Spatio-temporal distributions of *Meligethes aeneus* and its parasitoids in an oilseed rape crop and their significance for crop protection

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ABSTRACT
The distributions and phenology of *Meligethes aeneus* and its parasitoids were studied in relation to the potential value of spatio-temporal information for integrated crop management (ICM) and the conservation management of parasitoids. Insects were sampled at 40 spatially-referenced points within a crop of winter oilseed rape and the following winter wheat crop. Spatial distributions were analysed and compared using Spatial Analysis by Distance IndicEs (SADIE). A quarter of *M. aeneus* larvae were parasitised by *Phradis interstitialis* and *Tersilochus heterocerus* but fewer than two percent of parasitised hosts gave rise to parasitoid adults. Adult *P. interstitialis* emerged from overwintering two weeks before *T. heterocerus* which was the more abundant. Both adult and larval *M. aeneus* distributions showed clustering in the north-eastern half of the field. The distribution of *P. interstitialis* larvae was associated with that of their host whereas the eggs of *T. heterocerus* were spread evenly across the field. Opportunities for conservation of parasitoids by spatio-temporal targeting of insecticides are discussed.

Key words: *Meligethes aeneus* – *Tersilochus heterocerus* – *Phradis interstitialis* – spatio-temporal distribution – integrated crop management

INTRODUCTION

Parasitoids have significant potential for controlling insect pests of oilseed rape (Alford, 2003) but are vulnerable to insecticides. The development of resistance to pyrethroids in the pollen beetle, *Meligethes aeneus* (Fab.), in Europe has accentuated the need for control strategies which optimise the role of biocontrol agents and minimise insecticide use. Recent studies have demonstrated that spatio-temporal patterns of pest infestation in oilseed rape can be complex and that insecticide application can be temporally targeted to conserve parasitoids (Murchie *et al*., 1997; Ferguson *et al*., 2003). Here, the spatio-temporal relationships between *M. aeneus* and its larval endoparasitoids in a winter oilseed rape crop are investigated in relation to the value of incorporating spatial information in sampling for decision support and the potential for conservation management of parasitoids by targeting insecticide applications.

MATERIALS AND METHODS

All samples were taken from a 2.4 ha field with crops of winter oilseed rape, *Brassica napus* (L.) (cv. Apex) in 1998/1999 and winter wheat in 1999/2000. No insecticides were applied after autumn 1998. Forty sample locations were defined on three concentric polygons and a central line at 3, 20, 40 and 58-66 m from the crop boundary (Fig 2 f). Overwintered adult *M. aeneus* colonising the crop were sampled on five occasions from green bud stage to mid-flowering by beating 20 plants per location over a white tray. Mature second instar *M. aeneus* larvae falling from plants to pupate in the soil, were collected in trays (220x260 mm) containing water with detergent. They were counted and dissected to assess the presence of eggs and larvae, respectively, of the endoparasitoids *Tersilochus heterocerus* Thomson and *Phradis interstitalis* (Thomson). The emergence of new generation insects from the soil was assessed using 0.5m^2 emergence traps in June – July 1999 for *M. aeneus* and in April – May 2000 for the parasitoids (unlike their hosts, these parasitoids overwinter in the soil). Results were analysed using Spatial Analysis by Distance IndicEs (SADIE; see Ferguson *et al*., 2003) to statistically define areas of clustering and gaps in the distribution of insects and to compare distributions.

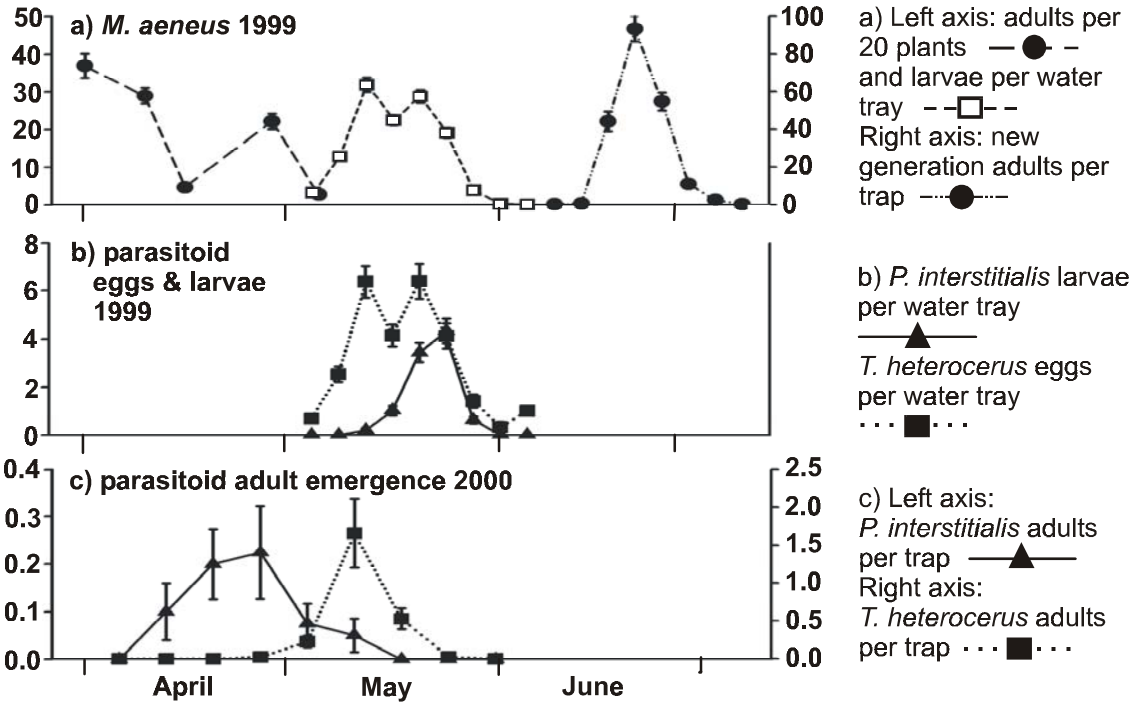

Fig. 1. Phenologies of *M. aeneus* and its parasitoids in 1999 and 2000 (mean numbers ± SEM).

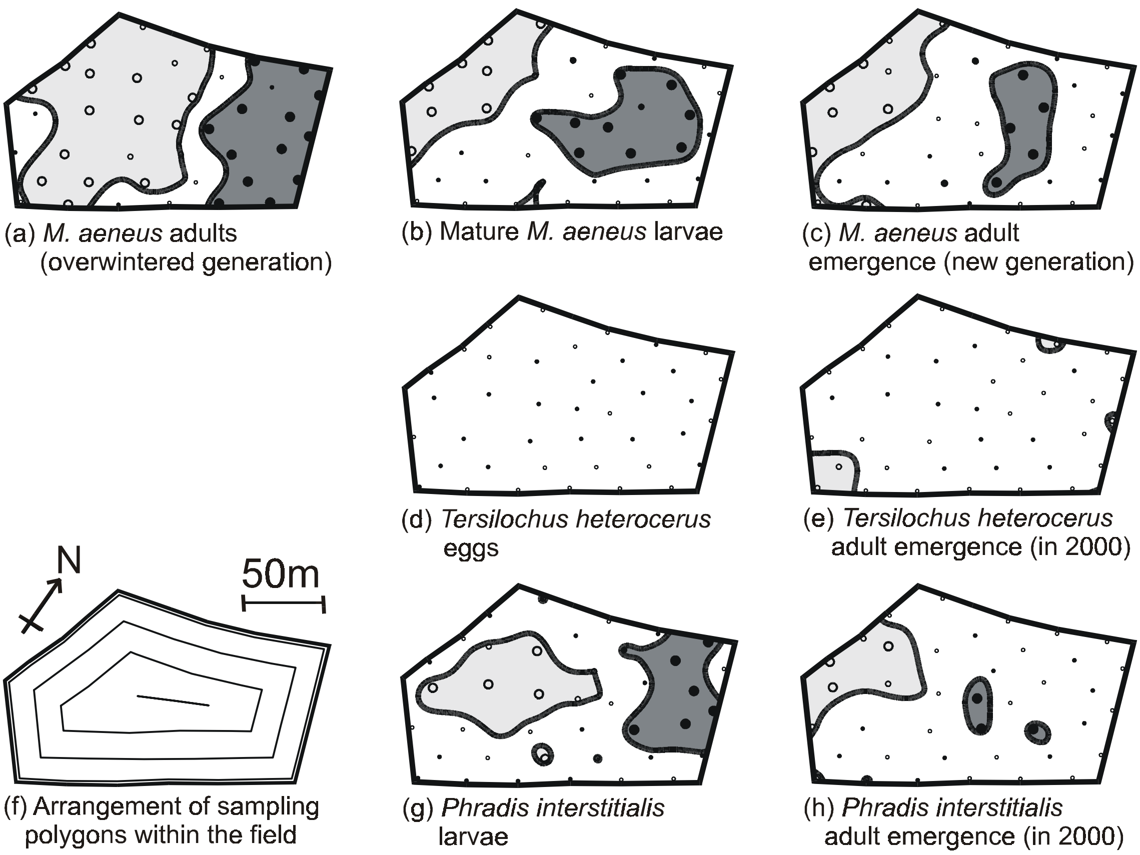

Fig. 2. Spatial analysis of *M. aeneus* and its parasitoids. Dark grey and pale grey areas indicate clusters and gaps, respectively. Large filled circles indicate individual sample locations with significant clustering (P≤ 0.05), large open circles indicate locations with significant gappiness.

Table 1. Summary of total *M. aeneus* and parasitoid numbers and survival rates.

Species	No. of eggs or larvae per m^2 (mean ± SEM)	% larvae parasitised	No. of new generation adults per m^2 (mean ± SEM)	% survival to adult
M. aeneus	1597 ± 74	23.7	415 ± 27	26.0
T. heterocerus	336 ± 25	-	4.9 ± 1.07	1.5
P. interstitialis	125 ± 11	-	1.3 ± 0.41	1.0

RESULTS

A quarter of *M. aeneus* larvae were parasitised, most commonly by *T. heterocerus,* but fewer than 2% of parasitoids survived to adulthood (Table 1). Adult *P. interstitialis* emerged from the soil in April, the period when adult *M. aeneus* colonises the crop, whereas *T. heterocerus* emerged in early May, the period when mature *M. aeneus* larvae begin to fall from plants (Fig. 1). The larvae of *M. aeneus* and both generations of adults were clustered in the north-east half of the field (Fig. 2 a-c) and the distributions of adults and larvae were significantly associated. The distributions of *P. interstitialis* were associated with those of their host (Fig. 2 g & h) but by contrast those of *T. heterocerus* showed little pattern (Fig. 2 d & e).

DISCUSSION

The existence of clusters and gaps in the spatial distribution of *M. aeneus* larvae was in accord with previous data (Ferguson *et al*., 2003) and reflected the distribution of immigrating adults, the main target for insecticides. Patterns of sampling for decision support which take into account the characteristics of spatial distribution would enable more accurate modelling of potential yield loss and allow spatial targeting to minimise insecticide usage and conserve parasitoids. Adult *T. heterocerus* emerged later in the season than the decline in numbers of *M. aeneus* adults on the crop the previous year, and *T. heterocerus* larvae were equally abundant outside dense host patches as within them. Spatio-temporal targeting of insecticide applications early (Nilsson, 1985) and against patches of adult *M. aeneus* might therefore be especially effective at conserving this parasitoid. As in Sweden (Nilsson, 1985), *P. interstitialis* emerged first, and being closely associated temporally and spatially with the distribution of its adult hosts, it may be more vulnerable to insecticide treatments, perhaps explaining its lesser abundance. Losses of overwintering parasitoids can be reduced by minimum tillage (Nilsson, 1985).

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