

ECOSYSTEM DIVERSIFICATION TO ENCOURAGE NATURAL ENEMIES OF CEREAL APHIDS.

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ABSTRACT

In order to enhance the predatory potential of native natural enemies of cereal aphids, such as certain species of Carabidae, Staphylinidae and Araneae, overwintering habitats were created in the centres of three cereal fields. These habitats recreated the important features of natural field boundaries necessary to support high densities of overwintering predators.

Successional change altered the balance of predator community structure from initial dominance by pioneer species to more permanent specialised species. By the third winter, the predator communities were dominated by species normally restricted to overwintering in established natural boundaries.

Studies on predator emigration showed that the overwintering predator populations from the new habitats could influence dispersal patterns in the spring, providing an even spread of predators throughout the crop early in the season.

INTRODUCTION

Sotherton (1984, 1985) showed that some field boundary types are of particular importance in providing overwintering refuges for many species of polyphagous invertebrate predator in arable field systems. The removal of natural boundary structures associated with farming intensification in conventional arable systems (Davies & Dunford 1962; Edwards 1970; Greaves & Marshall 1987) has therefore resulted in a reduction in overwintering habitat. In an attempt to redress the natural balance, new habitats have been created to provide improved overwintering conditions for polyphagous predators in arable land. Rather than just manipulate or create boundary habitats however, field size has been reduced by creating linear "island" habitats which are effectively facsimiles of boundary underbanks, at the field centre. The aim of this paper is to present details of successional change in overwintering predator community structure, during the first three years of habitat establishment. Also, to investigate the influence of the new habitats at the time of predator dispersal in the spring.

MATERIALS AND METHODS

Although three within-field habitats were created, data are presented for only one.

Site description

The within-field refuge took the form of an earth-ridge island habitat (0.4m high, 1.5m wide, 290m long) created at the centre of a 20 ha winter wheat field in autumn 1987. Six-meter long sections of the ridge were sown (spring, 1987) with various grass species in a linearly randomised block design. The treatments sown were (1) *Dactylis glomerata*, (2) *Lolium perenne*, (3) *Agrostis stolonifera*, (4) *Holcus lanatus*, (5) mixture of three species

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(*A. stolonifera* absent), (6) mixture of four species, (7) a bare ground control and (8) a pollen and nectar source flower treatment.

Predator sampling

During winter 1987/88, ground-zone quadrat surface-searching (six 0.1m² quadrats per treatment replicate) was carried out in all treatments. During the second winter (1988/89), three destructive samples (turves of 0.04m², 0.1m deep) were taken from each replicate of the single grass species treatments. This process was repeated in winter 1989/90 with four destructive samples taken from each single grass species treatment replicate.

During the 1989/90 winter, natural field boundaries were also sampled. Ten destructive samples (one every 5m) were taken from a representative 50m section of each boundary surrounding the adjacent field.

To assess spring predator dispersal, transects of vacuum-net (Thornhill 1978) samples (at 0m, 3m, 10m, 30m, and 60m from one ridge) were taken at weekly intervals from April to late May 1989. Samples at each distance in an individual transect comprised 15 contiguous 0.092m² sub-samples of 10 seconds' duration each, parallel to the ridge. Samples were taken from five transects running at right angles to the ridge adjacent to the *Dactylis glomerata* treatments in each of five blocks.

RESULTS

Although all treatments were sampled in winter 1987/88, only data for the four single-grass species treatments are presented. These were the only treatments sampled in all winters and therefore the only ones to provide data on changes in predator community structure through time.

Beetles of the family Carabidae were divided into "boundary" carabids (those species that are dependent on boundary habitats as overwintering refuge sites e.g. *Agonum dorsale*, *Bembidion lampros*, *Demetrias atricapillus* (Sotherton 1984,1985)) and "open-field" carabids (i.e. those species that have regular patterns of dispersion in agricultural land and are present at the field centres even during the winter period e.g. *Bembidion obtusum*, *Notiophilus biguttatus* and *Trechus quadristriatus* (Sotherton 1984,1985)). The number of boundary carabids, as a proportion of the total number of both types in the different treatments over the three winters, plus the average proportion of boundary carabids from the four natural boundaries surrounding the adjacent field (sampled during the 1989/90 winter), are presented in Table 1.

The table shows the carabid population to be dominated by open-field species during the first winter. Few boundary carabid species were found on either ridge at this time. Following this, there was a significant increase in the proportion of boundary carabids through time (one-way analysis of variance of proportions ($\sqrt{\text{arcsine transformation}}$) for each treatment between years, followed by Tukey's (1949) test). In the final winter, proportions of boundary carabids were at their highest in all treatments except for *Lolium perenne*, which showed no significant difference between second and third winters (*A. stolonifera* $F_{2,63} = 27.72$, $P < 0.001$; *D. glomerata* $F_{2,63} = 39.02$, $P < 0.001$; *H. lanatus* $F_{2,63} = 90.52$, $P < 0.001$; *L. perenne* $F_{2,63} = 32.92$, $P < 0.001$). A further analysis of variance between proportions of boundary carabids in the ridge treatments and proportions in the natural boundaries surrounding the adjacent field (the four boundaries being pooled), showed there was no significant difference between the ridge treatment and the natural boundary communities taken as a whole, during the final winter ($F_{4,130} = 0.84$, $P = 0.505$).

Temporal changes in the ratio of Lycosid:Linyphiid spiders in the various treatments on the ridges are also presented in Table 1. One-way analysis of variance (log(n+0.1) transformation) revealed a significant increase through time in the lycosid:linyphiid ratio in the four grass treatments (A. stolonifera $F_{2,50} = 15.04$, $P < 0.001$; D. glomerata $F_{2,52} = 33.15$, $P < 0.001$; H. lanatus $F_{2,53} = 20.29$, $P < 0.001$; L. perenne $F_{2,60} = 19.26$, $P < 0.001$). Similar to the Carabidae, there was no significant difference between the ridge treatment and natural boundary lycosid:linyphiid ratios ($F_{4,102} = 0.71$, $P = 0.585$).

TABLE 1. Mean proportion of boundary carabids and mean ratio of Lycosidae:Linyphiidae overwintering on one within-field ridge during 1987/88, 1988/89, 1989/90 winters. Different letters indicate significant between-year differences for individual treatments, at the 5% level (one-way analysis of variance, followed by Tukey's test).

Boundary carabids	Winter 1987/88	Winter 1988/89	Winter 1989/90
<u>Agrostis stolonifera</u>	0.18 ± 0.077 (c)	0.44 ± 0.078 (b)	0.87 ± 0.034 (a)
<u>Dactylis glomerata</u>	0.12 ± 0.045 (c)	0.56 ± 0.113 (b)	0.84 ± 0.067 (a)
<u>Holcus lanatus</u>	0.06 ± 0.043 (c)	0.67 ± 0.060 (b)	0.89 ± 0.059 (a)
<u>Lolium perenne</u>	0.09 ± 0.035 (b)	0.85 ± 0.284 (a)	0.90 ± 0.059 (a)
Natural boundaries	-	-	0.83 ± 0.039
Lycosid:linyphiid ratio			
<u>Agrostis stolonifera</u>	0.00 (b)	0.30 ± 0.186 (b)	1.22 ± 0.460 (a)
<u>Dactylis glomerata</u>	0.04 ± 0.017 (b)	0.20 ± 0.107 (b)	1.25 ± 0.291 (a)
<u>Holcus lanatus</u>	0.04 ± 0.019 (b)	0.22 ± 0.079 (b)	1.16 ± 0.330 (a)
<u>Lolium perenne</u>	0.00 (c)	0.79 ± 0.494 (b)	1.05 ± 0.296 (a)
Natural boundaries	-	-	1.47 ± 0.387

The results of the 1989 emigration study for the carabid beetle Demetrias atricapillus and the staphylinid beetle Tachyporus hypnorum, are presented in Figures 1 and 2 respectively. Asterisks beneath the figures denote significant differences at the 5% level between distances along transects for individual dates (one-way analysis of variance ($\sqrt{\text{arcsine}}$ transformation of proportions of totals caught/date) followed by Tukey's test). Figure 1 shows significantly higher proportions of D. atricapillus immediately adjacent to the ridge up until 3/5/89, after which the proportions tended to become more evenly distributed with no significant differences between distances. Figure 2 shows two significant peaks of proportions (0m and 60m) of T. hypnorum until 18/4/89. Although no consistent spatial patterns occurred following this, significantly lower proportions of T. hypnorum were found on the ridge than in the crop by the end of the study.

DISCUSSION

Analysis of carabid communities revealed considerable changes over the three years of the study. The proportion of boundary to open field carabids on the ridge did not differ

boundary carabids was achieved via clear successional changes over the three years. Open-field carabids, already represented at the field centre, dominated the carabid community during the ridge's infancy. As ridge maturity increased, so did the proportion of boundary carabids, until the final year, where this group of species was dominant.

Succession was also apparent within the spider community. The low lycosid:linyphiid ratio during the 1987/88 winter indicated a dominance by the linyphiid spiders on both ridges in the first year. Following this, the ratio increased until the final year, where the lycosid:linyphiid ratio on both ridges did not differ significantly from the ratios in the natural boundaries bordering the respective adjacent fields. This change in the ratio of Lycosidae:Linyphiidae therefore probably reflected succession from pioneer species (r-strategists i.e. Linyphiidae) towards more permanent and specialised (K-strategist i.e. Lycosidae) species (Nentwig 1988).

The results of the spring study suggested that the ridge, by providing a nucleus predator population at the field centre from which emigration could take place, enhanced field colonisation thus improving the opportunity for biocontrol. This was particularly apparent for *Demetrius atricapillus*, which following a period of close association with the ridge habitat appeared to penetrate the field resulting in a uniform dispersion through the crop. A similar pattern was observed for *Tachyporus hypnorum*, although as this species has a more rapid dispersal than *D. atricapillus* (Coombes & Sotherton, 1986) the influence of the natural hedgerow population as well as the ridge population could be seen. That is, the observed dispersion pattern was achieved via emigration from both ridge and hedgerow sources resulting in higher numbers away from, rather than adjacent to, the ridge habitat.

The successional changes which were observed as the ridge habitat matured, indicated a shift away from initial dominance by pioneer species, towards more permanent specialist species. Although this change may only be over a small range of the r-K-continuum, the increased spatial heterogeneity provided by the ridges could be considered to be sufficient to provide an increase in stability of the agro-ecosystem as a whole (Mader 1988; Nentwig 1988). As conventional arable systems tend to provide fragmented and unstable environments (Wratten 1990), such habitat creation schemes could provide a useful measure to strengthen natural control mechanisms disrupted by intensive food production (Mader 1988).

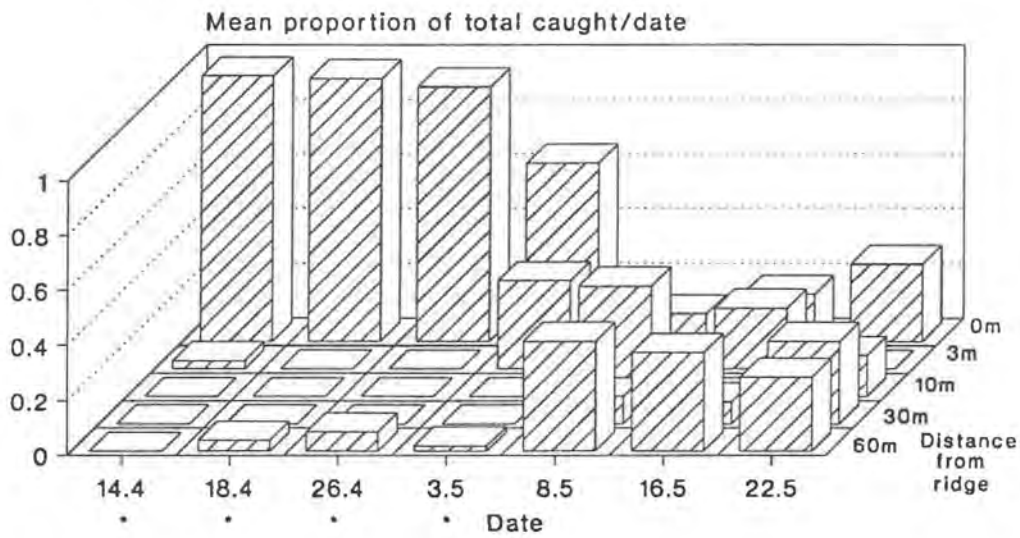
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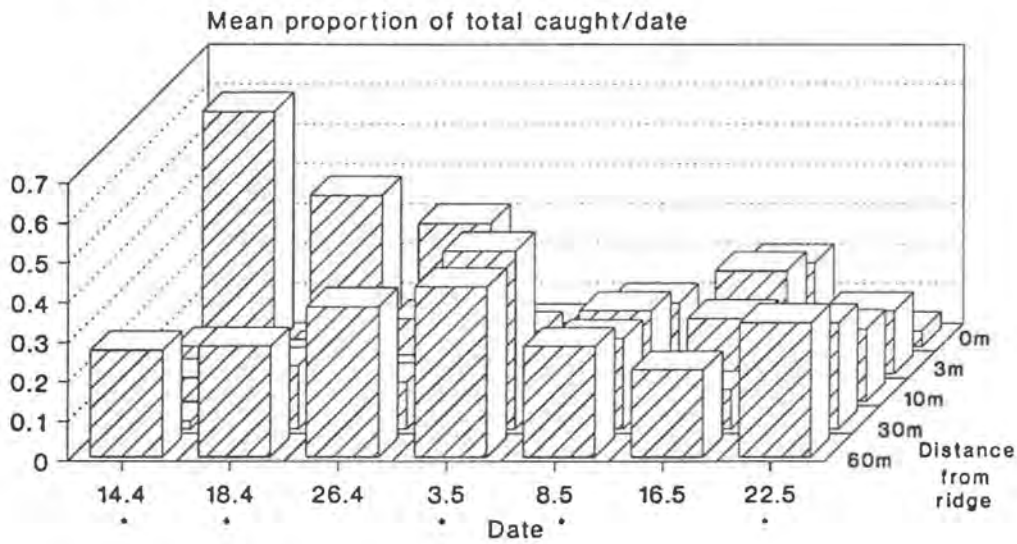
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FIGURE 1.
Emigration of *Demetrius atricapillus*,
spring 1989.



* Denotes significant between-distance differences at the 5% level.

FIGURE 2.
Emigration of *Tachyporus hypnorum*,
spring 1989.



* Denotes significant between-distance differences at the 5% level.

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