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Field Margins and Buffer Zones: Ecology, Management and Policy

Arthropod prey of farmland birds: their spatial distribution within a sprayed field with and without buffer zones

By J M HOLLAND

The Game Conservancy Trust, Fordingbridge, Hants SP6 1EF, UK

L Winder

Department of Land Use and Rural Management, Seale-Hayne faculty, University of Plymouth, Newton Abbot, Devon, TQ12 6NQ, UK

and J N Perry

Department of Entomology and Nematology, IACR Rothamsted, Harpenden, Herts., AL5 2JQ, UK

Summary

The distribution of arthropods was investigated within two cereal fields using a two-dimensional grid of pitfall traps. One field was then sprayed with dimethoate leaving a 6m unsprayed margin around one half of the field. Reinvasion was then monitored over the following month. Data was analysed using Spatial Analysis by Distance Indices (SADIE) incorporating a new clustering index. Arthropods exhibited a heterogeneous distribution within the fields which fluctuated through time, although numbers were usually highest within 60m of the field edge. Arthropods within the 6m buffer zone did not appear to be protected at the time of spraying, however, reinvasion was more extensive within the area of field surrounded by a buffer zone.

Key words: Beneficial arthropods, SADIE, field margins, non-target arthropods

Introduction

Many farmland birds are declining in the UK. The widespread species such as the grey partridge, tree sparrow, turtle dove, bullfinch, song thrush and spotted flycatcher have all declined by more than 70%, whilst the lapwing, skylark, linnet and reed bunting have declined by over 50% in the last 20-30 years (Fuller *et al*., 1995; Campbell *et al*, 1997). These declines have been associated with the intensification of agriculture over this period. One of the main changes has been the development of more efficient pesticides and an increase in the proportion of farmland which is sprayed. This has reduced the availability of invertebrates and plant food produced within the crop (Aebischer, 1991; Ewald & Aebischer, 1999) which many species of farmlands bird are dependant upon to varying extents (Wilson, Taylor & Muirhead, 1996).

Buffer zones aim to protect water courses from pesticide contamination (Croxford, 1998) but they also allow arthropods and weeds to survive in the unsprayed area, as has been demonstrated with Conservation Headlands (Sotherton, 1991). Such insecticide free areas may also protect arthropods in the field margin thus reinvasion of treated fields from these areas may be quicker and more extensive than fully sprayed fields. Reinvasion by Carabidae and Linyphiidae was predominantly from the field margins inwards (Jepson & Thacker 1990; Thomas, Hol & Everts 1990). Protecting the headland areas of a field is also important because these areas harbour a greater number and diversity of arthropods important for farmland birds (Moreby, Southway & Boatman, this volume) compared to the field centre. Indeed many arthropod species are heterogeneously distributed within fields (Hengeveld, 1979; Duffield & Aebischer, 1994; Holopainen, 1995; Thomas, Parkinson & Marshall, 1998) depending on their environmental and dietary requirements, although how the arthropods important in the diet of farmland birds are distributed is not understood. Insect spatial pattern is rarely investigated, partly because of the excessive sampling effort required to gain such information but also because of previous limitations in statistical methodology. However, techniques are now available which can detect and measure the degree of spatial pattern in spatially-referenced count data (Perry, 1998b). These have now been modified so that the location of areas of higher or lower than average density can be identified (Perry, Winder, Holland & Alston, 1999).

Many insecticides are toxic to arthropods consumed by farmland birds (Moreby & Sotherton, 1997) but the effects may often be underestimated if the treated area is too small to overcome the effects of reinvasion (Duffield & Aebischer, 1994). Only field scale evaluations will provide a realistic measure of the impact of an insecticide. Whether buffer zones are likely to help preserve feeding areas for farmland birds will depend upon how the arthropods are initially distributed within arable fields and on the impact of the insecticides applied. Arthropod distribution was therefore examined in two cereal fields. The impact of a field scale application of insecticide within one of these fields with and without buffer zones was then monitored.

Materials and Methods

Arthropods were collected using pitfall traps. A single pitfall trap (6cm diam., partly filled with water and detergent, open for two days) was used at each sampling point. In 1996 a field (250m $\times$ 180m) of organic winter wheat, near Wimborne, Dorset, UK, was sampled on a 9×7 sampling grid with 30m spacing, on six occasions between 7 June and 12 July. In 1997 arthropods were sampled in a 16ha winter wheat field near Durdle Door, Dorset, UK. This was sampled on five occasions at fortnightly intervals between May and July using pitfall traps. The sampling grid was 8 units wide and between 8 to 11 units long, with 75 sampling positions approximately 30m apart. In 1997 the outer sampling position was approximately 3m from the field edge. Each sample location was surveyed and located using the national grid reference. Two days after the fifth sampling occasion in 1997 the field was sprayed with dimethoate (0.86 l ha^{-1}) leaving a 6m unsprayed buffer zone around the top half of the field. The field was then sampled as above on three occasions, 8, 22 and 36 days after spraying.

In the pitfall traps the majority of the catch comprised of the larger Carabidae and Staphylinidae, Lycosidae and some Linyphiidae. The distribution of total arthropods known to be consumed by farmland birds was mapped using the programme Surfer. To explore the potential of recently developed spatial analysis techniques the data was analysed using an improved SADIE method described in Perry *et al*. (1999). This technique indicates whether the arthropods were clustered, either in patches of higher than average density (indicated by indices v_i and their average value $\bar{v}_i$) or in gaps of lower than average density (indicated by indices v_j and their average value $\bar{v}_j$). Unlike previous methods, the degree of clustering is measured at each location sampled, for each of which there is an index of clustering. Values of $v_i > 1$ indicate greater patchiness and values of $v_j < -1$ indicate the presence of greater gap clustering than would be expected by chance.

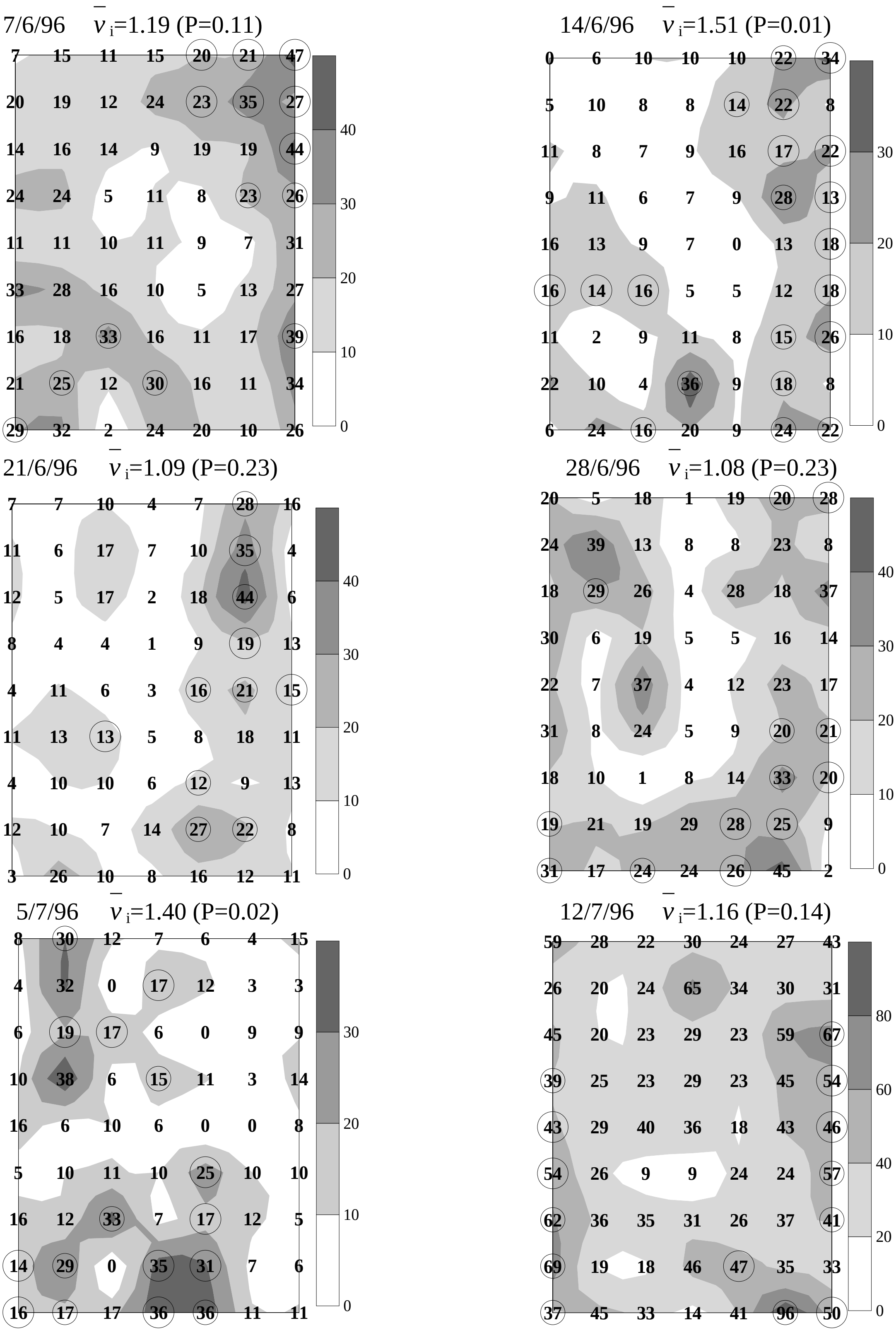

Figure 1. Arthropod counts sampled on an approximately rectangular 30m grid in a wheat field during 1996, categorised by interpolated contouring into equally spaced shaded density classes. Above-average clustering at each sample unit is measured by the clustering index, v_i. Counts exceeding mean have patch clustering measured by index v_i; small circle: $1 < v_i < 1.5$; large circle: $1.5 < v_i$. In each case, the average value of the patch clustering for the entire sample, $\bar{v}_i$, is shown above the map, together with its statistical significance on the null hypothesis that the observed counts were arranged randomly amongst the sample units.

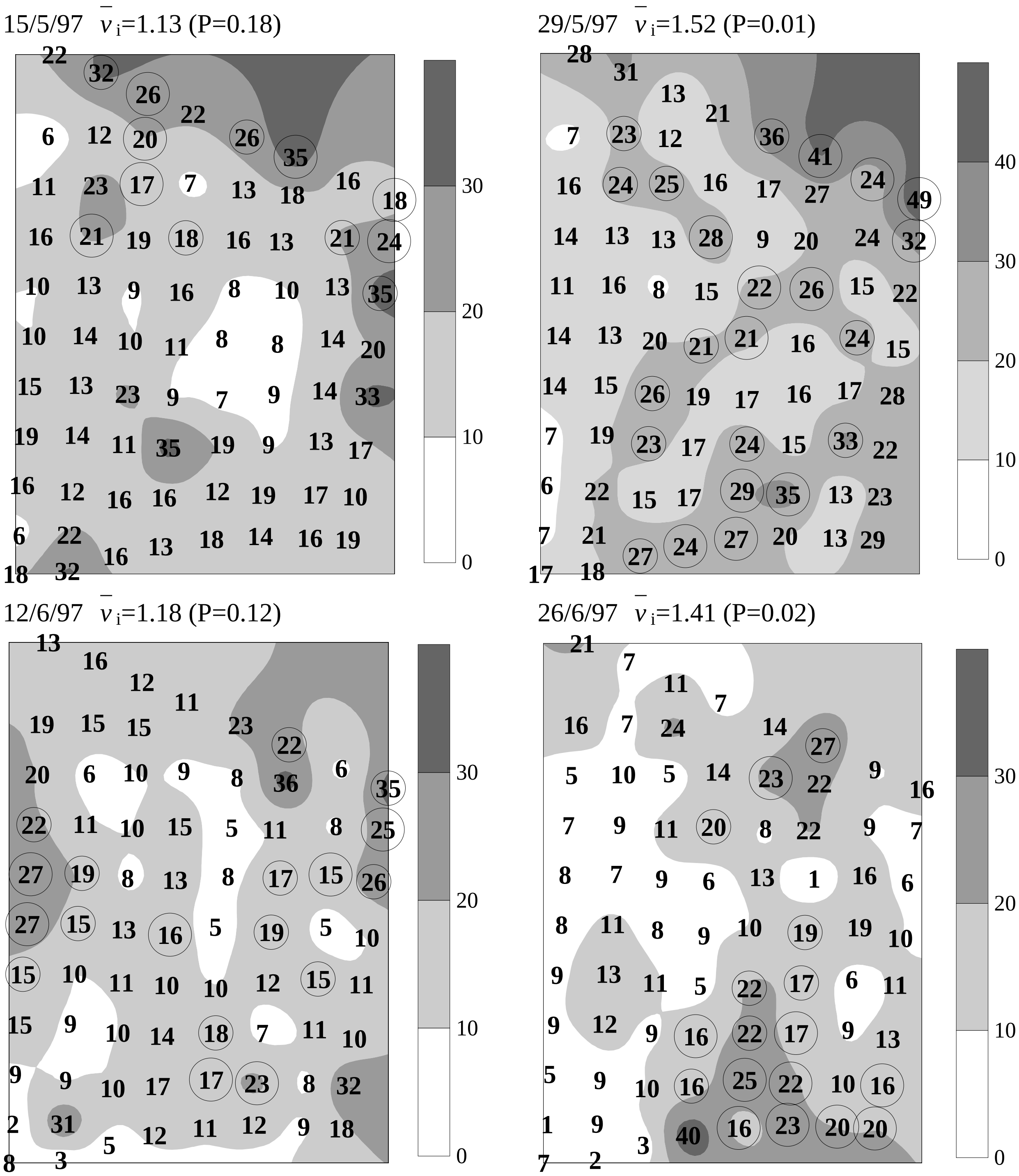

Figure 2. Arthropod counts sampled on an approximately rectangular 30m grid in a wheat field during 1997, categorised by interpolated contouring into equally spaced shaded density classes. Above-average clustering at each sample unit into patches of greater than average neighbouring counts is measured by the clustering index, v_i. Units with clustering index v_i greater than unity, indicated by circles, exhibit a greater degree of clustering than expected by chance. Strong clustering into patches is indicated by units surrounded by larger circles with $1.5 < v_i$. In each case, the average value of the patch clustering for the entire sample, $\bar{v}_i$, is shown above the map, together with its statistical significance on the null hypothesis that the observed counts were arranged randomly amongst the sample units. For clarity, the other form of clustering, into gaps of smaller than average neighbouring counts, is not shown here, but generally attains similar significance to that of the patches. Notation, methodology and symbols are the same as in Figure 1.

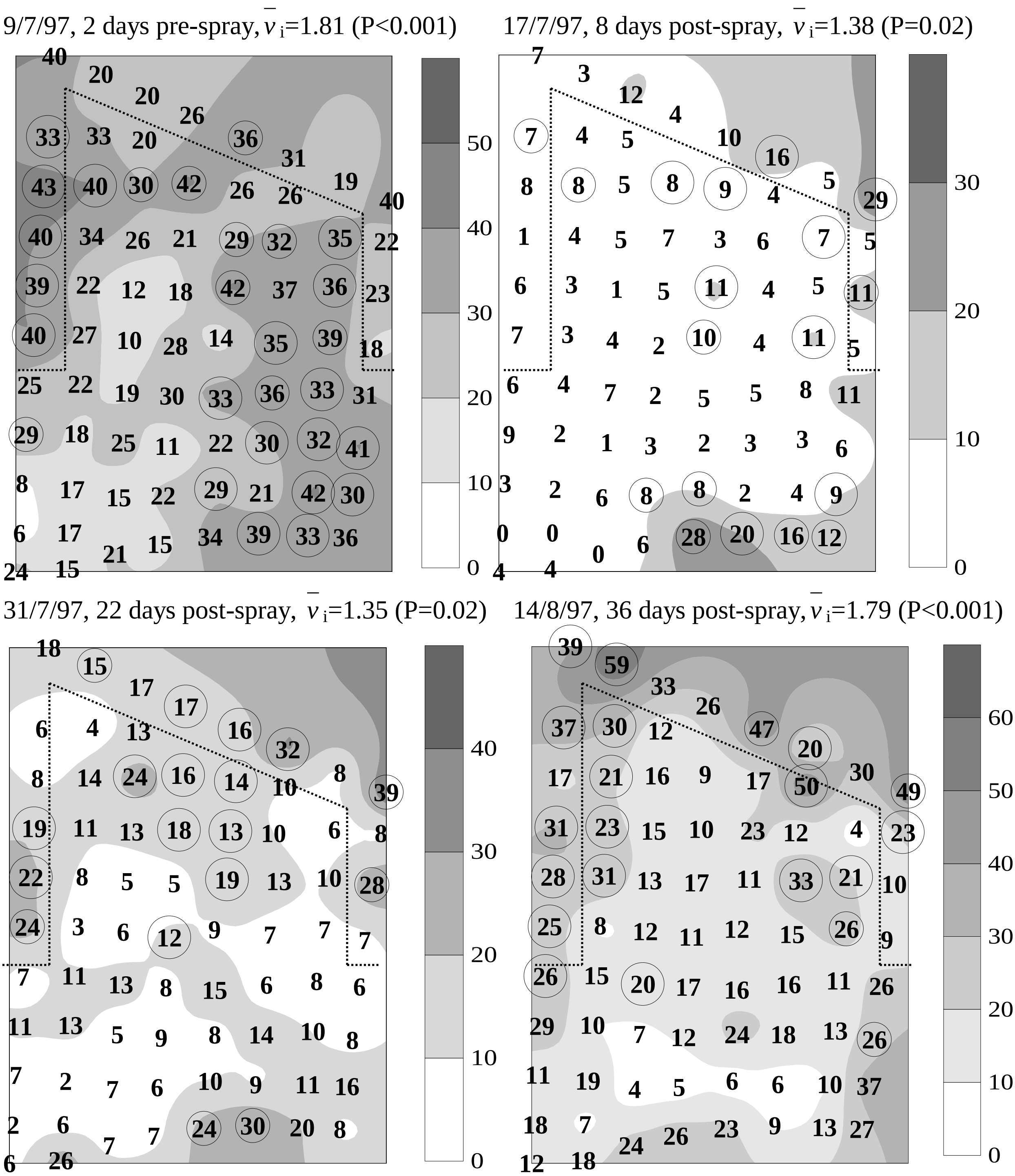

Figure 3. Arthropod counts sampled on an approximately rectangular 30m grid in a wheat field during 1997, just prior to and after spraying with dimethoate. The description of the figures, the notation, methodology and symbols are the same as in Figure 2. The area encompassed by the buffer zone is marked with a dashed line.

Results

Arthropod distributions in 1996

Overall, the majority of arthropods was captured within 60m of the field edge although there was some variation through time (Fig. 1). On the first date, arthropod density was low within the field centre ($\bar{\nu}_j$ =-1.33, P=0.05) but by the second date patches had developed on the right and lower ends of the field ($\bar{\nu}_i$ =1.51, P=0.01). Over the next two dates, as population density increased, evidence for clustering became weaker. Strong evidence of patchiness near field edges and gaps ($\bar{\nu}_i$ = 1.40 and $\bar{\nu}_j$ =-1.40, P=0.02) was found on 5 July; edge patchiness was also notable on 12 July. On most dates the arthropods were concentrated in highest numbers along the right hand side of the field, where the ground was elevated, the soil more chalky and as a consequence the crop was more open.

Arthropod distributions in 1997

The arthropods were again mostly concentrated around the outer 60m of the field (Fig. 2). The distributions fluctuated with time being most patchy on 29 May ($\bar{\nu}_i$ =1.52, P=0.01) and 26 June ($\bar{\nu}_i$=1.41, P=0.02). On all dates arthropods were most frequently captured on the upper and lower right edges of the field.

Two days prior to spraying the arthropods were most numerous within 60m of the field edge (Fig. 3) and there was significant clustering into patches in the lower-right and upper-left corners ($\bar{\nu}_i$ =1.81, P<0.001) and gaps ($\bar{\nu}_j$=-1.76, P=0.02). Eight days after spraying total numbers had decreased considerably ($\bar{\nu}_i$=1.38, P=0.02) but patches were still evident in the lower and upper right corners (Fig. 3). Reinvasion then began from the field margins. By 22 days after spraying there was one main patch in the upper half of the field ($\bar{\nu}_i$ =1.35, P=0.02) and by 36 days after treatment this had consolidated and spread down both right and left field edges ($\bar{\nu}_i$ =1.79, P<0.001).

The total number of invertebrates captured in the pitfall traps located within the buffer zone, the unsprayed edge and the field centre decreased sharply after spraying (Fig. 4) but then started to increase after 17 July. In the buffer zone the arthropods recovered to a higher level than in the edge area which was sprayed. Similarly, 36 days after spraying more arthropods were captured in the field centre enclosed by the buffer zone compared to the half of the field which was fully sprayed.

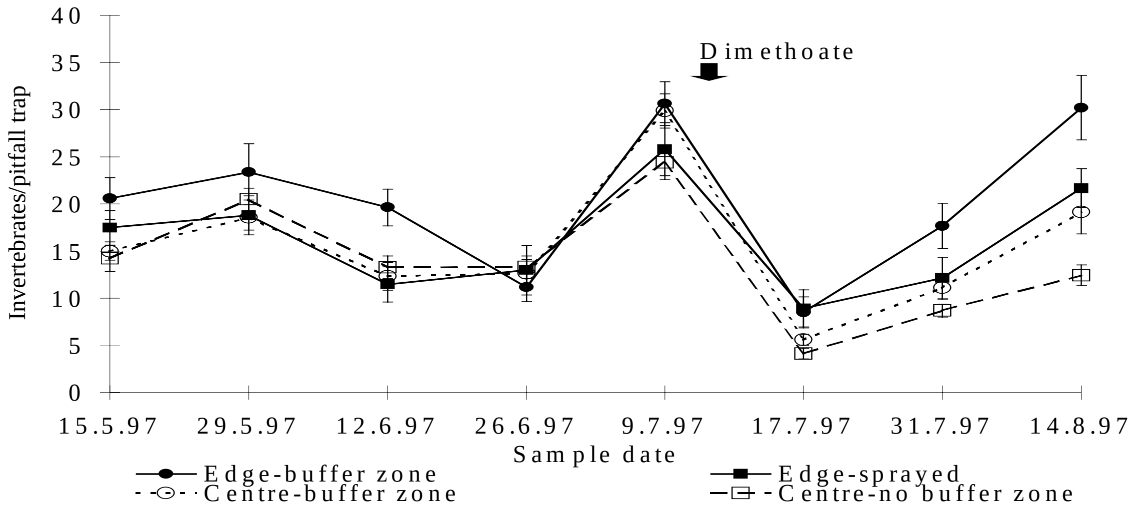

Figure 4. Mean arthropod numbers captured within the buffer zone, sprayed field edge and sprayed field halves with and without the buffer zone.

Discussion

The intensive two-dimensional sampling approach revealed that arthropods were most active around the field edges, as found by Moreby *et al*. (this volume). The distribution of individual species varies. Some appear to favour the mid-field and some the edges; this will be reported elsewhere. It is therefore important that insecticide use is restricted close to the field edges if this food resource for farmland birds is not to be depleted. However, if spraying is unavoidable the presence of a 6m buffer zone is recommended. Although the zone may not have protected many arthropods at the time of spraying, it appeared to encourage faster recolonisation, perhaps because it prevents spray drift into the field margins (Cuthbertson, 1988; Longley *et al*, 1997) and protects this as a resource from which recolonisation can occur. As arthropod density was highest within 60m of the field edge, a wider buffer zone or a restriction to selective insecticides would only preserve a greater proportion of arthropods. Such measures would benefit those bird species feeding predominantly at the field edges, such as the grey partridge.

This study also revealed that bird species feeding in the centre of fields, for example skylarks, not only have inherently less food available, but suffer greater impact from insecticide applications because of the delay before reinvasion occurs, as also shown by Duffield & Aebischer (1994). The rate of reinvasion depends on many factors including the species' mobility, persistence of the insecticide, prey availability and size of resource from which it can occur. Thus, the surrounding habitat and its treatment is also important.

The fluctuations in distributions through time would be expected when pooling counts for a number of species because individual species vary in their phenological distribution according to their environmental requirements and biology. In addition, the efficiency of pitfall traps varies considerably between species; even within a species efficiency is influenced by activity (Adis, 1979). However, suction samples were also taken and although less arthropods were captured they revealed the same trends in distribution and response to the insecticide treatment.

Although results are presented from a single field only, with and without, buffer zone areas, these may be treated with a considerable degree of confidence because of the intensity of the sampling approach. Moreover, the heterogeneous distribution of arthropods found in this study highlights the importance of selecting an adequate sampling strategy. Where and when arthropods are sampled could give completely different results if such heterogeneity is not adequately addressed. The spatial statistical techniques now available (Perry, 1995; Perry, 1998a) will allow this approach to be more widely adopted. The red-blue SADIE approach was successful in identifying the presence of clusters and gaps even when located along the edge of the sample area (Perry *et al*, 1999), and was consequently an improvement on the original technique (Perry, 1995; Perry, 1998b).

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