

THE ROLE OF PREDATION IN CARROT RUST FLY (*PSILA ROSAE*) EGG LOSS

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ABSTRACT

The role of invertebrate predators in carrot rust fly (*Psila rosae* Fab.) egg loss was estimated from January to April using artificially placed eggs of the Indian meal moth (*Plodia interpunctella*) in an organic carrot crop. Petri dishes baited with freeze-killed eggs were placed in a transect from the boundary into the crop. After 24 h exposure in the field, the dishes were recovered and assessed by recording the number of eggs removed and the number damaged. Predation rate was significantly higher in the crop boundary than it was within the crop over the sampling period. A higher proportion of eggs was removed rather than damaged in the boundary compared with the crop. The implications of the results for the biological control of the carrot rust fly are discussed.

Keywords: egg predation, carrot rust fly, crop boundary

INTRODUCTION

Heavy reliance on synthetic insecticides and herbicides and other intensive farming techniques has contributed to the decline in populations of some invertebrate natural enemies in agricultural systems (Croft and Brown 1975; Aebischer 1991; Holland *et al.* 1994). However in organic agriculture, which excludes the use of synthetic fertilisers and pesticides, cultural and crop husbandry techniques are used to restrict insects, weeds and other yield-reducing organisms to acceptable levels. Enhancing natural control by exploiting existing knowledge of the potential of natural enemies has important implications in organic agriculture. In conventional systems, understanding the role of predator populations in pest control is also important to allow for the maximisation of the contribution of beneficial arthropods in Integrated Pest Management programmes (Dent 1991).

In Europe, studies have established that field boundaries hold higher predator populations than does the crop itself (Sotherton 1984). It has also been established that predator abundance and diversity are higher in organic crops compared with conventional ones (Dristchilo and Wanner 1980; Kromp 1989; Berry *et al.* 1995). However, most studies investigating the role of predators in agricultural systems have relied on assessing the 'abundance' of predators rather than their predation rate and have relied on limited sampling methods, such as pitfall trapping, to do this (Greig-Smith *et al.* 1992; Holland *et al.* 1994). One method of quantifying predation rate of pest invertebrates is to use some form of bait. Speight and Lawton (1976) used pupae of the fruit fly *Drosophila*, while Burn (1980) used eggs of the carrot fly, derived from laboratory cultures.

The aim of the present work was to evaluate predation rate over time in a carrot field and its margins using insect eggs as baits.

MATERIALS AND METHODS

Experimental work was carried out over a season in a 2.4 ha organic (ie. grown under Bio-Gro Organic Production Standards) carrot field sown on 20 December 1994 at Leeston, Canterbury. Egg predation was assessed using laboratory-reared (25 °C,

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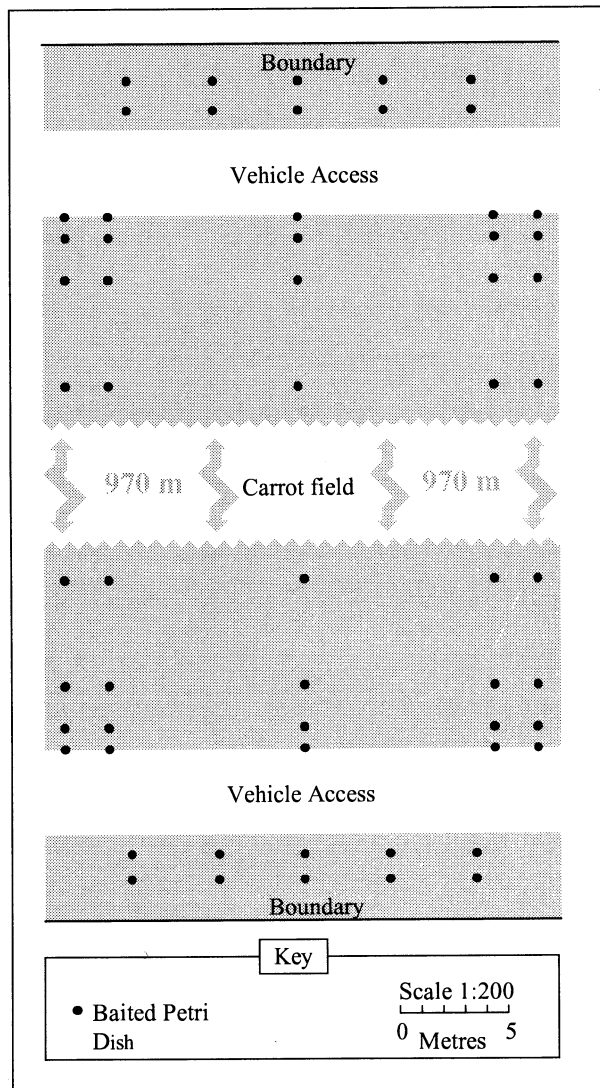


FIGURE 1: Field layout and positions of baited Petri dishes. ‘Boundary’ = fence and grasses or pine litter and grasses. All other baited Petri dishes were in the carrot crop.

50 % RH) eggs of the Indian meal moth (*Plodia interpunctella* Hubner). This species was used as the eggs are almost identical in size to those of the carrot rust fly and because this species is easily reared, unlike carrot rust fly (Burn 1980). Twenty eggs were placed amongst moist soil crumbs in a Petri dish (50 x 9 mm) to mimic natural oviposition by the carrot rust fly. Petri dishes were partially buried in the field to leave

their surface level with the soil surface to prevent any obstruction to surface-moving predators. A ring of sodium chloride was applied around the perimeter of each dish to prevent slug 'predation' of the eggs. A metal roof was placed over each dish to prevent dehydration of the eggs and to keep rain off the ring of salt.

To assess how predation varied with distance from the field boundary, dishes were placed in transects progressing from each of two opposite boundaries (0 m) into the crop at 5, 6, 8 and 13 m (Fig. 1). One boundary consisted of a post-and-wire fence above mixed grasses, while the opposite boundary was comprised of a narrow grass strip, behind which was a line of pines (*Pinus radiata* D. Don) with associated pine litter. Eggs were exposed to predation for 24 h. The dishes were then recovered and assessed by recording the number of eggs removed and those damaged. Two rows of baited Petri dishes were placed in each boundary (only the dishes closest to the field were used for this analysis) to quantify predation at two sites within the boundary. Egg predation was measured on five sampling occasions: 31 January, 8 February, 21 February, 7 March and 15 April, 1995.

The effects of distance and time on egg predation were analysed using repeated measures ANOVA. Data was log-transformed prior to analysis to stabilise variances. Geometric means are used in the figures.

RESULTS

Mean egg predation (eggs removed and eggs damaged) changed significantly between sampling dates ($P < 0.001$) (Table 1). The effect of distance from the boundary into the crop on egg predation was also dependent on date ($P < 0.01$) (Table 1).

Egg predation was significantly higher ($P < 0.001$) in the boundary compared with that in the crop over the sampling period (Table 1), except on 8 February where there was no statistically significant difference between predation rates over all distances ($P > 0.05$). Egg predation also differed significantly ($P < 0.05$) between the two boundaries and their respective crop areas. In one boundary the mean percentage eggs predated in 24 h was 25 % while in the other boundary it was 38 %.

TABLE 1: Mean percent egg predation (eggs removed and damaged) in 24 h from the boundary (0 m) into the crop at 5, 6, 8, and 13 m over all sampling dates (95 % C.I.'s included).

Distance	Sampling date				
	31.1.95	8.2.95	21.2.95	7.3.95	15.4.95
0 m	54.7 (30.2-98.6)	52.6 (20.9-129.3)	56.57 (22.8-137.4)	11.59 (2.2-47.9)	28.43 (8.6-89.2)
5 m	9.76 (3.2-26.1)	38.33 (24.7-59.2)	6.09 (1.8-17.8)	1.78 (0.2-5.5)	1.40 (0.01-4.6)
6 m	16.91 (5.7-46.7)	56.57 (41.1-77.3)	11.88 (14.3-30.03)	1.29 (-0.03-4.4)	2.44 (0.5-6.7)
8 m	7.31 (2.3-20.1)	30.63 (23.6-39.4)	4.94 (1.2-15.3)	3.92 (0.6-13.9)	1.32 (-0.01-4.4)
13 m	12.28 (4.17-33.1)	29.53 (17.5-49.4)	5.39 (2.7-13.8)	2.15 (0.25-6.90)	0

The proportions of eggs damaged and eggs removed differed significantly ($P < 0.001$) between the crop and the boundary (Fig. 2). In the boundary, only 2% of egg predation was in the 'damage' category, while 26% of egg predation in the crop was in this category.

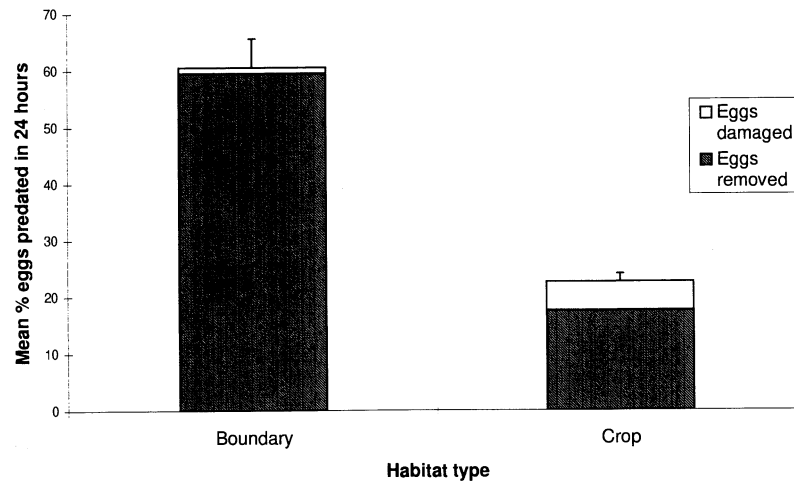


FIGURE 2: The proportions of eggs predated (\pm S.E.) between the crop and the boundary, and the ratios of eggs damaged to eggs removed (see text for statistical analysis).

DISCUSSION

The artificially placed eggs of the Indian meal moth proved valuable as surrogates of carrot rust fly eggs and for the first time in New Zealand egg predation rate has been quantified in an arable crop. Egg predation (eggs removed and damaged) ranged from 0% to 100% in the baited Petri dishes. Egg predation declined significantly from summer to autumn and also differed between the crop and its boundaries. This is consistent with past studies in Europe which have established that field boundaries contain higher predatory populations and diversity than the crop itself (Sotherton 1984). In the current work, the main significant difference in predation rate was between that in the grassy boundaries and that in the crop itself. There were no significant within-crop differences in predation rate. However, on 8 February, the boundary and its predator populations seemed to have an influence on egg predation within the crop.

Egg predation was significantly higher in one boundary and crop area than the other. The boundary with the higher predation rate comprised mixed grasses, while the other had a narrow grass strip, behind which was a line of pines with associated pine litter. This implies that the quality and composition of the boundary may be important in determining egg predation rates.

The two main horticultural pests of carrots in New Zealand are the carrot rust fly and the carrot aphid (*Cavariella aegopodii* Scopoli). Work in Europe has shown 60-100 species of carabid and staphylinid beetles predated on carrot rust fly eggs (Burn 1980). However, virtually nothing is known about the predators and parasitoids of this pest in New Zealand, where carabid populations on farmland are low (Wratten and Pearson 1982) and may not contribute to suppression of carrot rust fly populations in cultivated land.

In work parallel to this study, pitfall traps and Vortis samples were used to help determine the predators responsible for egg predation. Though the contents of these samples were not analysed for the purpose of this paper, they will eventually help to determine the relative abundance and activity of surface-active predators during the period of the study. As egg predation could be separated into those removed and those damaged, this may suggest two different predator 'guilds' (Putman and Wratten 1984)

are responsible for egg predation. These guilds may also differ between the crop and its boundary, as the proportions of eggs damaged and eggs removed differed significantly between these habitats. Another method to help determine which predators are responsible for egg predation is time-lapse video recording. For example Wratten *et al.* (1984) used time-lapse video to study the foraging behaviour of a nocturnal carabid, *Agonum dorsale* (Pont.), in relation to patches of its aphid prey in a large-scale laboratory arena of wheat seedlings, and Halsall and Wratten (1988) used video in the field to quantify predation rate (see Wratten 1994). This work has shown, however, that predation rate of surrogates of carrot rust fly eggs is high in Canterbury, even though the pest was introduced without its complement of natural enemies. The challenge now is to identify the predators involved and to put into place habitat manipulation practices to enhance their populations.

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