Session 3

Management of Field Margins

Session Organisers & Chairmen	DR R J FROUD-WILLIAMS & DR H M CARNEGIE

MANAGING FIELD MARGINS FOR HOVERFLIES

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ABSTRACT

In this paper we consider the effectiveness of providing flowering strips along the border of fields to augment the density of aphidophagous hoverflies. It is now fairly well established that additional floral resources can increase the local density of adult hoverflies. The evidence that higher densities of adult hoverflies actually promote significant control of aphid populations is however rather equivocal and the possible reasons for these incongruous results are discussed. Finally, we address some of the wider implications of this management programme including a discussion of its economic justification and the possibility of undesirable side effects.

INTRODUCTION

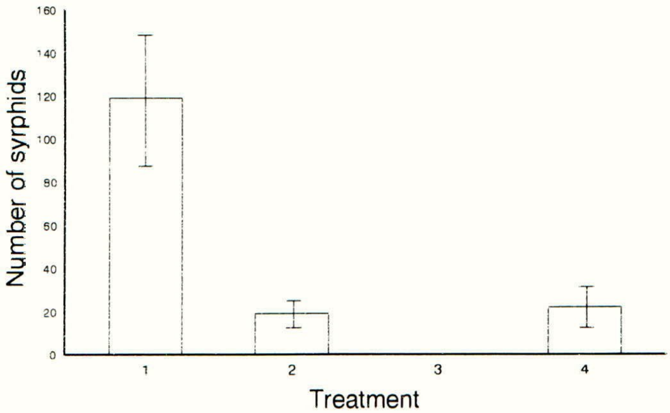
One reason for managing field margins is to enhance the local densities of predators of agricultural pests and thereby improve the degree of biological control. The larvae of a number of species of hoverfly (Syrphidae) feed on aphids and in this paper we consider:
i) whether the local density of adult hoverflies can be increased by providing strips of wild flowers along field margins
ii) whether higher densities of adult hoverflies results in less aphids, and
iii) some other implications of this management practice.

CAN FLOWERING STRIPS BE USED TO INCREASE THE DENSITY OF HOVERFLIES ?

A considerable amount of work has already demonstrated that the provision of floral resources on farmland may lead to an increase in both the local density of Syrphidae and their species diversity (e.g. Ruppert & Molthan 1991, Sengonca & Frings 1988, Weiss & Stettmer 1991). Work at Southampton has augmented this work by examining the effectiveness of a variety of modern field margin management regimes in promoting hoverflies.

Harwood, Wratten & Nowakowski (1992) drilled three field margins with mixtures of indigenous British wild flowers and grasses and compared hoverfly captures from transects of yellow pan traps perpendicular to these margins with hoverfly captures from transects of traps extending from three unmanaged field margins. The results suggested that the numbers of the total aphidophagous Syrphidae within an unmanaged arable field margin and within the adjacent field (up to 100m) can be increased by planting the field margin with wild flowers. This increase was not however shown for the most abundant aphidophagous syrphid, *Episyrphus balteatus*. The most significant treatment effect was seen in the Eristalinae (e.g. *Eristalis arbustorum*), whose larvae do not feed on aphids. Further studies have compared the number of adult syrphids observed in plots with (1) wild flower mixtures and grasses (managed by mowing and selective graminicide application), (2) grasses only, (3) bare ground, and (4) natural regeneration after cultivation, (Harwood, in prep.). Wild flower drilled margins were found to contain significantly more aphidophagous Syrphidae than bare ground, grass and natural regeneration treatments (Figure 1).

Figure 1. Number of aphidophagous syrphids observed in field-margin plots on 2nd August 1992 +/- S.E. Treatment 1 was drilled with a wild flower and grass mixture in September 1991 and mown in April and May 1992, Treatment 2 was cultivated in September 1991 and left to regenerate natural vegetation, Treatment 3 was a bare ground treatment (control) sprayed with a broad spectrum herbicide in September 1991, Treatment 4 was drilled with a grass mixture only in September 1991.



In a separate experiment, MacLeod (1992) looked at the role of alternative and novel crops as a source of pollen and nectar for foraging hoverflies. Results suggested that of all the flowering crops tested, species such as *Coriandum sativum* (Coriander) and *Fagopyrum esculentum* (Buckwheat) were the most attractive to hoverflies. However a field trial using strips of coriander along two edges of a cereal field did not produce significantly higher densities of hoverflies in the coriander bordered field than in an unmanaged control field.

Hickman & Wratten (in prep.) planted field margins with *Phacelia tanacetifolia*. This species is a member of the family Hydrophyllaceae, a family of plant which does not occur naturally in the U.K., and as such has a characteristic pollen shape. By using gut dissections of *Episyrphus balteatus* caught in transects of traps extending from the field margin into the crop it was possible to establish that hoverflies which had fed in the *Phacelia* strips moved up to 250 metres into the crop. Comparison of the numbers of hoverflies caught in transects extending from *Phacelia* margins and from control margins showed that hoverfly numbers (including *E. balteatus*) were increased in the treatment transects, and that this increase was greatest at a time when the *Phacelia* was in full bloom.

HOVERFLY OVIPOSITION AND APHID NUMBERS

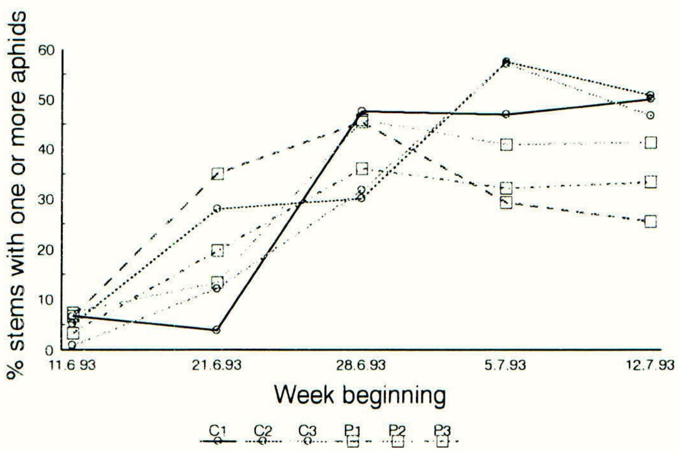
The control of aphids is the basic rationale behind a number of research programmes concerned with managing field margins for hoverflies. Hoverfly adults are highly mobile and while one might expect them to lay more of their eggs close to where they have fed, this is not necessarily the case. Evidence for an increase in oviposition and reduction of the local density of aphids, as a result of this field margin management, is sparse. Studies by van Emden (1965), investigating syrphid oviposition on Brussels sprouts at different distances from flowering strips, and Pollard (1971), who compared oviposition in arable and woodland sites, did show higher rates of hoverfly oviposition near flowers. However the first study was unreplicated and the author of the second concluded that the difference between his sites could be explained by the fact that some species of hoverfly were restricted to woodland. Chandler (1968a) found no difference in oviposition in small replicated plots of Brussels sprouts between those with buckets of flowers added and those without. Sengonca & Frings (1988) recorded higher aphid density in control plots of sugar beet than in those with *Phacelia tanacetifolia* patches or borders but ironically the density of syrphid eggs was also higher in the controls. This highlights an important confounding effect: aphidophagous hoverflies tend to lay more eggs on stems that contain more aphids (Chandler, 1968b), so we should not treat evidence for high hoverfly egg densities alone as evidence for control of aphids!

Hickman (in prep.) conducted a large scale experiment on a farm in North Hampshire U.K. during 1992 and 1993. In this study she compared hoverfly oviposition and aphid numbers between three winter wheat fields with *P. tanacetifolia* borders along two of the four sides, and three control fields (different fields were used in the two years). In both years, and on several different dates from the time when the *P. tanacetifolia* flowered, a number of stems at eight distances from the field borders (up to 180m in 1992; 100m in 1993) were taken and examined for the presence of syrphid eggs and aphids. Although syrphid larvae were recorded when seen, they were not specifically searched for since they conceal themselves in the crop during the day and are most active at night when most of their predation occurs.

During the 1992 season very few syrphid eggs were found in the crop and no significant differences in the mean density of aphid populations were detected between treatments. One reason for this may have been that the wheat crop ripened about two weeks earlier than usual. The early emergence of wheat ears enabled them to be colonised by the grain aphid *Sitobion avenae* while numbers of gravid hoverflies remained low. Syrphid oviposition may also have been deterred by the early yellowing senescent condition of the wheat. The mean number of syrphid eggs found on aphid infested baits in the *P. tanacetifolia* - bordered fields (3.03 per bait) was higher than the mean number of eggs found on baits in the control fields (2.00 per bait) although the difference was not statistically significant ($P > 0.05$).

In 1993, 320 stems were checked in each experimental and control field during each week that aphids remained in the crop. A total of 61 syrphid eggs were found in *P. tanacetifolia* - bordered fields and 21 in control fields, with the majority being found between 11.6.93 and 27.6.93. No clear patterns could be seen between treatments for the percentage of stems infested with one or more aphids, until the week beginning 5.7.93.; from this point percentages of infested stems were lower in all *P. tanacetifolia* - bordered fields than any control field. This period coincided with the main appearance of third instar syrphid larvae (the most voracious instar) in the crop. Levels of parasitoid activity (as assessed by the number of aphid mummies seen) appeared similar between treatments and there was very little evidence of aphid death from pathogens. We therefore consider it likely that the differences in aphid levels between treatments were the result of increased predation by syrphid larvae in the *P. tanacetifolia* - bordered fields.

Figure 2 Percentage of wheat stems with one or more aphid in *P. tanacetifolia* - bordered and control fields on different dates. Each line represents a separate field. P = *P. tanacetifolia* borders; C = control.



From the above it does appear that the provision of suitable flowering strips for hoverflies can sometimes, under relatively large scale conditions, promote measurable local control of aphids.

MISCELLANEOUS CONSIDERATIONS

The underlying philosophy behind managing field margins to promote control agents of agricultural pests is rarely made explicit. Since our intention is to manage field margins in order to promote hoverflies, then the following basic questions come to mind:

1) Does the provision of floral resources actually increase the regional total population size of hoverflies, or does it simply influence their spatial distribution?

2) Where are the floral resources best positioned for maximum control of aphids?

3) Is the provision of flowering strips for aphidophagous hoverflies likely to make economic sense?

4) Are there any potentially deleterious effects of providing additional floral resources along field margins?

These questions are now considered in turn;

1) Clearly from the time additional floral resources are first provided, then

initially any increase in the number of hoverfly adults comes about from the spatial re-distribution of adults. It has been known since 1948 that female syrphids require pollen to develop their ovaries (Schneider, 1948), but it is still unknown whether pollen availability is a limiting factor in the life of some species of hoverfly. Studies have been published on the key factors affecting survivorship of syrphids in the egg, larval and pupal stages, but factors affecting the adult stage have not been recorded (Verma & Makhmoor,1989). Furthermore it is still unclear as to whether or not the quality of the pollen and nectar resources influences total fecundity and egg fertility. Work is currently being undertaken at Southampton to address this possibility.

2) This question has never been considered directly. Clearly flowering strips should be in large enough blocks to attract hoverflies, but they should also be spread out over fields to ensure that the adult hoverflies penetrate into all sides over the fields before laying their eggs. Any impediments to movement of beneficial syrphids around an arable system ought to be considered before deciding upon the positioning of flowering strips in the landscape. Figure 3 shows how a higher proportion of syrphids containing *P. tanacetifolia* pollen are caught in yellow traps 10m from a strip of *Phacelia* when there is no physical barrier between the strip and the traps, than in traps also 10m from a *Phacelia* strip, when there are barriers between the pollen source and the traps (Hickman & MacLeod, in prep). So far our work suggests that hoverflies may be reluctant to cross such features which cause a break in vegetational ground cover.

Figure 3. Mean distribution of the percentage of all hoverflies containing *P. tanacetifolia* pollen caught on either side of linear features on a farm.

3) An examination of the costs involved in this management option indicates that even if *P. tanacetifolia* borders were provided all around a field the economic burden on the farmer would not be a great one. In the Southampton experiment, the seeds were drilled in what would otherwise have been a sterile strip round the crop, thus there was no reduction in crop area. *P. tanacetifolia*, drilled at the recommended rate of 5kg/ha costs approximately 0.5p/m^2; the cost of seeds for a 1m strip round the largest field would be little more than £10. Once drilled or hand broadcast the strips require no further maintenance, and can be ploughed in with the stubble after harvest. Thus any reduction in insecticide use should result in increased profit for

the farmer in addition to the other benefits of reducing inputs.

4) We can see two potentially deleterious effects of providing flowering strips along field margins. One concern is that by providing a "sink" for hoverflies, one may achieve a **local** reduction in aphid density but actually augment it over a **regional** scale. Thus, while a crop in one field benefits from an increased number of syrphid larvae predating upon aphids, another nearby crop suffers and could allow aphid numbers to build up with winged aphids emigrating to surrounding fields, making the pest worse in the long term. We are currently assessing the likelihood of this scenario using a simulation model which is parameterised from field data. Another concern is that by providing additional floral resources, we could potentially reduce the amount of pollination in native wild plants. Our feeling is that the amount of additional floral resources provided would have to be on a massive scale before these more subtle side effects became important.

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FIELD MARGIN FLORA AND FAUNA CHANGES IN RESPONSE TO GRASSLAND MANAGEMENT PRACTICES

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ABSTRACT

Agricultural land use in Northern Ireland is dominated by high stock numbers and grass-based enterprises. An experiment was established in 1990 to examine the impact of grass field boundary management strategies on flora and fauna species diversity. Three well-managed hawthorn hedges separating paired grass fields formed the sites for the research. Four treatments were imposed, each 30 m long and extending 10 m into the field either side of the hedge. The treatments were as follows: (i) fertilised and rotationally grazed with sheep; (ii) 2 m strip ploughed adjacent to the hedge and sown with a game cover crop, the remaining 8 m being taken for silage; (iii) as (ii) but with the ploughed strip left unmanaged; (iv) unmanaged control.

Plant species presence and percentage cover have been recorded annually in permanent quadrats located in the hedge, hedge base, and at 0.5, 2, 6, and 9 m into the field. Carabid beetles were trapped using pitfall traps placed 1-2 m from the hedge and 8-10 m into the field. Plant species diversity was greatest within 0.5 m from the hedge base. Grazing and fertiliser use significantly reduced species diversity of carabids and plants relative to all other management treatments. If wildlife is to be conserved, hedges and field margins must be protected from grazing and other intensive grassland management operations.

INTRODUCTION

In Northern Ireland agriculture is largely pastoral. Approximately 1.5 x 10^6 cattle and 2.3 x 10^6 sheep utilise 1.1 x 10^6 hectares of grassland and approximately 83% of gross margins are derived from livestock enterprises (Department of Agriculture for N Ireland, 1993). Farms are small (mean size 35.1 ha) with a relatively large number of small fields (mean size 1.8 ha) and there are estimated to be 152,000 km of field boundaries. In such a rural scenario, field boundaries form an important component of the visual landscape. It has been estimated that between 1976 and 1982 the rate of loss of hedges in the Republic of Ireland was 14% (An Foras Forbartha, 1985) though this estimate was based on a sample of only 12 km^2.

The rate of hedgerow loss in N Ireland is poorly documented. From a landscape ecological survey of the Mourne Mountains Area of Outstanding Natural Beauty, Cooper & Murray (1987a) estimated an annual loss rate of 0.5%. The rate of removal was greater in the lowland area. In the Antrim Glens and Causeway Coast Areas of Outstanding Natural Beauty 12.3% of field boundaries were removed in the lowland area between 1975 and 1987 (Cooper & Murray, 1987b). The overall loss rate was 5.2 %. In the Fermanagh district (Murray *et al.*, 1991) 13.9% of field boundaries were removed since 1962, with the greatest loss in the lowland areas where grassland management was most intensive.

It is well documented that an increase in soil nutrient status, disturbance by cultivation and spray drift has resulted in many field boundaries having a species-poor flora. Sheep densities have increased substantially on N Ireland farms over the past 10 years (DANI, 1992). Sheep graze close to the ground and this selects against the survival of non-rosette plants with apical meristems borne aloft. Hence, sheep grazing can reduce associated hedge flora diversity and can restrict regrowth of managed hedges by eating regenerating shoots. Agricultural practices such as dereliction, increased use of fertiliser, use of slurry, zero grazing, conservation for silage instead of hay have resulted in loss of botanical diversity in hedgerows and grassland in favour of species which respond positively to soils with a high nutrient status.

Much research has been conducted on the impact of cropping practices and conservation value of arable field margins (eg Way & Greig-Smith, 1987; Thomas *et al.*, 1991). However, research into the impact of agricultural practices on the grass field margins is much sparser. In view of the importance of hedges to an intensive, grassland farming country such as Northern Ireland, the decline in hedgerows and the damage which grassland management can have on hedges, an investigation was initiated to investigate the effects of four grassland management practices on the flora and fauna of grass field boundaries. The aim of this long term project was to recommend the best strategy for maximising wildlife value of field boundaries.

MATERIALS AND METHODS

Treatments

Three well-maintained, mature hedges separating paired grass fields formed the blocks for the study. The predominant hedgerow species was hawthorn (*Crataegus monogyna*). Within a block, 4 treatments, each 30 m long, were randomly arranged across the hedge extending 10 m into the fields. The treatments first imposed in 1990 were as follows:

(1) Fertilise/graze. Plots were fertilised (100 kg N/ha) and rotationally grazed with sheep down to a target sward height of 2-3 cm.

(2) Plough/game cover. A 2 m strip adjacent to the hedge was ploughed and sown initially with a game cover crop of kale, mustard and quinoa; the remaining 8 m was fertilised (150 kg N/ha) and two cuts of silage taken. In March 1993 Jerusalem artichokes were planted as the game cover crop. These subsequently failed to grow and a change in the cover species will be made in 1994.

(3) Plough/unmanaged. This was similar to the previous treatment except that the 2 m strip was left unseeded and allowed to colonise naturally.

(4) Unmanaged control. No fertiliser or management treatments.

Flora and fauna recording

Plant species presence and percentage cover were recorded in July 1991 and August 1993 in 1 m x 1 m permanent quadrats in the hedge and hedge base, and at 0.5, 2, 6 and 9 m into the field. Quadrats were placed along three randomly arranged line transects on both sides of the hedge. Carabid beetle species were trapped annually in each plot using three pitfall traps placed 1-2 m ("margin" sample) and 8-10 m ("field" sample) either side of the hedge. Monthly catches were taken in March, May, July and September of each year.

Data Analysis

The species recorded in each set of three quadrats at a particular distance from the hedge were added together giving a total of 144 samples for each sampling session. The resultant data matrix was subjected to classification and ordination using TWINSPAN (Hill, 1979a) and DECORANA (Hill, 1979b) respectively (Bell *et al.*, 1994). An analysis of variance of the mean total number of species per treatment was carried out for treatments and distance from the hedge base. The catches for each set of three pitfall traps were combined to produce a total of 48 samples. The number of Carabid species occurring in each sample was counted and a Modified Simpson's Diversity Index (Usher, 1986) calculated. The modification is that the calculated Simpson's index figure is subtracted from 1 to produce an index, the magnitude of which is directly proportional to the degree of species diversity, (a species diversity of 0 would be a monoculture).

RESULTS

There were highly significant differences ($P<0.001$) in plant species number per quadrat between treatments and distance from the hedge (Table 1). Fertiliser application and grazing resulted in significantly ($P<0.05$) fewer plant species than all other treatments and although there were more species in the two ploughed strip treatments than the unmanaged control (8.3 vs 7.7) the difference was not significant ($P>0.05$). More species tended to occur close to the hedge than in the field and there were significantly more species in the quadrats placed 0.5 m from the hedge than in the hedge itself or further out into the field.

There were significant differences among treatments in species diversity of carabids in July and September (Field margin) and in September (Field). On these occasions there were significantly fewer carabids trapped in the fertilised/grazed plots than any of the managed treatments (Fig 1). From previous TWINSPAN analysis (Bell *et al.*, 1994), eight species were selected as indicator species. *Abax parallelepipedus* a species normally found in hedgerows was found in significantly fewer numbers in the fertilised/grazed margin traps in May and July. *Agonum muelleri* was more abundant in field traps in all treatments except the unmanaged (especially in July). *Bembidion aeneum* was found in greater numbers in the fertilised/grazed traps in the field in July than any other month. *Clivina fossor* was found in significantly lower numbers in field traps outside the ploughed treatments than the fertilised/grazed or unmanaged treatments. *Leistus fulvibarbes* was not trapped in the fertilised/grazed plots in the field margin in September. There were significantly ($P<0.05$) greater numbers of *Loricera pilicornis* in field traps adjacent to the ploughed treatments and of *Pterostichus strenuus* in the fertilised/grazed margin in July. There were significantly fewer *Pterostichus melanarius* in margin traps in the fertilised/grazed plots in May compared with other treatments.

TABLE 1. The effect of hedge management techniques imposed in 1990 on the mean number of plant species at varying distances from the hedge in 1993.

TREATMENT	HEDGE	HEDGE BASE	0.5 m	2 m	6 m	9 m
Fertilised/grazed	5.7	7.0	7.0	6.0	5.0	5.3
Unmanaged	8.3	8.7	8.7	7.0	7.0	6.67
Plough/Unmanaged	8.7	9.3	9.3	8.3	6.3	7.7
Plough/Game cover	9.0	8.7	11.0	9.0	5.3	7.0
Mean	7.9	8.4	9.0	7.6	5.9	6.0

SEM Treatment = 0.32 ($P<0.001$); Distance from base = 0.39 ($P<0.001$)

DISCUSSION

The results of this experiment clearly illustrate the effect that sheep grazing and fertilisation have on the flora and carabid fauna of field margins. Two years after imposition of the alternative management treatments there are significantly more wild plant species and carabid beetles than in the fertilised/grazed treatment. Populations of four key (indicator) species - *Abax parallelepipedus*, *Clivina fossor*, *Leistus fulvibarbes* and *Pterostichus melanarius* were found to be reduced by grazing/fertilising, particularly in late summer. The game cover crop produced no effect on plant or carabid species diversity. The importance of the field margin as a source of biodiversity in grassland is clearly shown. Most species were found in the hedge, hedge base and 0.5 m out from the hedge, compared to the field.

If wildlife is to be conserved in field margins, protection from intensive grazing and fertiliser application is necessary. From a wildlife perspective, there is little advantage to be gained in fencing further out than approximately 1 m from the hedge base though each hedge and associated swards will have historic and management backgrounds which make prediction of the likely course of species colonisation very difficult. This is a long-term trial and monitoring will continue for a further 6 years.

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Fig. 1 Histograms showing variation in carabid species diversity with season and treatment (modified Simpson's indices of diversity).

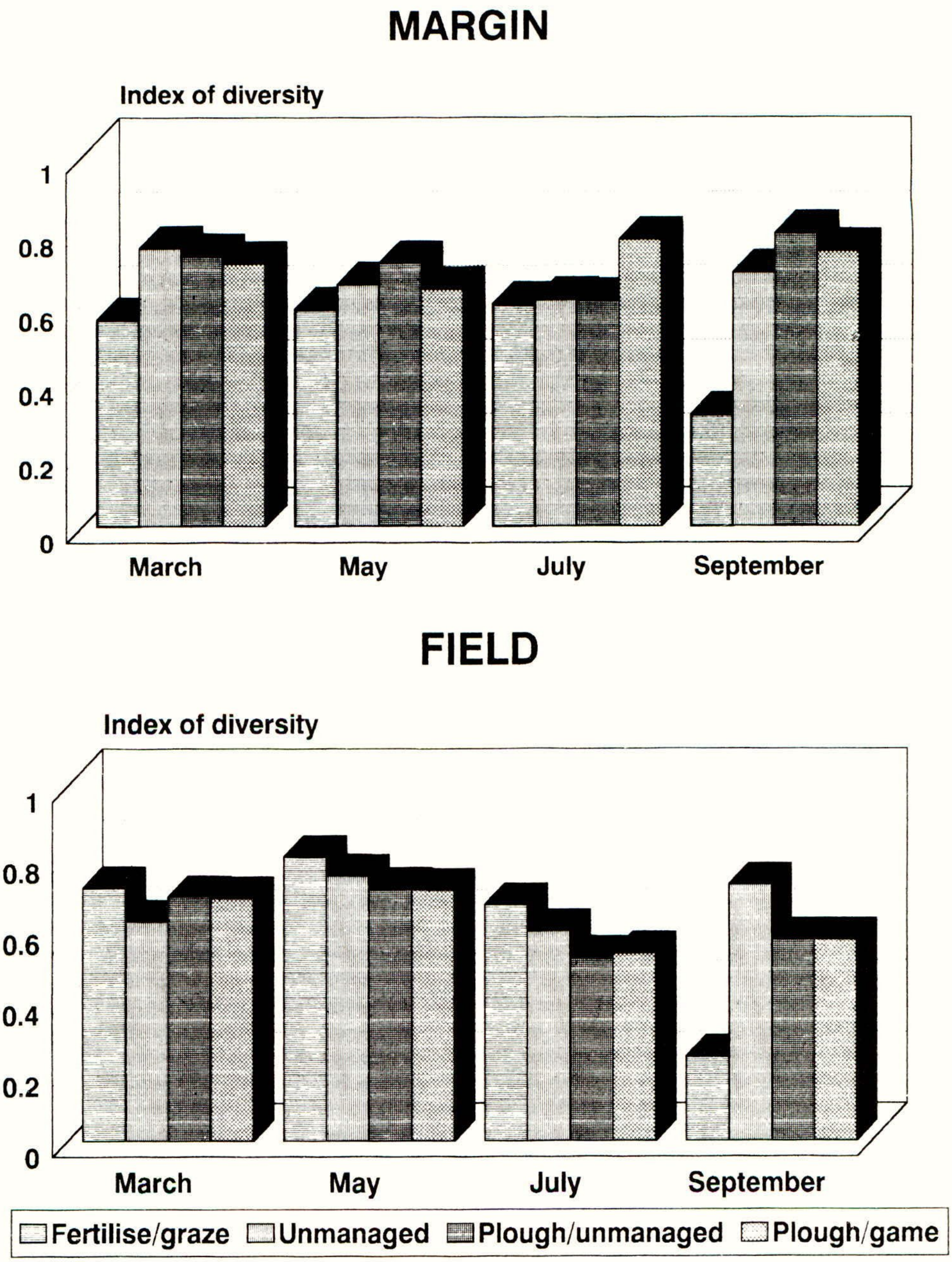

TABLE 2. Standard errors of the treatment means for the modified Simpson's index of carabid species diversity for the margin and field samples taken between March and September 1993.

	MARGIN	SEM (2df)	FIELD	SEM (2df)
March	0.089	NS	0.034	NS
May	0.043	NS	0.029	NS
July	0.036	*	0.054	NS
September	0.075	*	0.058	*