, 3, 5 m, one third of the distance to the paddock edge (10 m on paddock 1, 15 m on paddock 2), at the edge of the paddock (30 m on paddock 1, 50 m on paddock 2), and at the edge of the next paddock (about 100 m from the flowering strips) in both directions. The yellow pan traps were placed at 1 m height, filled with water and detergent; hoverflies were removed and the traps reset weekly. The trap catch was sorted under a microscope and stored in 70% ethylene. In the analysis, the results from the two paddocks were pooled.

Dissection methods

After removal from the alcohol, each hoverfly was placed on a microscope slide, identified to species and sexed. The gut contents were dissected out into two drops of 0.0025% aqueous safranin and any eggs present were counted. A 22 x 50 mm slide cover was then lowered so that the preparation spread longitudinally along the slide. The entire slide was scanned at 100x magnification and where necessary, identity of pollen was confirmed at 400x magnification.

RESULTS AND DISCUSSION

Dispersal from coriander strips

Between 3 January - 13 February 1992, a total of 155 adults of the hoverfly *Melanostoma fasciatum* (Diptera: Syrphidae) was caught in the yellow pan trap lines starting from a central strip of coriander, 88 of which were in suitable condition for dissection (49 males, 38 females). Nineteen females had an average of 9.6 eggs (S.D.=5.7, minimum 2, maximum 28) in their abdomen. Nearly half of all males (44.8%) but only 26.3% of females dissected contained coriander pollen in their guts (Table 1). Only seven flies (2 males, 5 females) were without any type of pollen, indicating a catholic pollen feeding habit also reported by Holloway (1976).

Numbers of trapped male hoverflies exceeded females (Kruskal-Wallis test, $H=5.41$, d.f.=1, $P<0.025$); this difference was significant up to 3 m from the coriander strip (Kruskal-Wallis $H=3.14$, $P<0.1$) but not farther (Kruskal-Wallis $H=2.33$, $P<0.2$; Table 2). No hoverflies caught at the edge of the paddock (30-50 m) or in the next paddock (<150 m) contained coriander pollen in their guts (Table 2). A higher percentage of males than females had coriander pollen in the gut at any distance. This could indicate either that more vigorous male dispersal or that more males than females fed on coriander pollen.

Dispersal from tansy leaf strips

Tansy leaf started to flower in mid-December, and yellow pan trap catches were collected between 13 December 1991 and 13 February 1992. A total of 157 adult *M.*

fasciatum were caught, 124 of which were dissected (76 males, 48 females). Eighteen females (37.5% of those dissected) had an average of 10.2 eggs (S.D. = 6.98, minimum 1, maximum 25) in their abdomen.

TABLE 1: Catches of *M. fasciatum* in yellow pan traps in two wheat fields with central strips of flowering coriander (between 10 Jan -7 Feb 1992) and tansy leaf (between 13 Dec 1991 - 13 Feb 1992). Flock House, North Island.

	Coriander	Tansy leaf
No. of males in sample	49	76
No. males with pollen	22	14
No. of females in sample	38	48
No. of females with pollen	10	8
No. of females with eggs	19	18

TABLE 2: Sex ratio, coriander pollen content, and eggs in adults of *M. fasciatum* in relation to the position of capture within the fields.

	Distance from coriander strip, m					
	0	1	3	5	10/15	>30
No. of hoverflies in sample (males:females)	6:2	7:7	15:9	6:5	8:9	7:6
% females with pollen	50	29	33	40	22	0
% females with eggs	50	71	44	60	33	50
% males with pollen	50	71	47	67	38	0

The proportion of flies containing pollen was lower than for coriander and there was little difference between the sexes: 18.4% for males, and 16.7% for females (Table 1). The proportion of males without any pollen (13.2%) was twice that of females (6.3%).

More males than females were caught at several distances from the central tansy leaf strip (Table 3). When grouped according to catching distance, this was significant overall (Kruskal-Wallis test, $H=7.41$, d.f.=1, $P<0.01$) and up to 10/15 m from the strip (Kruskal-Wallis $H=6.82$, $P<0.01$). One female caught at the edge of the paddock contained tansy leaf pollen; males containing the pollen were trapped up to 15 m. The spatial distribution of flies with tansy leaf pollen indicated dispersal up to the edge of the paddock. Female dispersal was similar to the situation found for central coriander strips, but only 13% of males contained tansy leaf pollen in their guts at the distance of 10/15 m while the corresponding percentage with coriander pollen was 38% (Table 2). The proportion of females with eggs was 34.6%, vs. 50% in the region of the coriander strip. From the comparison of the data on Tables 2 and 3, it seems that the degree of female dispersal after feeding on either coriander or tansy leaf pollen offered in the central strips was similar, but 75% of males caught at 10/15 m had fed on coriander while only 13% of males caught at this distance had fed on tansy leaf. With no data on nectar feeding or the chemical composition of the two pollen types, the significance of this is not possible to evaluate.

Only one of the total of 245 hoverflies dissected contained both types of pollen, although most flies contained more than one pollen type (Hickman, unpublished). This lack of pollen cross-feeding is remarkable. There was nothing to prevent hoverflies from moving between the different flowering strips instead of moving into the paddock. Our dissection data add support to the widely held (Powell 1986) but

unproven (Jervis *et al.* 1993) belief that parasitoids (and hoverflies) commute between host-containing and food-containing areas. The behaviour of hoverflies in this respect is analogous to that of a host-seeking parasitoid wasp. Hoverfly females need pollen for egg maturation. For subsequent oviposition, they have to locate suitable patches of prey; eggs are laid near these prey patches on which the larvae feed.

TABLE 3: Sex ratio, tansy leaf pollen content, and eggs in adults of *M. fasciatum* in relation to the position of capture within the fields.

	Distance from tansy leaf strip, m					
	0	1	3	5	10/15	>30
No. of hoverflies in sample (males:females)	8:2	16:8	15:13	16:10	15:4	11:12
% females with pollen	50	0	38.5	0	25	8
% females with eggs	50	37.5	23	40	0	58
% males with pollen	12.5	25	0	37.5	13.3	0

Our results seem to indicate that attractive flower patches planted in a spatially suitable pattern can direct the activity of flower-feeding natural enemies to the desired crop areas. For hoverflies, these patches should be about 30 m from each other as they would disperse at least 15 m into the crop from both directions. This distance is remarkably similar to the planting distance of 24 m, suggested for optimal dispersal into the crop by ground-active natural enemies in Europe (Heitzmann *et al.* 1992).

ACKNOWLEDGEMENTS

This study was supported by the Foundation for Research, Science and Technology through grants to MAF Technology and AgResearch, by the British Council (Higher Education Link 00984; GLL & SDW), and the Royal Society of New Zealand (GLL), all of which is gratefully acknowledged.

REFERENCES

- Heitzmann, A., Lys, J.-A. and Nentwig, W., 1992. Nützlingsförderung am Rand - oder: vom Sinn des Unkrautes. *Landwirtschaft Schweiz* 5: 25-36.
- Holloway, B.A., 1976. Pollen-feeding by hoverflies (Diptera: Syrphidae). *N.Z. J. Zool.* 3: 339-350.
- Jervis, M.A., Kidd, N.A.C., Fitton, M.G., Huddleston, T. and Dawah, H.A., 1993. Flower-visiting by hymenopteran parasitoids. *J. Nat. Hist.* 27: 67-105.
- Lövei, G.L., McDougall, D., Bramley, G., Hodgson, D.J. and Wratten, S.D., 1992. Floral resources for natural enemies: the effect of *Phacelia tanacetifolia* (Hydrophyllaceae) on within-field distribution of hoverflies (Diptera: Syrphidae). *Proc. 45th N.Z. Plant Protection Conf.*: 60-61.
- Lövei, G.L., Hodgson, D.J., MacLeod, A. and Wratten, S.D., 1993. Attractiveness of some novel crops for flower-visiting hoverflies (Diptera: Syrphidae): comparisons from two continents. Pp. 1-8 *In: Pest control and sustainable agriculture*, S.A. Corey, D.J. Dall and W.M. Milne (Eds); CSIRO Publications, Canberra.
- Powell, W., 1986. Enhancing parasitoid-host interactions, and the implications for biological control. Pp. 319-340 *In: Insect Parasitoids*, J.K. Waage and D.J. Greathead (Eds); Academic Press, London.
- Thomas, M.B., Wratten, S.D. and Sotherton, N.W., 1992. Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and species composition. *J. Appl. Ecol.* 29: 524-531.