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# The effects of organic farming on pest and non-pest butterfly abundance

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**Abstract**

Butterfly transects were conducted on eight pairs of organic and conventional farms in the UK in 1994, and ten pairs of farms in 1995. Each transect included areas of conventional and organic farmland. All species seen, and the abundance of each species, were recorded separately for the uncropped field boundary and the crop edge. In both years, significantly more non-pest butterflies were recorded on organic than on conventional farmland, and more non-pest butterflies were recorded over the uncropped boundary habitat than over the crop edge habitat in both systems. By contrast, there was no significant difference in either year in the abundance of two pest species, *Pieris brassicae* (the large white) and *Pieris rapae* (the small white) between the two systems. Implications of the results for the conservation of butterflies within agricultural systems are discussed. © 1997 Elsevier Science B.V.

*Keywords:* Farming systems; Field margins; *Pieris brassicae*; *Pieris rapae*

## 1. Introduction

The intensification of arable agriculture over the last 50 years has been associated with substantial losses of biodiversity (Potts, 1991; Gibbons et al., 1993; Firbank et al., 1994; Stewart et al., 1994). Several factors have been implicated, including loss of habitat (e.g. Moore, 1962; Webb, 1990), the direct and indirect effects of pesticides and herbicides (e.g. Potts and Aebischer, 1991; Newton and Wyllie, 1992), increased use of drainage and inorganic fertilisers (Fuller, 1987), the loss and degradation of field boundary features (Barr et al., 1993) and changing patterns of cropping (Gibbons et al., 1993). Over the last 10 years or so, there has been an increased awareness of the potential environmental, health and amenity benefits of agriculture which (along with the food surpluses within the European Union during the 1980s) has led to an increase in interest in low-input and organic agriculture. Such farming systems tend to be less productive in terms of yield per hectare than high input systems, but this can be outweighed by savings on inputs and by improved product quality and environmental benefits (e.g. Lampkin, 1990; El Titi, 1991; Jordan and Hutcheon, 1995).

As with all such analyses, much depends upon what is included in the accounts, and on how they are valued, making it difficult to generate full and comparative accounts of different farming systems (O'Riordan and Cobb, 1996). Furthermore it is not

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always easy to tell whether an environmental benefit of a farming system is specific to that system, or could be generated by other systems. For example, organic and low-input systems can be managed to reduce the risk of pest outbreaks, and it is widely assumed that environmental benefits follow because of the absence of pesticides (Lampkin, 1990), but could the same environmental goals be achieved in different ways on conventional farms? The answer to this question has a great bearing on how farming practice can be reconciled with environmental policy.

In this paper we consider the effects of organic and conventional farming systems on the abundances of butterflies in southern England. These insects are of interest because they are emblematic of an attractive countryside, and yet include two common economic pest species, the large white *Pieris brassicae* (L.) and the small white *Pieris rapae* (L.). These are highly mobile species and their larvae feed on a wide range of cruciferous and related foodplants, causing millions of pounds sterling damage annually within the UK (Feltwell, 1982). With the exception of these species, the butterfly fauna of lowland arable UK is becoming the subject of conservation interest. The general reduction in plant diversity in hedge bottoms (Barr et al., 1993) and grasslands (Fuller, 1987; Barr et al., 1993) has reduced the range and abundance of foodplants for many species (Feber and Smith, 1995), and butterflies in hedgerows are also susceptible to spray drift from insecticides (Davis et al., 1991; Cilgi and Jepson, 1995). It is therefore feasible that different farming systems support different levels of both pest and non-pest butterflies.

In order to address this question, we adopted a paired farm approach, matching, as far as possible, organic and conventional farms across southern England. Here, we report 2 years of butterfly surveys using fixed transect routes across these farms.

## 2. Methods

Butterfly abundance was recorded on eight pairs of organic and conventional farms between June and September in 1994, and between April and September in 1995, when the survey was extended to include two more pairs of farms. Farm pairs were located across England in an area roughly bordered by Dorset, Shropshire, Lincolnshire and Essex.

Butterflies were recorded by volunteer recorders at approximately fortnightly intervals during the summer months of 1994 and 1995. The abundance of butterflies was measured using recording methods modified from those developed by Pollard et al. (1975), which are used for the Butterfly Monitoring Scheme. Butterfly abundance on organic and conventional sections were always recorded on the same day.

Three criteria were observed to provide a degree of standardisation. These were: (1) counts were started after 10:45 h British Summer Time (BST) and completed before 15:45 h; (2) counts were made above 13°C, and then only in sunny conditions unless the temperature was 17°C or above; (3) counts were not made when the wind was in excess of five on the Beaufort scale.

Recorders walked a fixed transect route which was divided into sections corresponding to crop and/or boundary type. Each transect included an area of organic and an area of conventional farmland. For each section, all butterflies seen, and the abundance of each species, was recorded. Butterflies seen over the crop edge were recorded separately from those seen over the uncropped field boundary. Approximately the same width of crop edge and field boundary were recorded. Details of management type, crop and boundary were recorded for each section of the transect route. The length of each transect section was recorded to allow standardisation of butterfly abundances. Dates of management operations such as harvest, hedge-cutting and ploughing were also recorded.

### 2.1. Analysis of results

The dependent variable was defined as the total butterfly count for the season for each system (organic or conventional) in each farm pair, on both the crop edge and the uncropped field boundary, standardised to a count per unit length of transect walked. Data were $\log(x + 1)$ transformed for analysis.

Three separate analyses were carried out; the first on the total number of butterflies regardless of their pest status, and two further analyses on the data partitioned into pest (*P. brassicae* and *P. rapae*) and non-pest (all other) individuals.

Each comprised a two-way analysis of variance, which included system type (subsequently referred to as 'system') and crop or margin ('habitat') as within-subject effects. The SAS 'repeated' option was used to define the within-subject effects (SAS PROC GLM: SAS Institute Inc., 1988). When significant interactions were detected, the data were stratified within the levels of the appropriate effect. Further analyses were then applied to clarify these interactions. The data for each year were analyzed separately.

## 3. Results

### 3.1. Effects of farming system and habitat on overall butterfly abundance

Total butterfly abundance was significantly higher on organic farms than on conventional farms in both years, and in both years significantly more butterflies were recorded on the uncropped field boundary than

Table 1
ANOVA summary for effects of farming system and habitat type (crop or field margin) on pest (*P. brassicae* and *P. rapae*) and non-pest (all other) butterfly abundance in 1994 and 1995

| Factor | Year | | | |
|---|---|---|---|---|
| | 1994 | | 1995 | |
| | *F* | *P* | *F* | *P* |
| *All butterflies* | | | | |
| Organic vs. conventional (system) | 9.22 | * | 31.46 | *** |
| Crop vs. margin (habitat) | 13.00 | ** | 22.83 | *** |
| System × habitat | 5.16 | ns | 6.40 | * |
| *Pest butterflies* | | | | |
| Organic vs. conventional (system) | 0.12 | ns | 0.00 | ns |
| Crop vs. margin (habitat) | 1.78 | ns | 18.38 | ** |
| System × habitat | 2.20 | ns | 0.77 | ns |
| *Non-pest butterflies* | | | | |
| Organic vs. conventional (system) | 27.66 | *** | 31.32 | *** |
| Crop vs. margin (habitat) | 68.35 | *** | 26.35 | *** |
| System × habitat | 3.08 | ns | 10.50 | * |

Degrees of freedom for all *F* ratios: 1,7 in 1994 and 1,9 in 1995. *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, ns = not significant ($P > 0.05$).

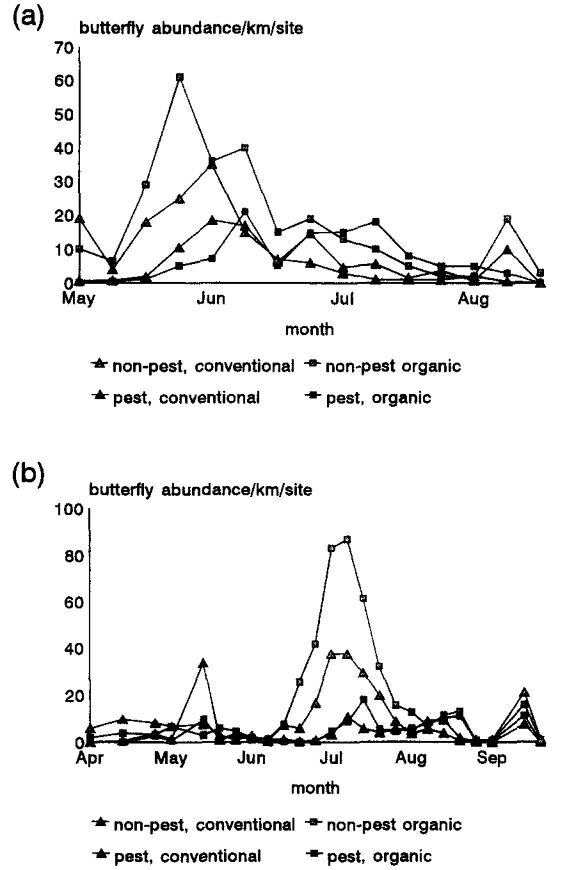


Fig. 1. Mean pest and non-pest butterfly abundance per kilometre per site per week, on organic and conventional farmland in (a) 1994 and (b) 1995.

on the crop edge (Table 1). There was a significant interaction between the two factors in 1995, and an interaction which approached significance in 1994 ($F_{(1,7)} = 5.16$, $P = 0.057$), with the difference in butterfly abundance between crop and margin being greater in conventional than in organic systems.

### 3.2. Effects of farming system on pest butterfly abundance

There was no significant difference in the abundance of *P. brassicae* and *P. rapae* between the two farming systems in either year (Table 1, Fig. 1). In 1994, the abundance of these species did not differ significantly between crop and boundary habitat, although in 1995 significantly more pests were associated with the boundary than the crop habitat (Table 1). By contrast with the non-pest butterflies, though, abundances of pests were higher on conventional than organic boundaries in both years, although not significantly so. There was no significant effect of system on pest butterfly abundance on either the surveyed boundary ($F_{(1,7)} = 0.31$, $P > 0.05$ in 1994 and $F_{(1,9)} = 0.16$, $P > 0.05$ in 1995) or crop habitats ($F_{(1,7)} = 0.79$, $P > 0.05$ in 1994 and $F_{(1,9)} = 0.07$, $P > 0.05$ in 1995) in either year (Fig. 2).

### 3.3. *Effects of farming system on non-pest butterfly abundance*

By contrast with the pest butterflies, the abundance of non-pest butterflies was significantly higher in organic than in conventional systems in both years (Table 1, Fig. 1), with more butterflies recorded on the boundary than the crop (Table 1, Fig. 2). The management of the uncropped boundary had a significant effect on non-pest abundance, with organic boundaries attracting higher numbers of butterflies than conventional boundaries ($F_{(1,7)} = 9.70$, $P < 0.05$ in 1994 and $F_{(1,9)} = 13.92$, $P < 0.01$ in 1995). Similarly, the abundance of non-pest butterflies within the surveyed cropped habitats was significantly greater on the organic farms ($F_{(1,7)} = 23.19$, $P < 0.01$ and $F_{(1,7)} = 34.85$, $P < 0.001$ in 1994 and 1995 respectively; Fig. 2).

### 3.4. *Effects of crop type on pest and non-pest butterfly abundance*

The cropping patterns on the surveyed sites differed considerably between the organic and conventional components. For example, in 1994, approximately six times as much grass ley was surveyed on the organic areas than the conventional areas, while

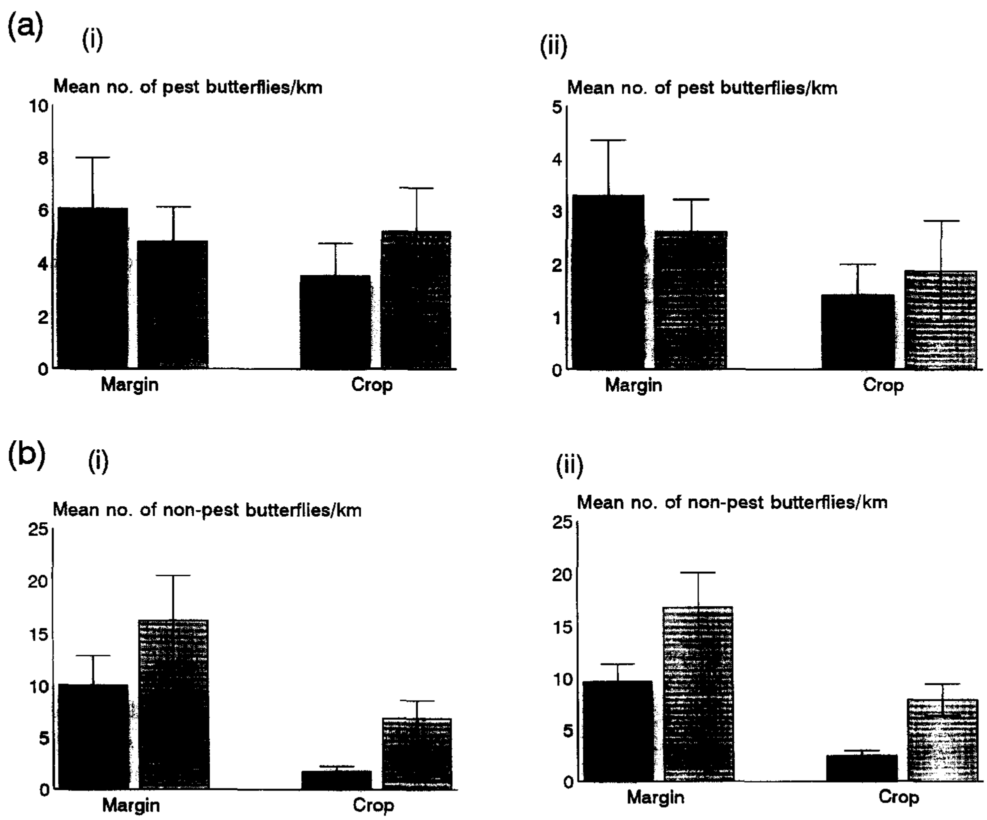


Fig. 2. Mean abundance of (a) pest and (b) non-pest butterflies on crop and boundary habitats, on organic and conventional farmland in (i) 1994 and (ii) 1995 per kilometre per site per week. Shaded, organic; solid, conventional. Bars are 1 × SE.

Table 2
The lengths of each crop type (km) surveyed for butterflies in organic and conventional systems in 1994 and 1995

| Crop | Organic system | | Conventional system | |
|---|---|---|---|---|
| | Length (km) 1994 | Length (km) 1995 | Length (km) 1994 | Length (km) 1995 |
| Winter wheat | 3.16 | 5.90 | 3.42 | 9.26 |
| Barley | – | 0.46 | 0.92 | 2.05 |
| Oats | 0.66 | 2.65 | – | 0.26 |
| Beans | 0.80 | 0.30 | 2.45 | 0.82 |
| Linseed | – | – | 0.68 | 0.30 |
| Oilseed rape | – | – | 0.62 | 1.08 |
| Grass ley | 7.14 | 2.68 | 1.47 | 1.22 |
| Permanent pasture | 0.68 | 3.84 | 1.97 | 1.29 |
| Set-aside | 0.69 | 0.33 | 0.12 | 1.49 |

oilseed rape was not encountered on any organic area (Table 2). Cropping patterns in 1995 were similar to those in 1994. In both years, crop type and farming system were highly confounded. Statistical comparison of butterfly abundances on individual crop types between systems were all non-significant ($t$-tests, $P > 0.005$), although all sample sizes were low. However, some patterns of butterfly abundance were consistent over the two years (Table 3). For example, non-pests were more abundant on grass leys than pests, while cereal crops attracted similar numbers of pest and non-pest individuals. By contrast, oilseed rape attracted higher numbers of pest than non-pest butterflies.

## 4. Discussion

In our study, the patterns of abundance of pest and non-pest butterflies showed a striking consistency between years. Overall, there were more butterflies per length of transect on organic farms compared with the conventional ones, and more were found in the field margin than in the main crop. This

Table 3
Abundances (per km per site) of pest and non-pest butterflies on different crop types and farming systems in 1994 and 1995

| Crop | 1994 | | | | 1995 | | | |
|---|---|---|---|---|---|---|---|---|
| | Organic | | Conventional | | Organic | | Conventional | |
| | Pest | Non-pest | Pest | Non-pest | Pest | Non-pest | Pest | Non-pest |
| Winter wheat | 1.56 | 3.57 | 1.89 | 1.70 | 2.81 | 6.14 | 1.35 | 2.06 |
| Barley | – | – | 1.37 | 1.63 | 0.73 | 6.41 | 1.27 | 1.81 |
| Oats | 5.05 | 13.52 | – | – | 0.49 | 2.01 | 0.43 | 6.03 |
| Beans | 5.19 | 2.08 | 8.94 | 2.51 | 2.65 | 11.26 | 1.18 | 1.99 |
| Linseed | – | – | 8.27 | 0.15 | – | – | 0.83 | 0.42 |
| Oilseed rape | – | – | 2.58 | 1.61 | – | – | 1.05 | 0.97 |
| Grass ley | 1.39 | 6.91 | 0.48 | 2.23 | 5.80 | 8.91 | 0.66 | 2.18 |
| Permanent pasture | 2.38 | 11.83 | 0.59 | 1.03 | 4.59 | 10.04 | 3.25 | 3.55 |
| Set-aside | 16.12 | 8.13 | 9.8 | 21.1 | 1.34 | 17.40 | 0.69 | 1.92 |

was due almost entirely to the greater abundance of non-pest butterflies on the organic farms and in the field margins, while the pest abundances were not influenced by farming system and favoured the margin to a lesser extent.

We were unable to detect any effect of farming system on the abundance of either pest or non-pest butterflies for a given crop type, although our sample sizes are too small to be certain of this. We suggest that the increased suitability of the field areas of organic farms for non-pest species results from the pattern of cropping, rather than from crop management practices. Oilseed rape, for example, a suitable crop for the pest whites, is found to a much lesser extent on organic than on conventional farms, while the butterfly-rich grass clover leys of the organic rotations are much less frequent under conventional systems (Lampkin, 1990).

Organic field margins were richer in non-pest butterflies than conventional ones, presumably reflecting some local management or farm system scale differences. There are several potential mechanisms, which include lack of spray drift, the greater chance of bordering a suitable crop habitat, and greater abundance and diversity of food plants on organic field boundaries.

Our data do not show whether this increase in abundance can be repeated on conventional farms, but other evidence suggests that it can. For example, selectively sprayed conservation headlands increase nectar resources for butterflies (Dover et al., 1990), and field margins (Feber et al., 1996) and even whole set-aside fields (Firbank et al., 1993) can be managed to encourage a greater diversity and number of non-pest butterflies.

To conclude, as far as butterflies are concerned, it appears that there are environmental benefits associated with organic farming without increased costs from pests. Those benefits derived from different patterns of cropping cannot readily be recreated under conventional systems, unless set-aside is managed appropriately at a large enough scale. While we have shown that organic field boundaries are richer in butterflies than those under conventional farms, there are enough data from other systems to suggest that both abundance and species richness of butterflies can be enhanced even under intensive systems, given steps to restore the vegetation and ensure its protection from pesticide drift and other damaging operations.

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