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Delivering arable biodiversity

Impacts of field margins, landscape and crop on the distributions of Syrphidae on an arable farm

By E J P MARSHALL and T M WEST

Marshall Agroecology Ltd., 2 Nut Tree Cottages, Barton, Winscombe, Somerset, BS25 1DU, UK
jon.marshall@agroecol.co.uk

Summary

Hoverflies (Syrphidae) were caught in modified water traps from 31 contiguous arable fields on an estate in Gloucestershire, UK. Traps were located in the crop centre and within four field margins from each field and serviced for three weeks in June/July in 2004. Trap locations were classified according to local habitat, crop, flower numbers and distances to other features, including woodland and water. Multivariate and regression analyses indicated that hoverfly numbers and species richness were significantly enhanced by proximity to winter oilseed rape crops, which maintained a significant weed flora below the crop canopy, compared with cereals. Catches were reduced close to set-aside and linseed, but margin type and flower numbers did not often contribute to models. Proximity to woodland was important for *Ferdinandea cuprea* and *Episyrphus balteatus*. Traps on the west side of fields, had lower catches than traps located elsewhere. Hoverflies appeared to be responding to factors at the field-scale, reflecting crop management and weed control, as well as non-crop habitat in the landscape.

Key words: hoverfly, field boundary, sown margin strip, GLM, distance, community

Introduction

Sown field margin strips at the edges of arable fields have been shown to enhance the abundance and diversity of several faunal groups, including grasshoppers, bees and spiders (Marshall *et al*., 2006). The creation of vegetation strips has been encouraged under agri-environmental support schemes (DEFRA, 2003) and has proved popular amongst arable farmers in the UK. Nevertheless, a variety of such strips has been created, ranging from simple grass-only mixes to complex flower and grass margins and temporary strips based on legumes and cereals (Marshall & Moonen, 2002; Marshall, 2004; Marshall, 2005). Whilst more diverse field margin vegetation is likely to enhance a more diverse fauna (Thomas & Marshall, 1999), there are a number of ecological questions that remain unanswered. In particular, how do different margin types affect associated fauna? How much recreated habitat is needed to enhance beneficial invertebrates? How should such habitat be arranged within a landscape? This study set out to investigate the impacts of newly created field boundary habitat, crop type and landscape structure on the hoverfly (Syrphidae) assemblages of an arable estate in central England. The Syrphidae, part of the Diptera, are a diverse insect group with 271 species recorded in Britain (Ball & Morris, 2001; Gilbert, 1993; Stubbs, 2002). A number of guilds are represented, but most adults feed on pollen and nectar and are plant pollinators. Floral resources in the landscape are expected to influence the occurrence and diversity of adult hoverflies. A number of species have larvae that are important predators of arable crop pests (Ten Humberg & Poehling, 1995; White *et al*., 1995), particularly aphids. The group is therefore regarded as important for biocontrol. The creation of new habitat allowed a series of hypotheses to be tested. First, that new flower-rich habitats significantly enhanced the abundance and diversity of hoverfly assemblages, second that different arable crops affect hoverflies in different ways, third that landscape structure influences the assemblages found.

Materials and Methods

A large, mainly arable, estate was located near the village of Great Barrington, Oxfordshire, England where a variety of field margin strips had been introduced under the Countryside Stewardship Scheme (DEFRA, 2001). The 6m wide and 2m wide margin strips were more than 4 years old, but new habitat strips and blocks had been established in autumn 2003, prior to this study. This offered the potential to compare spatial patterns of insect occurrence in the two following summers, when the new habitat might provide different floral resources within the local landscape. In this paper, the data from 2004, the first year of the study, are presented. A series of contiguous arable fields over an area of approximately 3 km^2 were selected and divided *a priori* into three groups according to local landscape features. These were a) Mixed - an area with rolling topography, some woodland blocks and conservation grassland, b) Open - an open area with flat topography and little woodland and c) Wooded – and area adjacent to a large block of deciduous woodland. Each area was further divided into two groups of five fields each, either in an area with new habitat blocks or without newly created margins. One extra field was included in the Open area to keep the blocks contiguous. In 2004, there was considerable crop diversity, including a number of set-aside fields in the Mixed area. In 2005, the majority of fields were sown to winter wheat and winter oilseed rape.

Combination water and window traps were located in the 31 contiguous arable fields, with a trap in the centre of each field boundary (N, S, E & W) and a crop centre trap in each field (= 5 traps per field). Water traps were plastic pot holders 28cm in diameter, fitted with gauze-covered overflow holes and painted white (Disney *et al*., 1982). Clear Perspex windows 30 cm by 25 cm were mounted vertically above the traps and orientated SW-NE at each of the 155 locations. Traps were filled with water and 1% detergent to reduce surface tension and set for three one-week trapping periods in June-July 2004. Samples were collected after one week and the traps reset. The contents of the trap were filtered through gauze and the gauze and retained insects were placed in plastic tubs. Once collected, the samples were preserved in 70% alcohol. The Syrphidae were sorted, sexed and identified under a binocular microscope with the aid of standard texts (Gilbert, 1993; Stubbs, 2002). Data in this paper do not distinguish between males and females.

Environmental data were collected at each trap location. Numbers of open flowers were estimated by eye; flower numbers in the boundary were estimated 5m either side of the trap from the crop to the hedge centre. In the crop centre, an area of 100m^2 around the trap was assessed for flower density. Flower numbers were divided into three groups for analysis: small flowers, tube flowers (Leguminosae, Labiateae), and large flowers (Umbelliferae, Asteraceae, etc.). These data were used to test the hypothesis that greater floral resources affect the species composition and abundance of hoverflies. Data on trap location, habitat size, local features, margins types and size, crop type and distances to water, woodland, new habitat, organic cropping (to the East of study fields), oilseed rape, linseed and tracks were derived from field visits and cartographic data.

Data were subject to single factor analysis using ANOVA using GenStat 7. Hoverfly communities and factors determining these were investigated using multivariate correspondence analysis with the CANOCO program (ter Braak, 1987). Regression analyses were made using

GLM on field centre and field margin trap data separately, to determine the likely importance of environmental factors affecting the occurrence of hoverfly species. As stepwise regression analyses have been shown to problematic (Whittingham *et al.*, 2006), data from the full model were investigated here.

Results

Total numbers of hoverflies caught were 1060 in 2004 and 1319 in 2005, comprising 28 species in 2004 and 45 species in 2005. Numbers of individuals per trap in 2004 varied considerably (0 – 58) and numbers of species from 0 to 9 per location. The most abundant species (Table 1), not surprisingly, were dominated by common species with aphidophagous larvae and are often found in arable crops. The exception, *F. cuprea*, is a woodland species that has larvae that develop on rotten wood, tree bark and sap runs.

Table 1. *The most abundant hoverfly species recorded. * = Aphidophagous larvae*

Species	No. individuals trapped	Habitat
**Platycheirus manicatus*	31	Grassland
**Episyrphus balteatus*	170	Arable, grassland
**Eupeodes corollae*	106	Arable, hedgerows
**Eupeodes luniger*	77	Arable, hedgerows
**Sphaerophoria scripta*	273	Grass, hedges, wood edges
**Syrphus ribesii*	161	Hedgerows, woodland
Ferdinandea cuprea	133	Woodland; trees

Table 2. *Mean numbers of hoverflies per trap collected over 3 weeks in 2004 from 31 arable fields. Transformed data (√ + 0.05) with raw data averages in (brackets) for (A) trap location and (B) different crops.*

(A)

Trap location	North	South	East	West	Field centre	sed (df)
2004	2.59 (9.2)	2.31 (7.7)	2.55 (9.2)	1.84 (3.8)	1.61 (4.8)	0.371 (150)

(B)

Crop	Winter wheat	Winter barley	Winter oilseed rape	Linseed	Spring oilseed rape	Set-aside	Organic spring barley	sed (df)
2004	2.27 (6.2)	2.49 (8.5)	3.71 (18.0)	0.89 (1.1)	1.92 (4.2)	1.62 (3.3)	4.13 (23.8)	0.589 (148)
No. fields	11	4	3	5	1	4	1	

Single factor analysis of the numbers per trap and number of species per trap indicated significant differences between landscapes, crop type and trap position. Also, areas with new habitat had significantly fewer hoverflies compared with control areas in 2004. Trap position (which was balanced across treatment, crop and landscape) had a significant effect on numbers and species richness (Table 2). Traps in the centre and on the West side of fields had lowest catches. Species richness was also lowest in field centres. There were seven different crops in the 31 fields and significantly more hoverflies were trapped in winter oilseed rape and organic spring barley than other crop types.

Nevertheless, there were different numbers of fields sown to particular crops and the data were unbalanced, with crop type also confounded with landscape area. The three winter oilseed rape fields were adjacent to each other and located in the Open and Wooded landscape areas. To investigate factors affecting the hoverfly assemblages, canonical correspondence analysis (CCA) was preformed on the total catches for each location. Initial analyses indicated that a unimodal model was appropriate and that rare species had marked effects on the ordination of some locations. One species, *Ferdinandea cuprea*, was particularly associated with fields adjacent to woodland, reflecting its association with woodland habitats. Analysis of the data with and without down-weighting of rare species showed significant effects of only five environmental variables on the hoverfly assemblages (Table 3). The first two axes of the ordination (Fig. 1) explained 12.2% of the variance of species data and 42.2% of the variance of the species-environment relation.

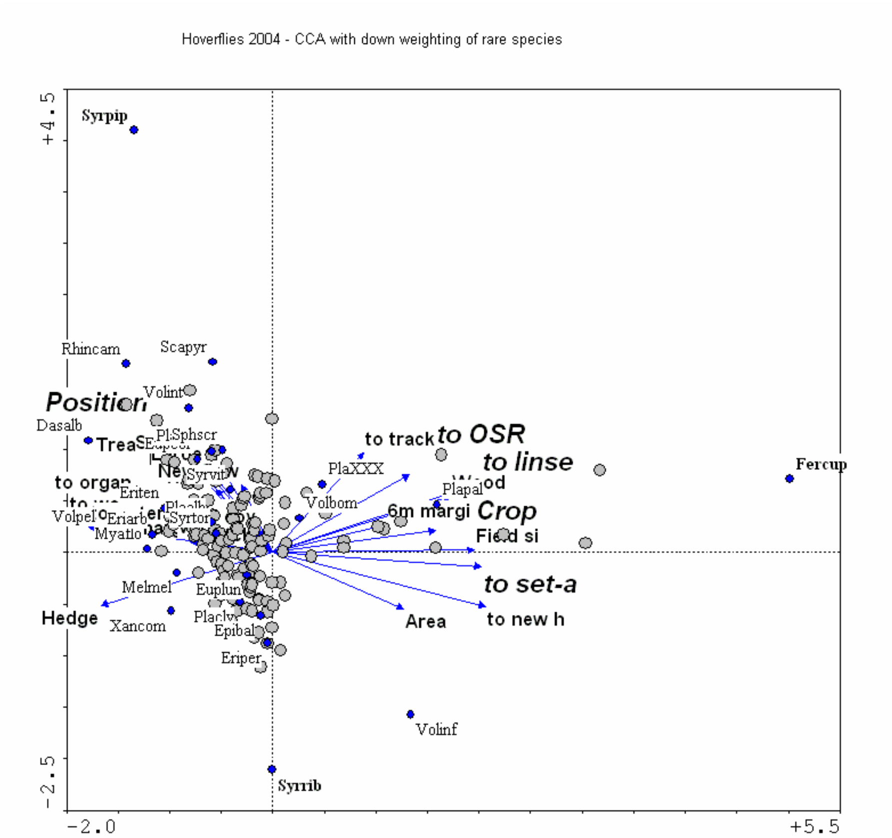

Fig. 1. CCA ordination of hoverfly assemblages from 155 trap locations across 31 contiguous arable fields in southern England. Data collected in 2004. Significant environmental variables (See Table 3) in bold. ( ) = Sites. Species names abbreviated: Fercup = *Ferdinandea cuprea*; Syrpip = *Syritta pipiens*; Syrrib = *Syrphus ribesii*.

Table 3. *Environmental variables that showed significant conditional effects on hoverfly assemblages in 155 trap location.*

Environmental variable	*P*	F	*P*	F
	No down weighting		Rare species down weighted	
Distance to set-aside	0.005	8.12	0.005	6.7
Distance to oilseed rape	0.005	5.10	0.005	5.18
Distance to linseed	0.015	3.17	0.02	3.05
Position (N, S, E, W, C)	0.01	3.23	0.005	3.72
Crop type	0.02	2.21	0.03	2.56

Regression analyses

GLM analysis of the catches from 31 field centres only gave best fits with the Poisson distribution. Total numbers of individuals and species richness were most significantly affected by distance to oilseed rape. Highest counts were found in winter oilseed rape fields, which were also the weediest and most flower-rich of the different crops. One species, *Sphaerophoria scripta*, dominated the catches and the only other species of sufficient abundance for analysis was *Eupeodes luniger*. The model for *S.scripta* included significant effects of numbers of tube flowers (positive), large flowers (negative) and the presence of woodland (positive). As a common and widespread species, it appeared to be responding to flowers within the crop and the presence of adjacent woods. *E.luniger* was affected by distance to oilseed rape crops.

Analysis of data from 124 traps in the field boundaries indicated that two of the significant factors affecting total hoverfly numbers in catches were proximity to oilseed rape and distance away from set-aside (Fig. 2).

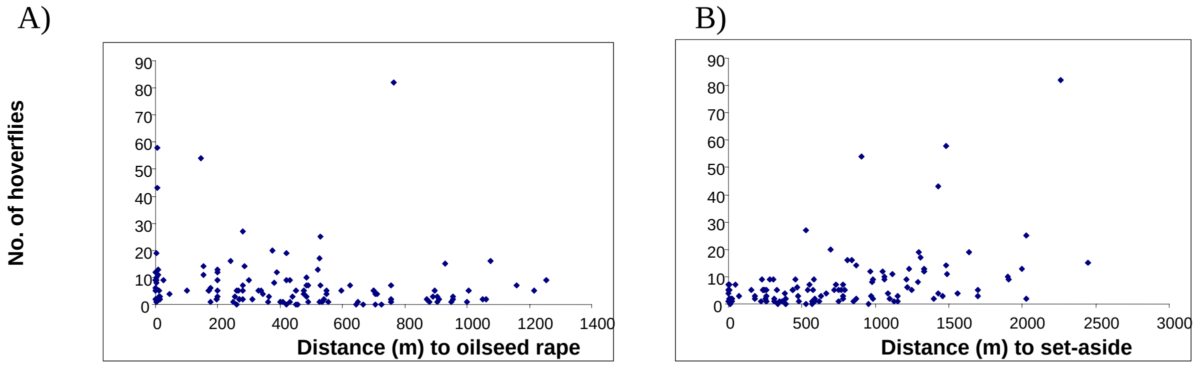

Fig. 2. Scatter plot of total hoverfly numbers in margin traps and distance to (A) oilseed rape crops and (B) set-aside fields.

Six species were sufficiently abundant for regression analysis and the variables that contributed significantly to models are given in Table 4. Species richness was enhanced closer to oilseed rape fields. Oilseed rape fields had positive effects on numbers of *E. balteatus, S. scripta* and *S. ribesii*. *E. balteatus* was positively influenced by woodland. In contrast, *P. manicatus* was more abundant further from rape fields. Flower resources around the trap were generally not important in the models, as most were negatively associated with hoverfly numbers. The exception was *E. corollae,* which was positively associated with small flower numbers and was more abundant away from woodland. The presence of vetch/triticale strips at the field edge had a positive influence on total numbers and *E. balteatus*. Trap orientation or location was a significant influence on total hoverfly abundance and for four species, *E.*

balteatus, E, corollae, S. scripta and *S. ribesii*, reflecting fewer catches on the West sides of fields.

Discussion

Hoverfly trapping took place over a limited period during the summer, so the number of species recorded could not be a representation of the entire fauna present on the farm through the year. Nevertheless, the trapping periods in June and July matched the time of year when the highest numbers of Syrphidae species are likely to be caught (Ball & Morris, 2001). Whilst a formal test was not made, the addition of the window above the trap was likely to have increased trapping efficiency. Certainly large numbers of bumblebees, solitary bees, Lepidoptera, Coleoptera and other Diptera were collected in the traps. This may indicate that in addition to the white trap acting as an attractant to flower-seeking insects, the Perspex window also caught a number of flying insects.

Multivariate analyses of the data indicate that winter oilseed rape fields had a major influence on catches. Highest abundances were found within or close to these fields, though numbers within the spring rape field were low. As well as flowering later, this crop was less weedy than the winter-sown fields. Winter-sown oilseed rape fields were generally much weedier than cereal fields and therefore had more flowers low in the canopy during the trapping period. This effect was clearly shown from the catches from within the centre of the crop fields, but was also a major influence on catches within the field boundaries. Rotational set-aside fields had low hoverfly numbers. This probably reflects the low floral resource of these fields in summer, when much bare ground is present and cutting or herbicide application are often used to reduce weed seed return. Curiously, hoverfly catches within linseed were also low. Linseed was flowering at the start of the trapping period and there may have been some interaction between trap apparency and floral resource availability. With an abundance of pale flowers in the locality, possibly trap catches were reduced. A number of boundary traps were located in margin strips dominated by *Leucanthemum vulgare* (oxeye daisy). These also tended to have low catch numbers. However, this needs to be balanced against the high numbers of hoverflies trapped close to rape.

There were some consistent differences in catch number associated with location in the field. Regression models and single factor analysis indicated that fewer hoverflies were caught in trap located on the western side of fields. Most fields were surrounded by hedges over 2m tall. It is therefore likely that traps located on the western side of fields were in the lea of the hedge from the predominantly south-westerly winds. The result may reflect insect behavioural patterns or physical wind movement of insects beside hedges. Earlier work indicated that insects accumulate in the lea of hedges (Lewis, 1969), which one might have expected to increase trap catches, rather than giving the observed reduction. Further work is required to explain the observations.

Examination of the full models using regression analysis has been shown some logical differences in occurrence of individual hoverfly species in relation to habitat features. Proximity to woodland was important for *E. balteatus*. Factors at the landscape scale dominated over local habitat factors in a study of European hoverfly communities (Schweiger *et al.*, 2005), while the present study indicates that field-scale factors were most important. Overall, these results indicate that factors associated with different crop types, particularly oilseed rape, influence hoverflies in an agricultural landscape, together with the location of non-crop habitat, notably woodland. Within-field factors, particularly the availability of common weeds, may explain this importance. The quality of habitat patches has been shown to affect flower visitation by hoverflies (Kleijn & van Langevelde, 2006). This appears to be the case within arable crops, reflecting the effects of crop management, particularly weed control.

Table 4. *Variables significantly contributing to full regression models of hoverfly numbers in field margins at Barrington Park in 2004. + = Positive effect of feature; - = negative effect of feature; ✓ = significant effect*

Variate	Total hoverfly No.	Species richness	*Platycheirus manicatus*	*Episyrphus balteatus*	*Eupeodes corollae*	*Eupeodes luniger*	*Sphaerophoria scripta*	*Syrphus ribesii*
Oilseed rape	+	+	-	+			+	+
Set-aside	-						+	
New habitat	-							-
Woodland	+			+	-			
Track or road	+			+		+		+
Vetch/triticale strip	+			+				
Flower numbers (large, tube, small or total flowers)	- small			- small	+ small	+ total - large		- large
Trap location or orientation	✓			✓	✓		✓	✓
Crop type		✓						
Field size			✓					

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