British Trust for Ornithology

BTO Research Report No. 154

THE EFFECT OF ORGANIC FARMING REGIMES ON BREEDING AND WINTER BIRD POPULATIONS

PART III

Habitat Selection and Breeding Success of Skylarks *Alauda arvensis* on Organic and Conventional Farmland

J. Evans, J.D. Wilson* and S.J. Browne

British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU
***BBSRC-NERC Ecology & Behaviour Group, Department of Zoology, University of Oxford, South Parks Road, Oxford, OX1 3PS**

A research project funded by
Ministry of Agriculture, Fisheries and Food
&
World Wide Fund for Nature UK

SUMMARY

1. The habitat selection, territory density, nesting success and diet of skylarks breeding on one organic farm and one conventional farm in north Suffolk were investigated during a two-year study to investigate the impact of organic farming practices on skylark breeding populations.

2. Territory density was higher on the organic than on the conventional farm and this difference could be explained largely by differences between the two farms in field size, boundary characteristics and cropping. Rotational and five-year set-aside, short-term grass leys and spring cereals (confined to the organic farm) were the most attractive field types to skylarks. Overall mean density on conventional cereals was less than half that on organic cereals, organic set-aside and conventional set-aside.

3. Densities of territorial male skylarks remained constant throughout the breeding season on all field types, with the exception of conventional winter cereals in 1993, when most territories were abandoned in late April and early May. In 1994, territory densities showed no such reduction. Possible reasons for this difference include differences in crop structure and growth rate due to differences in weather conditions between the two years.

4. Nesting activity commenced simultaneously on both farms but the timing varied between crops. On the organic farm nesting was earliest in set-aside but later on spring cereals. On the conventional farm nesting was earliest on winter cereals and set-aside but latest on sugar beet.

5. Breeding success (mean chicks fledged/nest) was higher on the organic farm than on the conventional farm in both years. On both farms, however, success was higher in 1993 than 1994 probably due to poor weather in the second year. In 1993 there were few nesting attempts, and no successful nests, on conventional cereals in striking contrast to organic cereals and set-aside. In 1994, however, nesting attempts were more frequent in conventional cereals than in 1993 and success in conventional cereals was similar to that on organic cereals and organic set-aside. These differences between years may have been a consequence of the fact that conventional crops grew more slowly and were patchier in 1994 than in 1993.

6. Broods on the organic farm were significantly heavier than broods of the same age on the conventional farm. A condition index, which examined body mass in relation to body size, tended to be greater on the organic farm but not significantly so.

7. Both rotational and non-rotational set-aside have great potential as nesting and feeding habitats for skylarks, but successful nesting on set-aside depends on farmers refraining from cutting close to the ground surface or cultivating set-aside between late April and the end of June.

8. Recommendations are made for further research on the ecology of skylarks on arable farmland.

1. INTRODUCTION

The skylark is a characteristic species of lowland farmland and other open habitats. It tends to avoid tall structures, for example trees and tall hedges, and rather than deliver its song from a raised perch, it usually does so either from the ground or in flight. The nest is a simple cup of woven grass lined with finer material, usually in a shallow depression in the soil. Both nest-building and incubation are carried out by the female. Clutch size is usually three or four (exceptionally two or five) with incubation beginning after the last egg is laid and lasting 11 days. Clutches laid later in the season tend to be larger. The young hatch synchronously and are tended by both parents. They leave the nest at 8-10 days old and fledge at 18-20 days, becoming independent at about 25 days old. Individual pairs make up to three, or exceptionally four, nesting attempts in one year. Territory size varies greatly according to different habitat characteristics, but most territories cover 0.25-2 ha. Pairs may shift or abandon their territories during the course of the season if vegetation structure becomes unsuitable. The above information is summarised from Cramp (1988).

Common Birds Census (CBC) data show a 54% decline of the breeding population of skylarks on British farmland between 1968 and 1991 (Fuller *et al.*, in press). The current population estimate of 1.35 million breeding pairs on British farmland (Gibbons *et al.*, 1993) implies a loss of over 1.5 million breeding pairs in 22 years. Similar declines have been reported in Denmark, Sweden, Germany and Switzerland (Busche, 1989; Zbinden, 1989; Hustings, 1992; Jacobsen, 1992). These declines have often been attributed to the intensification of arable agriculture in recent decades.

Analysis of farmland CBC plots in the early 1960s indicated that breeding skylarks preferred areas where cereal and root crops were predominant to areas which comprised mainly pastures and leys (Williamson, 1967). More recently, O'Connor and Shrubb (1986) showed that skylark population fluctuations during the period 1975-83 were positively correlated with the percentage of grassland in England and Wales which was ley grass under five years old. Both arable and grassland habitats have experienced changes in the latter half of this century. There has been a dramatic switch from spring- to autumn-sown cereals since the 1960s, which has led to a large-scale reduction in the area of stubble available for skylarks and other seed-eating passerines during the winter. At the same time, increased pesticide usage and improved harvesting methods have reduced the quantities of cereal and weed seeds available in stubbles, changes which have already been implicated in the decline of the cirl bunting *Emberiza cirlus* (Evans & Smith, 1994, 1995). Cereal grain and leaves are important components of the diet of skylarks, spring sown grain in particular being an important source of food in early spring when other food is scarce (Green, 1978). Changing farming practices have also led to a reduction in the area of ley grassland. This, combined with intensification of grazing, mowing and fertilising regimes, may have contributed to the decline in the British skylark population. Busche (1989) describes severe declines of skylark populations in Germany as a consequence of such changes.

In Britain, the first detailed study of the population ecology and breeding biology of skylarks took place in the Ravenglass dune system in Cumbria (Delius, 1963, 1965). More recently, detailed studies of the breeding biology and ecology of skylarks on farmland were carried out in Switzerland in the 1980s (Schläpfer, 1988; Jenny, 1990a,b,c). This research suggests that highest densities are reached when crop diversity is high so that different crop types provide suitable nesting habitat throughout the season. Where habitat is homogeneous over large areas, for example in intensively farmed areas, the overall density is lower and the distribution is often clumped. The reasons for this are unknown. Schläpfer (1988) found that dense vegetation exceeding 30-35 cm high was avoided and suggested that the reason for this was hindrance of movement at ground level. Poulsen (1993) found that winter cereals tended to support low territory densities (< 0.03 ha^{-1}) with higher densities on spring cereals and grassland (0.03-0.10 ha^{-1}) and the greatest concentrations on five-year set-aside land (0.28 ha^{-1}).

Census work during the 1992 breeding season, as part of the BTO's Organic Farming and Birds Project, on 11 pairs of organic and conventional farms, plus two farms with a mixture of organically and conventionally managed fields, showed higher densities of territorial male skylarks on organic cereal and grass fields in comparison with conventional counterparts (Wilson, 1995). One reason for this difference may be that organic cereals provide a more suitable nesting habitat for skylarks (see Schläpfer, 1988) because they are less heavily fertilised and are often sown later and less densely than conventional cereals (Lampkin, 1990). Similarly, organic grass is often short-term ley, which may provide a more suitable vegetation structure for nesting than the dense, heavily fertilised swards of herbage seed, silage or permanent grass on conventional farms. In addition, food availability may be greater on organic farms due to the withdrawal of pesticide inputs and the retention of rotational practices such as undersowing. The latter favours invertebrates that only overwinter successfully in undisturbed soils, for example sawfly larvae, which have been shown to form a large proportion of the diet of skylark chicks (Barker, 1992). Finally, the greater crop diversity associated with organic crop rotations may provide better opportunities for repeat nesting attempts than exist on conventional farms and also contribute to a greater diversity and abundance of invertebrate food sources for skylarks.

Given the findings of the 1992 breeding season census work, we decided to initiate a more detailed investigation of habitat selection, nesting success, diet and chick condition on organic and conventional farms in order to understand better the apparent benefits of organic farming systems for breeding Skylarks. The work took place during the 1993 and 1994 breeding seasons on one pair of farms in East Anglia. This report documents the results of this work and makes recommendations for further work in this field.

2. METHODS

2.1 Study area

Two study plots in Suffolk were used, one at Village Farm, Market Weston (TL9878), the other at Hall Farm, Coney Weston (TL9678). The Village Farm plot, which has been at Soil Association organic standards for over 20 years, comprised 12 fields with a total area of 46 ha. At Hall Farm, which is under a conventional regime, 13 fields with a total area of 133 ha were studied. In 1993, Village Farm grew winter and spring cereals, one short-term grass/clover ley, three fields under MAFF five-year set-aside grassland and one field of naturally regenerating oat stubble under the new rotational set-aside (RSA) regulations. In 1994, no winter cereals were grown, the winter triticale stubble had been under-sown with clover and two fields had been left fallow after ploughing (Figure 1). In both 1993 and 1994, Hall Farm grew winter cereals, sugar beet and peas, under an intensive pesticide and fertiliser application regime. In 1993, one field was sown with perennial ryegrass under RSA regulations. In 1994, however, linseed was sown as a set-aside crop (Figure 2). A full list of crops and field types is given in Table 3.1

2.2 Territory mapping

Identical methods were used in both years. Each study plot was visited on 12 occasions between mid-March and mid-June. On each occasion the location of all singing male skylarks was recorded on 1:2,500 maps. Particular attention was paid to plotting the start and end points of song-flights. These were found to be good indicators of the 'core' territories of paired males. Any subsequent nest was usually found within an area defined in this way. All mapping visits were made in the morning, between 6am and midday. In areas of high territory density, song frequency (i.e. song output per individual) was higher than in areas where territory density was very low (unpublished data). Consequently, there was less likelihood of detecting a single isolated territory on every visit than there was of detecting one with many others nearby.

Table 3.1 Areas (ha) of crops and field types on Hall and Village Farms in 1993 and 1994.

	CONVENTIONAL (HALL FARM)		ORGANIC (VILLAGE FARM)	
	1993	1994[1]	1993	1994
Spring barley	0	0	3.3	4.5
Spring wheat	0	0	5.0	4.8
Spring oats	0	0	4.5	7.0
Winter barley	25.5	31.1	0	0
Winter wheat	35.8	9.8	7.8	0
Winter oats	14.5	16.1	0	0
Winter triticale	0	0	2.0	0
Peas	9.8	7.0	0	0
Sugar beet	36.3	31.3	0	0
Linseed	0	26.8	0	0
Ley	0	0	3.5	3.5
Fallow	0	0	0	9.0
Rotational set-aside	11.0	0	4.8	2.0
5-year set-aside	0	0	15.8	15.8

[1] One field of 10.8 ha that had been surveyed in 1993 was not surveyed in 1994 by mistake.

2.3 Field characteristics

In both years, vegetation height and percentage ground cover were recorded at 10 points on a diagonal transect across each field. The points on each transect were evenly spread, so that the distances between each point and between the start and end points and the respective field corners were all equal. Measurements were taken on three occasions - mid-April, mid-May and mid-June. At each location, height was measured using a tape measure, and percentage ground cover (including both crop and weeds) was estimated by eye with the aid of a 50 cm × 50 cm quadrat divided into a 5 × 5 cm grid. Mean values were then calculated for each field for each of these months and graphs plotted of mean vegetation height versus mean percentage cover.

An index of field boundary structure was calculated by dividing the perimeter of each field into sections, according to the following numerical categories (0=no vertical structure, 1=low hedge/wall/bank, 2=tall hedge/wall/bank, 3=hedge with trees or line of trees, 4=woodland edge, or boundary of other unsuitable habitat such as gardens, scrub, buildings etc.). The length of each section was multiplied by its category score and the sum over all sections divided by the perimeter length to give a 'boundary index' for that field. Values range from 0 (no vertical structure in field boundary) to 4 and provide a crude index which can be used to examine the influence of the field boundary on the attractiveness of the field to skylarks. An index of field shape was calculated by expressing the actual perimeter of each field as a proportion of the minimum perimeter for a field of the same area (i.e. the perimeter if the field was circular).

2.4 Location of nests

In 1993, several techniques for locating skylark nests were tested. By far the most productive technique for finding nests was found to be to watch skylark activity for a minimum period of 45-60 minutes per field in any one day and look for evidence of nesting activity. Thus, in 1994, this was the only technique employed and the majority of nests were found by watching the female carrying nesting material and subsequently discovering a partially completed nest cup. A few others were found at the egg and chick stage. All but the most distant nests were located within an hour of noting the first evidence of nesting behaviour.

At any stage of the nesting period, it is essential to make the visits to the nest as brief as possible. This is particularly important during nest-building and incubation, when the female is more likely to desert the nest. Searches for nests during these stages were therefore very brief in order to cause as little disturbance as possible, both to the nest being searched for and to any others in the vicinity. Subsequent visits to the nest were usually made after a period of observation, when the parents were known to be absent.

2.5 Nest checks

The same protocol was followed in both years. Nests were visited on a daily basis, at approximately the same time of day, to record clutch or brood size and ring and measure chicks. Each chick was fitted with a BTO ring on the right leg and a single colour-ring on the left leg. In 1993, red rings were used for chicks hatched on Village Farm and yellow rings for chicks hatched on Hall Farm. In 1994, orange rings were used for chicks hatched on Village Farm and light blue rings for chicks hatched on Hall Farm. From three to nine days old, tarsus length of each chick was measured daily to an accuracy of 0.1 mm using vernier callipers, and mass was recorded to an accuracy of 0.1 g using a Pesola balance. In 1993, all measurements were recorded by the same observer. In 1994, two observers were involved, the second in the latter stages of the breeding season. All measurements of any individual brood, however, were taken by a single observer.

Faecal sacs were collected, preserved in 70% alcohol and analysed at the Institute of Arable Crops Research at Rothamsted.

2.6 Data analysis

All analyses were carried out using release 6 of the SAS statistical package.

3. RESULTS

3.1 Factors affecting territory density

Throughout both seasons densities of skylarks were consistently higher overall on the organic farm ($P<0.05$, Mann-Whitney tests comparing densities estimated on individual visits). Densities on conventional cereals and sugar beet (only present on conventional) were markedly lower than those on organic cereals, grass leys (only present on organic) and set-aside. Densities on conventional cereals were less than half those on organic cereals and set-aside (Figure 3).

Densities of territorial skylarks throughout the two seasons are shown for selected crop types in Figure 4. On the conventional farm in 1993 densities were consistently high on rotational set-aside. Densities were lower on the conventional winter cereals, and were especially low on winter wheat. Densities in conventional cereals declined rapidly after late April/early May, falling virtually to zero. There was no such decline in densities on organic cereals where densities were considerably higher throughout the breeding season. In 1994 there was no seasonal decline in skylark density in conventional cereals. Numbers remained relatively constant and densities in winter barley and winter oats were slightly higher than in 1993. There was no rotational set-aside on the conventional farm in 1994. On the organic farm there was an increase in densities on spring barley and spring oats towards the end of the 1994 breeding season.

There were differences in field structure between the two farms, for example the conventional fields were larger than the organic fields (Respective medians 9.75 ha, 4.00 ha; Mann-Whitney $P<0.001$). In 1993, ordination by Principal Components Analysis (PCA) was used to examine relationships between field structure and skylark abundance. PCA was undertaken on the following four field variables: field type (organic=1, conventional=2), boundary index, shape index, and field area. The first three principal components (PCs) together explained 96.2% of the total variance in field structure (54.1%, 26.3% and 15.8% respectively). PC1 was positively correlated with all four variables and reflects a gradient from open fields with relatively short boundaries (negative scores) to enclosed fields with relatively long boundaries (positive scores). In other words, PC1 reflects the basic differences in field structure between the organic and the conventional farm. PC3 reflects a gradient from open fields with relatively long boundaries (negative scores) to enclosed fields with relatively short boundaries (positive scores). PC2 has no obvious interpretation. The scores for all three PCs along with the percentage vegetation cover (arcsine-square root transformed) and vegetation height were entered into least-squares multiple linear regression analyses to explain variation in the density of singing male skylarks on the same sample of fields at each visit. All densities were log (+0.1) transformed to give a better approximation to a normal distribution. The analyses explained between 36.2% (visit six) and 61.8% (visit three) of variation in the density of singing male skylarks, with PC1 by far the most important predictor variable in all cases (Table 3.2). As expected, PC1 was inversely related to skylark density with a coefficient varying from −0.296 to −0.474. PC3 also predicted a significant proportion of variation in skylark density (9.7% - 15.7%) on some visits.

Again, this component was inversely related to skylark density with a coefficient varying from −0.361 to −0.463. PC2 was uncorrelated with skylark density. In no case did vegetation cover or vegetation height emerge as a significant predictor of skylark density. In summary, therefore, the skylarks were strongly associated with small, open fields and tended to avoid fields that were enclosed by tall boundaries such as hedges.

3.2 Seasonal changes in vegetation structure

Figures 5 to 7 compare the vegetation data collected in 1993 and 1994 for all fields containing a crop type common to both years. The solid line indicates the stage at which Schläpfer (1988) suggested crops become unsuitable for nesting skylarks. We have extrapolated this line back (hatched), assuming that even the tallest cereal crops (c. 100 cm) remain tolerable if overall vegetation cover is very sparse and ground level movement remains relatively unhindered. The box at the origin demarcates fields which are too bare of vegetation to provide adequate cover for nesting skylarks. In the following discussion, we refer to crops as being 'suitable' and 'unsuitable' for nesting skylarks according to their position with respect to these threshold lines.

Figure 5 compares the 1993 and 1994 data for April and shows a very similar pattern of growth between years, the only difference being the degree of variability in percentage cover between individual fields of conventional cereals in 1994. In both 1993 and 1994, all the conventional cereals and some of the set-aside fields were 'unsuitable' in May but the height and percentage cover of conventional winter barley was more variable and sugar beet growth was less advanced (Figure 6). There are three notable differences between the vegetation data for June 1993 and June 1994 (Figure 7). The first is the marked difference in the growth of the sugar beet between years, being much more advanced in 1993 than in 1994. The second is that some of the set-aside fields have once again become 'suitable' having been cut and begun to regrow. The third is the difference in the organic spring cereals which showed a much higher percentage ground cover in 1994 than those in 1993, although the height was similar in both years. In both years, the organic spring cereals became 'unsuitable' in June, later than all other cereals.

Table 3.2 **Relationship between skylark density and field and vegetation structure in 25 fields, March-June 1993. Skylark density on each visit is the dependent variable and field structure (as shown by principal components), vegetation cover and vegetation height are independent variables. Only statistically significant predictors (at $P<0.05$) are shown.**

Source	% Variance Explained	Regression Coefficient	Visit
TOTAL	47.8		1 (March)
PC1	43.4	−0.4711	1
TOTAL	52.9		2 (March)
PC1	31.7	−0.3940	2
TOTAL	61.8		3 (March)
PC1	38.4	−0.4039	3
PC3	11.3	−0.3809	3
TOTAL	54.2		4 (March)
PC1	26.6	−0.3445	4
PC3	9.7	−0.3612	4
TOTAL	44.0		5 (April)
PC1	26.9	−0.3281	5
PC3	14.3	−0.4833	5
TOTAL	36.2		6 (April)
PC1	24.4	−0.2957	6
PC3	14.8	−0.4665	6
TOTAL	51.2		7 (April)
PC1	44.8	−0.3595	7
TOTAL	56.5		8 (May)
PC1	50.3	−0.4136	8
TOTAL	56.9		9 (May)
PC1	53.3	−0.4342	9
TOTAL	60.1		10 (May)
PC1	53.6	−0.4735	10
TOTAL	44.1		11 (June)
PC1	30.1	−0.4073	11
TOTAL	51.1		12 (June)
PC1	31.5	−0.3901	12
PC3	15.7	−0.4378	12

3.3 Breeding season

A total of 41 nesting attempts was recorded in both 1993 and 1994. In 1993, the first clutch was initiated on 31 March and the last two on 11 June. In 1994, however, the first clutch was initiated much later, on 18 April, probably due to the unusually cold weather in the first half of the month. The last clutch was initiated on the 20 June, again later than the previous year. This may have been due to the delay in the start of the breeding season leading to a later finish, which was made possible by the long spell of warm, dry weather that lasted through most of June and the second half of July. Figure 8 shows the seasonal distribution of clutches in 1993 and 1994. In cases where the exact date was not known, the date of clutch initiation was estimated by extrapolation from the age of chicks or appearance of eggs, assuming an 11 day incubation period and four days from initiation to completion of the clutch. In both years, most clutches were laid in the last two weeks of April and the first two weeks of May.

Of 29 nesting attempts with known clutch size in 1993, one had two eggs, 16 had three and 12 had four (mean = 3.38±0.56SD). Of 26 nesting attempts with known clutch size in 1994, 19 had three eggs and seven had four (mean = 3.27±0.45SD). Larger clutches were laid later in the season (medians 121.5 and 143.5 for clutch sizes 3 and 4 respectively; Mann-Whitney $P<0.01$). In both years, mean clutch size was very similar to those recorded in other studies (Delius, 1965; O'Connor & Shrubb, 1986; Poulsen, 1993).

Figure 9 compares the mean clutch initiation date (±SE) for 1993 and 1994 on four field types: set-aside (organic and conventional), organic spring cereals, conventional winter cereals and sugar beet (1993) or grass verges (1994). Mean clutch initiation dates did not differ significantly between years (medians 126.5 and 128 for 1993 and 1994 respectively; Mann-Whitney $P>0.05$). Nesting activity commenced simultaneously on both farms but there were some differences in the timing of breeding between different field types. In both years, clutch initiation on the organic farm was earliest on the set-aside fields and much later on the spring cereals. On the conventional farm, clutch initiation was earliest on the conventional winter cereals and rotational set-aside. In 1993, later clutches were recorded on sugar beet, whereas none were recorded on sugar beet in 1994. Any attempts later in the season were recorded in the rough grass on the field margins but were not as late as those recorded on the organic spring cereals.

The much colder, wetter weather experienced early in the 1994 season meant that the conventional crops germinated more slowly than in 1993 and did not provide sufficient cover for nesting skylarks until approximately two weeks later than in 1993. This may have affected the mean clutch imitation date on conventional cereals, which was significantly later in 1994. The organic set-aside fields already provided sufficient cover for nesting skylarks at the start of the breeding season, while later on in the season, the weather conditions improved and the germination of the organic spring crops was relatively unaffected. Hence, the mean clutch initiation date on these fields was very similar between years.

3.4 Nesting success

Nesting success was higher on the organic farm than on the conventional farm in both years. The overall mean number of chicks fledged per nest (inclusive of all total failures) was 1.79 in 1993 and 0.89 in 1994 on the organic farm compared with 1.39 in 1993 and 0.36 in 1994 on the conventional farm. The lower productivity on both farms in 1994 reflects the poor weather conditions experienced early in the season. The effect was relatively greater on the conventional than the organic farm. In 1994, productivity on the conventional farm declined by 74% relative to 1993, but on the organic farm productivity dropped by 50% between the two years.

Figure 10 shows the mean number of chicks fledged per nest on each of seven field types in 1993 and 1994 and clearly demonstrates the greater productivity in 1993. The two most striking differences between the two years was the relative success of skylarks nesting on conventional winter cereals and conventional sugar beet in 1994 and 1993 respectively. In 1993, few nesting attempts were recorded on conventional cereals and no chicks fledged. In 1994, however, productivity was similar to that on organic spring cereals, organic set-aside and organic grass ley. Conversely, productivity on conventional sugar beet fields in 1993 was high due to a few successful late-season nesting attempts, whereas in 1994 no nesting attempts were recorded. Sugar beet grew much more slowly in 1994 due to the poor weather early in the season and was frequently sprayed and hoed. Thus, the crop would not have provided suitable nesting cover until later in the season and there would have been a higher probability of nest losses due to farming operations.

Table 3.3 shows the number of nest failures due to different causes. A much higher proportion of nests failed in 1994 than 1993, principally due to predation and starvation. The main causes of failure in 1993 were predation and farming operations. Of the five lost to farming operations, three were crushed by a tractor during the cutting of conventional rotational set-aside, one was destroyed by harrowing on an organic cereal field and one was trampled by farm workers hand-weeding an organic cereal field. No nests failed due to farming operations in 1994. The fact that there was no conventional rotational set-aside may have made a difference to losses of this nature on the conventional farm. In addition, the conventional farmer was managing the organic farm, causing a slight difference in the management regime between the two years. However, it may simply have been chance that no losses due to farming operations were recorded, since harrowing as a means of weed control continued to take place.

Table 3.3 Causes of nest failure on the organic (Village) and conventional (Hall) Farm in 1993 and 1994.

	1993		1994	
	Organic	**Conventional**	**Organic**	**Conventional**
Predation	4	2	8	6
Farming operations	2	3	0	0
Desertion	0	1	2	1
Starvation	0	1	0	3
Successful nests	17	11	14	7
Total nests found	23	18	24	17
Total nests failed (%)	6 (26%)	7 (39%)	10 (42%)	10 (59%)

3.5 Chick condition

Mean chick mass per brood was plotted against age separately for each farm in order to compare growth rates under the two regimes (Figure 11). On the organic farm the growth curve followed a pattern already documented in other small passerines, namely relatively slow growth in the first three days after hatching, followed by a rapid increase between four and eight days of age, before slowing down again as the chicks became old enough to leave the nest (O'Connor, 1984). The growth curve for broods on the conventional farm did not show this pattern, rather growth seemed to take place in short bursts throughout the nestling period. At five and eight days of age, broods on the organic farm were significantly heavier than broods of the same age on the conventional farm ($U=35$, $U=61$; Mann-Whitney $P<0.05$).

An index of condition of birds can be derived by examining residuals of mass on a measure of intrinsic body size (e.g. tarsus length) at a given age (e.g. Ormerod & Tyler, 1990). Birds with a higher than expected mass for their size are interpreted as being in good condition and birds with unexpectedly low masses as being in poor condition. However, the data for individual chicks within the same brood are not independent. Thus, for each age from three to nine days inclusive, the logarithm of mean brood mass was regressed on the logarithm of mean brood tarsus length using the least squares method. Log_{10} transformation was carried out because mass is not directly proportional to linear size and the regression may be expected to be based on some exponential relationship. The resulting regression equation:

$$\log_{10}\mathrm{mass} = \log_{10}a + b\log_{10}\mathrm{tarsus}$$

was rearranged to give:

$$\mathrm{mass} = a \times \mathrm{tarsus}^{b}$$

and expected mean chick masses for each brood were calculated from this equation.

The regression lines for each age explained between 98.8% (day 3) and 34.7% (day 9) of the variation in mass. The condition indices derived from these regressions ranged from +6.35g (day 6) to −9.75g (day 8). The mean condition index for all ages except three days was greater on the organic farm than the conventional farm (Figure 12), and the difference became more pronounced with age, but none of the individual differences was significant (Mann-Whitney $P>0.05$ for all ages).

These results may be affected by the fact that most of the successful nests on the conventional farm in 1993 were on a field of rotational set-aside which received no fertiliser or pesticide inputs during the breeding season. When the same data are re-cast according to the two dominant vegetation types (organic and conventional set-aside grass versus organic and conventional cereals), the mean mass of chicks in broods reared on set-aside was consistently heavier than chicks in broods of the same age reared on cereal fields (Figure 13). Moreover, this difference was significant for broods of three, four and five days of age (Mann-Whitney $P<0.05$). At all ages, except three and nine days for which the sample size was very small, the condition index for broods reared on set-aside was always positive, whereas for broods reared in cereal fields it was always negative (Figure 14), however there was no significant difference at any age (Mann-Whitney $P>0.05$).

4. DISCUSSION

Winter cereal crops have become an increasingly dominant feature of the lowland farmland landscape since the 1960s. In 1974, winter cereals comprised 35% of the total area of land in arable production (Chapman *et al.*, 1974), whereas in 1989-90, this had risen to 67%, more than 30% of lowland farmland (Davis *et al.*, 1990). During the same period, the British skylark population has declined by over 50%. Recent research indicates that winter cereals are a poor habitat for breeding skylarks and that changes in farming practices may therefore have contributed to their decline (Schläpfer, 1988; Jenny, 1990a,b; Busche, 1989; Poulsen, 1993).

Poulsen (1993) recorded very low territory densities on winter cereals in Hampshire and Dorset. During the present study, overall densities on the conventional farm were much lower than those on the organic farm and during the 1993 breeding season there was a dramatic fall in the number of skylark territories on conventional cereals. Schläpfer (1988) suggested that skylarks avoid vegetation which becomes too tall and dense to permit easy access to the ground and which restricts movement on the ground. Modern, heavily fertilised winter cereals usually grow rapidly from early April onwards and reach the height and extent of ground coverage that might be expected to deter skylarks by late April and early May, at exactly the time when most pairs would normally lay their first clutches. In 1994, no such abandonment of territories was observed and, on certain conventional winter cereal fields, skylark territory densities were similar to those observed on the organic farm. However, the first half of the 1994 breeding season was unusually cold and wet, affecting both the timing of clutch initiation and vegetation growth. The conventional crops in particular grew more slowly, showed less vegetative (leaf) growth and were much patchier than in 1993. The difference in the results between the two years may therefore be due to this difference in vegetation characteristics. It is possible that there is a critical period at the beginning of the season, before the first clutch is laid, during which birds will abandon a territory, but that once the female has laid a clutch the pair will remain on that territory at least until the end of that nesting attempt. The conventional cereal field where skylark densities were highest in 1994 had been rotational set-aside in 1993. Skylarks on the conventional farm which nested on set-aside were much more successful than those on conventional cereals. Another possible reason for the difference in results between the two years may be that the adults and juveniles from the successful nests in 1993 returned to the same field the following year. Past experience may cause birds to remain on their territory throughout the following breeding season despite unfavourable changes in vegetation height and density. Delius (1965) found that skylarks were extremely site-faithful, although he found no evidence to suggest that a successful breeding season increased the likelihood of a bird returning to the same site the following year.

Despite the difference in territory densities and territory occupation between the two years, both years saw very low productivity on the conventional farm. Productivity of nests that were built in winter cereals was particularly low. In 1993, only four nesting attempts were recorded in 76 ha of conventional winter cereals, from which no chicks fledged. This finding was very similar to that of Poulsen (1993), who found no nests in 580 ha of winter cereals even though territories were present at a density of 0.035 ha^{-1} in late April and May. In 1994, a much higher number of nesting attempts was recorded on conventional winter cereals, reflecting the higher territory density on this crop type and possibly its more suitable vegetation structure compared with 1993. The majority of these attempts were unsuccessful, but the few that were successful meant that the productivity in 1994 was much higher than in 1993 when no chicks fledged on conventional cereals.

Three reasons can be suggested for the breeding failure of skylarks in winter cereals. Firstly, the vegetation may become very tall and dense in the course of a nesting attempt, restricting movement and making provisioning of the chicks more difficult. Secondly, the microclimate of nests in this tall, dense vegetation may be detrimental to the survival of the chicks by being too cool and wet. Finally, there is evidence (Jenny, 1990a; Poulsen, 1993; Tucker, 1993) that the availability of invertebrate foods for Skylarks is much lower in winter cereals than on meadow or set-aside grasslands, again affecting brood provisioning.

Organic management produces a slower growing, shorter, sparser crop and there is evidence from other studies (Hald & Reddersen, 1990; Moreby *et al.*, 1994) that organic cereal fields hold higher densities of certain groups of invertebrates than conventional fields. Consequently, we might expect Skylarks on organic farms to benefit from amelioration of all three of the problems mentioned above, for conventional winter cereals. Accordingly, the present study found that skylark territory densities and breeding success remained higher throughout the breeding season on organic cereal fields than on their conventional counterparts. These findings are supported by those of the extensive part of the BTO's Organic Farming and Birds Project (Chamberlain *et al.*, 1995) and a similar Danish study (Braae *et al.*, 1988), which both provide more general indications that skylarks are present at higher densities on organic than on nearby conventional farms.

One problem with comparing densities and performance of skylarks in the present study is that effects of crop type and crop management could be confounded. In particular, the cereals on the conventional farm were winter sown whereas those on the organic were predominantly spring sown (this tends to be a general feature of the two systems (see Part II)). It would be highly desirable to compare skylark breeding biology on organic and conventional farms that each had reasonable areas of winter- and spring-sown cereals.

Nesting activity of skylarks started simultaneously on the two farms in both years, however in 1994 this occurred two weeks later than in 1993. On both farms, activity peaked in the first two weeks in May as the first broods, which were initiated simultaneously, hatched. On the organic farm there was a second smaller peak in late May/early June, whereas on the conventional farm few nesting attempts were recorded after mid-May. This may indicate that more first broods were successful on the organic farm, leading to greater synchrony (and hence the second small peak in activity) later in the season. A high failure rate, with failures occurring at all stages of the nesting period would lead to a breakdown in synchrony and no such peak in activity. The small number of attempts that were recorded later in the season on the conventional farm were on rotational set-aside, sugar beet or the grass verges of winter cereal fields. This number was particularly low in 1994, when there were no spring cereals or rotational set-aside grassland and the sugar beet, having germinated very slowly due to the cold, wet weather, only became suitable as nesting habitat much later in the season. The second peak in nesting activity on the organic farm occurred on the spring cereal fields. Lack of suitable nesting habitat may therefore lead to the premature termination of the breeding season on most conventional arable farms. Poulsen (1993) recorded successful nests into July, but it is unclear what stage these nests had reached when they were recorded. Delius (1965) recorded new clutches being laid in early July on a dune system, but also noted that skylarks nesting on adjacent arable land abandoned their territories in early June. In East Anglia, we observed skylarks carrying food to nestlings or fledged young throughout July on coastal grazing marshes and in forestry clearings. If truncation of the breeding season is a general phenomenon in agricultural habitats, it may have a considerable effect on the overall productivity of skylarks nesting on arable land. This effect will be two-fold: earlier in the season, clutch size is smaller and the weather is more likely to be cold and wet, resulting in low productivity. Later in the season, when clutch sizes tend to be largest (Delius, 1965; this study), and the weather warmer and drier, the number of nesting attempts possible will be limited by the area of suitable nesting habitat.

The more erratic pattern of growth recorded in broods on the conventional farm suggests that the food supply on this farm was much less predictable. The timing of hatching to coincide with a plentiful supply of invertebrates is critical, for example O'Connor and Morgan (1982) found that spotted flycatchers *Muscicapa striata* grew more slowly and suffered higher losses in cold, wet weather when insect activity is lowest. All documented cases of starvation of whole broods occurred on the conventional farm and there was a greater number of 'runts' in the broods. Skylarks hatch synchronously and their development should also be synchronous allowing the brood to fledge as a unit and maximise productivity (O'Connor, 1975). Thus, the presence of a runt in a brood is an indication that there is a food shortage. There was also a much higher incidence of predation in 1994 than 1993, a factor which can be associated with starvation. Dunn (1977) found that broods of great tits *Parus major* were more heavily predated by weasels *Mustela nivalis* in years when food was scarce because they were attracted by the begging calls of the hungry chicks. Broods on both farms fared badly in cold, wet weather but those on the conventional farm seemed to fare worse, for example all the cases of starvation of whole broods occurred on the conventional farm. If densities of invertebrate prey of skylarks are higher on organic than conventional farms this may have no apparent effect when the weather conditions are relatively benign but may be the difference between success and failure in unfavourable weather, when the adults will have difficulty in maintaining an adequate provisioning rate. Although there was no clear evidence of a strong correlation between chick condition and farm type, the overall pattern suggests that broods on the organic farm were in better condition than those on the conventional farm. When a comparison was made between chicks reared on set-aside and chicks reared in cereal fields, the results suggested that those reared on set-aside were heavier throughout the nestling period between day three and leaving the nest. Once again, the overall pattern suggests that skylark chicks on set-aside were in better condition than those on cereals. Since skylark chicks remain dependent on the adults for up to two weeks after leaving the nest, those chicks which are in poorer condition when they leave the nest may fare worse during this period and after independence and have a lower survival rate. After leaving the nest, the chicks invariably become separated but must still compete successfully for their parents' attention. The better developed a chick is, the more active and more alert it will be and the more likely that it will be able to attract its parents' attention (O'Connor, 1984).

Both Poulsen's and this study found high territory densities and breeding success on set-aside fields. On Hall Farm in 1993, 63% (12/19) of nesting attempts were on a single field of RSA with a sown ryegrass cover, comprising only 8% of the available field area. On the organic farm, and on the farms in Poulsen's study, fields in the final years of the MAFF five-year set-aside scheme were also very attractive to skylarks and had high territory densities and fledging success. The grass/clover ley and the triticale stubble under-sown with clover in this study were attractive early in the season when they had high territory and fledging success, although they became tall and dense later in the season and nesting activity declined. Grassland may prove particularly attractive for skylarks if it is unimproved and 'tussocky' thereby providing access to the ground even when it exceeds the average height thresholds suggested by Schläpfer (1988). Grassland on which there is little or no fertiliser or pesticide input may also be a richer source of invertebrate food for the chicks. This will be important not only when the chicks are in the nest, so that the adults do not have to travel far to find food, but also in the period between the chicks leaving the nest and becoming independent. During this period, when they are learning to search for food, the chicks are flightless and unable to move easily from areas of low invertebrate density to areas of high invertebrate density. Being raised in a crop which has a high density of invertebrates may therefore be crucial to their survival to independence.

Set-aside will occupy 10-20% (0.4-0.8 million ha) of arable land in Britain in coming years and has enormous potential to provide habitat for ground-nesting species such as skylark and grey partridge *Perdix perdix*. It will also provide important invertebrate and seed food resources for a much greater range of farmland birds throughout the year (Wilson *et al.*, 1995), although appropriate management techniques are required to avoid weed control measures, such as cutting and cultivation, taking place at the peak of the breeding season. In 1993, the management rules for RSA resulted in the cutting and ploughing in of most set-aside fields in May and June, which would have destroyed a high proportion of skylark nests. These rules now allow spraying with a herbicide as a means of weed control and this appears to be less disruptive to ground-nesting birds.

Multivariate analyses indicate that field area, field shape and the physical structure of the field boundary all have important effects on skylark density. Thus, when looking for other effects of the two farming regimes on skylark abundance and breeding success, an ideal study would compare farms with very similar field sizes, shapes and field boundary structures. In this study, the organic farm had smaller, more open fields leading to a high vegetation diversity in a relatively small area and indeed there were higher densities of skylarks here than on the conventional farm. This finding is consistent with Schläpfer's (1988) model of skylark habitat selection which predicts that population density will be highest in areas supporting mosaics of vegetation types which offer continuity of suitable structural conditions for the birds throughout the breeding season. There were, however, other important differences between the two farms. Not only was productivity higher but the growth rate of broods was less erratic and their condition better on the organic farm. The better condition of the chicks on the organic farm suggests that they were fed more and their less erratic growth rate suggests that the food supply available was more abundant and predictable. One reason for this may be that the less tall and dense crop structure on the organic farm resulted in greater accessibility of invertebrates enabling higher provisioning rates even though the overall numbers of invertebrates present were similar to those on the conventional farm. However, the differences observed also suggest that the chemical inputs used in a conventional farming regime, such as pesticides and fertilisers, may have an indirect effect on skylark productivity by reducing the availability of invertebrate food for the chicks. Any direct effects of these chemicals on skylarks are unknown and may be difficult to detect. Some species of birds are more susceptible than others to the effects of pesticides, because of differences in ecology, behaviour and physiology, and detecting any effect is often dependent on the reporting of mortality incidents by members of the public (Hart, 1990). More subtle effects may therefore pass unnoticed. Such effects might be detected by monitoring changes at population level, but these may only become clear after several years and even then it is rarely possible to decide unequivocally whether the changes are due to pesticide effects or to other factors such as changes in habitat (Hart, 1990). Although the decline in the skylark population has been linked to changes in agricultural practice, these changes include changes in cropping as well as massive increases in the use of chemicals. The mechanisms involved in the decline are therefore not yet fully understood but the results of this study have gone some way towards furthering that understanding.

5. RECOMMENDATIONS

1. Further work should be carried out on the ecology of skylarks on arable land and should, ideally, be carried out on a larger sample of farms including both organic and conventional systems, ideally with spring- and autumn-sown crops within each system (see above). It would be valuable to maintain work on territory distribution and breeding success at Village and Hall Farms in order to determine the relationship between breeding success and establishment of territories over a longer period. Work should concentrate on chick diet, foraging locations of adult skylarks during nest provisioning.

2. A large-scale survey of the distribution of singing male skylarks on lowland farmland throughout Britain is desirable to allow quantification of preferences for different crop types and phenologies and to assess the scale and timing of territory abandonment on different crop types. Such a survey should take place over two years and be carried out from mid-March to the end of July in each year. Data on the distribution of singing male skylarks should be combined with simple measurements of crop height and ground cover in each surveyed field. Survey methodology could be based on stratified random samples of squares (1 km^2 or tetrad), roadside transects or could use the existing network of Breeding Bird Survey 1 km^2 transects.

3. The establishment of colour-marked populations on two study areas will allow a more detailed examination of the factors affecting skylark breeding success on different crop types. In particular, it will be important to investigate whether there are differences between the attributes (age, pairing, physical condition, prior breeding history) of birds nesting in different crop types and to know the fates of those birds. It will also allow a study of the wintering ecology of skylarks, particularly habitat utilisation, over-winter survival and site fidelity and an investigation of how this relates to breeding success.

4. More detailed work should be carried out to investigate both indirect effects, such as the reduction in the availability of chick food invertebrates, and direct effects, such as activity suppression, of pesticides and inorganic fertilisers on Skylark breeding success. Work on the indirect effects would concentrate on chick diet, chick growth and foraging locations of adults during nest provisioning. Work on the direct effects would involve taking blood samples from the chicks for analysis of chemical residues and radio-tagging them to investigate post-fledging survival. Without a study of this kind, the roles of different aspects of agricultural intensification in the decline of the British skylark population will never be fully understood.

In addition, the results of such a study may identify the key factors in the population declines of a range of farmland species and provide the means to reverse those declines.

5. In the longer term, an ambitious but important experimental study would manipulate the density, height and growth rate of experimental cereal plots through alteration of sowing times and densities and input regimes, and monitor subsequent territory establishment and nesting success, foraging behaviour and diet of skylarks. Individual plots would need to be at least 5-10 ha in size to allow meaningful assessment of skylark densities and the array of plot treatments and replicates should be sited in an area of flat, open, 'prairie-like' cereal farmland. This will help ensure that field boundary structures and variations in field slope and aspect do not confound the effects of experimental treatments.

6. ACKNOWLEDGEMENTS

This work was funded jointly by the Ministry of Agriculture, Fisheries and Food and the World Wide Fund for Nature UK. Thanks are due to Bert and Jane Capon and John Wallace for allowing this work to be carried out on their land and to John Poulsen, Alex Schläpfer and Markus Jenny for invaluable advice on the design and execution of studies of skylarks on farmland. Rob Fuller, Chris Feare and Rowena Langston commented on earlier drafts of the manuscript. Sophie Foulger provided invaluable secretarial support.

7. REFERENCES

Barker, A. (1992). Sawflies and Farmland. *Game Conservancy Ann. Rev.* 24:75-76.

Braae, L., Nohr, H. & Petersen, B.S. (1988). *Fuglefaunaen pa konventionelle og okologiske landbrug*. Miloprojekt 102. Miljoministeriet, Miljostyrelsen, Copenhagen.

Busche, G. (1989). Drastische Bestandseinbussen der Feldlerche *Alauda arvensis* auf Grunlandflachen in Schleswig-Holstein. *Die Vogelwelt* 110:51-59.

Chamberlain, D., Wilson, J.D. & Fuller, R.J. (1995). *A Comparison of Breeding and Wintering Bird Populations on Organic and Conventional Farms*. BTO Research Report No. 154. PART II. To MAFF & WWF UK on Organic Farming and Birds.

Chapman, P.J., Sly, J.M.A. & Cutler, J.R. (1974). *Pesticide Usage Survey Report 11. Arable Farm Crops in England & Wales 1974.* MAFF, London; DAFS, Scotland.

Cramp, S. (ed) (1988). *Handbook of the Birds of Europe, The Middle East and North Africa. The Birds of the Western Palearctic.* Volume V. Oxford University Press.

Davis, R.P., Garthwaite, D.G. & Thomas, M.R. (1990). *Pesticide Usage Survey Report 85. Arable Farm Crops in England & Wales 1990.* MAFF, London.

Delius, J.D. (1963). Das verhalten der Feldlerche. *Z. Tierpsychol.* 20:297-348.

Delius, J.D. (1965). A population study of Skylarks *Alauda arvensis*. *Ibis* 107:466-492.

Dunn, E.K. (1977). Predation of weasels (*Mustela nivalis*) on brooding tits (*Parus* spp.) in relation to the density of tits and rodents. *J. Anim. Ecol.* 46:634-652.

Evans, A.D. & Smith, K.W. (1994). Habitat selection of Cirl Buntings *Emberiza cirlus* wintering in Britain. *Bird Study* 41:81-87.

Evans, A.D. & Smith, K.W. (1995). Conservation of Cirl Buntings in the UK. *Proc. XII Int. Cong. IBCC & EOAC.*

Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baillie, S.R. & Carter, N. (in press). Population declines and range contractions among lowland farmland birds in Britain. *Conservation Biology.*

Gibbons, D.W., Reid, J.B. & Chapman, R.A. (1993). *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991.* T. & A.D. Poyser, London.

Green, R. (1978). Factors affecting the diet of farmland Skylarks, *Alauda arvensis*. *J. Anim. Ecol.* 47:913-928.

Hald, A.B. & Reddersen, J. (1990). *Fugelfode i kornmarker - insekter og vilde planter.* Miljoprojekt 125. Miljoministeriet, Miljostyrelsen, Copenhagen.

Hart, A.D.M. (1990). The assessment of pesticide hazards to birds: the problem of variable effects. *Ibis* 132:192-204.

Hustings, F. (1992). *Bird Census News* 5(2). SOVON, The Netherlands.

Jacobsen, E.M. (1992). *Ynglefuglerapport 1992.* Danish Ornithological Society.

Jenny, M. (1990a). Nahrungsokologie der Feldlerche *Alauda arvensis* in einer intensiv genutzen Agrarlandschaft des schweizerischen Mittellandes. *Orn. Beob.* 87:31-53.

Jenny, M. (1990b). Populationsdynamik der Feldlerche *Alauda arvensis* in einer intensiv genutzen Agrarlandschaft des schweizerischen Mittellandes. *Orn. Beob.* 87:153-163.

Jenny, M. (1990c). Territorialitat und Brutbiologie der Feldlerche *Alauda arvensis* in einer intensiv genutzen Agrarlandschaft. *J. Orn.* 131:241-265.

Lampkin, N. (1990). *Organic Farming.* Farming Press, Ipswich.

Moreby, S.J., Aebischer, N.J., Southway, S.E. & Sotherton, N.W. (1994). A comparison of the flora and arthropod fauna of organically and conventionally grown winter wheat in southern England. *Ann. Appl. Biol.* 125:13-27.

O'Connor, R.J. (1975). Initial size and subsequent growth in passerine nestlings. *Bird-banding* 46:329-340.

O'Connor, R.J. (1984). *The Growth and Development of Birds.* John Wiley & Sons Ltd.

O'Connor, R.J. & Morgan, R.A. (1982). Some effects of weather conditions on the breeding of Spotted Flycatchers *Musciapa striatus* in Britain. *Bird Study* 29:41-48.

O'Connor, R.J. & Shrubb, M. (1986). *Farming and Birds.* Cambridge University Press.

Ormerod, S.J. & Tyler, S.J. (19900. Assessments of body condition in Dippers *Cinclus cinclus*: potential pitfalls in the derivation and use of condition indices based on body proportions. *Ring. & Migr.* 11:31-41.

Poulsen, J.G. (1993). *Comparative Ecology of Skylarks* (Alauda arvensis L.) *on Arable Farmland.* Unpubl. Cand. scient. thesis, University of Aarhus.

Schläpfer, A. (1988). Populationsokologie der Feldlerche *Alauda arvensis* in der intensiv Agrarlandschaft. *Orn. Beob.* 85:309-371.

Tucker, G.M. (1993). Effects of agricultural practices on field use by invertebrate-feeding birds in winter. *J. Appl. Ecol.* 29:779-790.

Williamson, K. (1967). The bird community of farmland. *Bird Study* 14:210-226.

Wilson, J.D. (1995). The effect of organic farming systems on breeding and wintering bird populations. In: *Britain's Birds: the conservation and monitoring review 1991-92* (ed. S. Carter), pp 67-72. BTO/JNCC.

Wilson, J.D., Evans, A.D., Poulsen, J.G. & Evans, J. (1995). Wasteland or oasis? The use of set-aside by breeding and wintering birds. *British Wildlife* 6:214-223.

Zbinden, N. (1989). *Die Entwicklung der Vogelwelt in der Schweiz.* Schweizerische Vogelwarte Sempach, Switzerland.

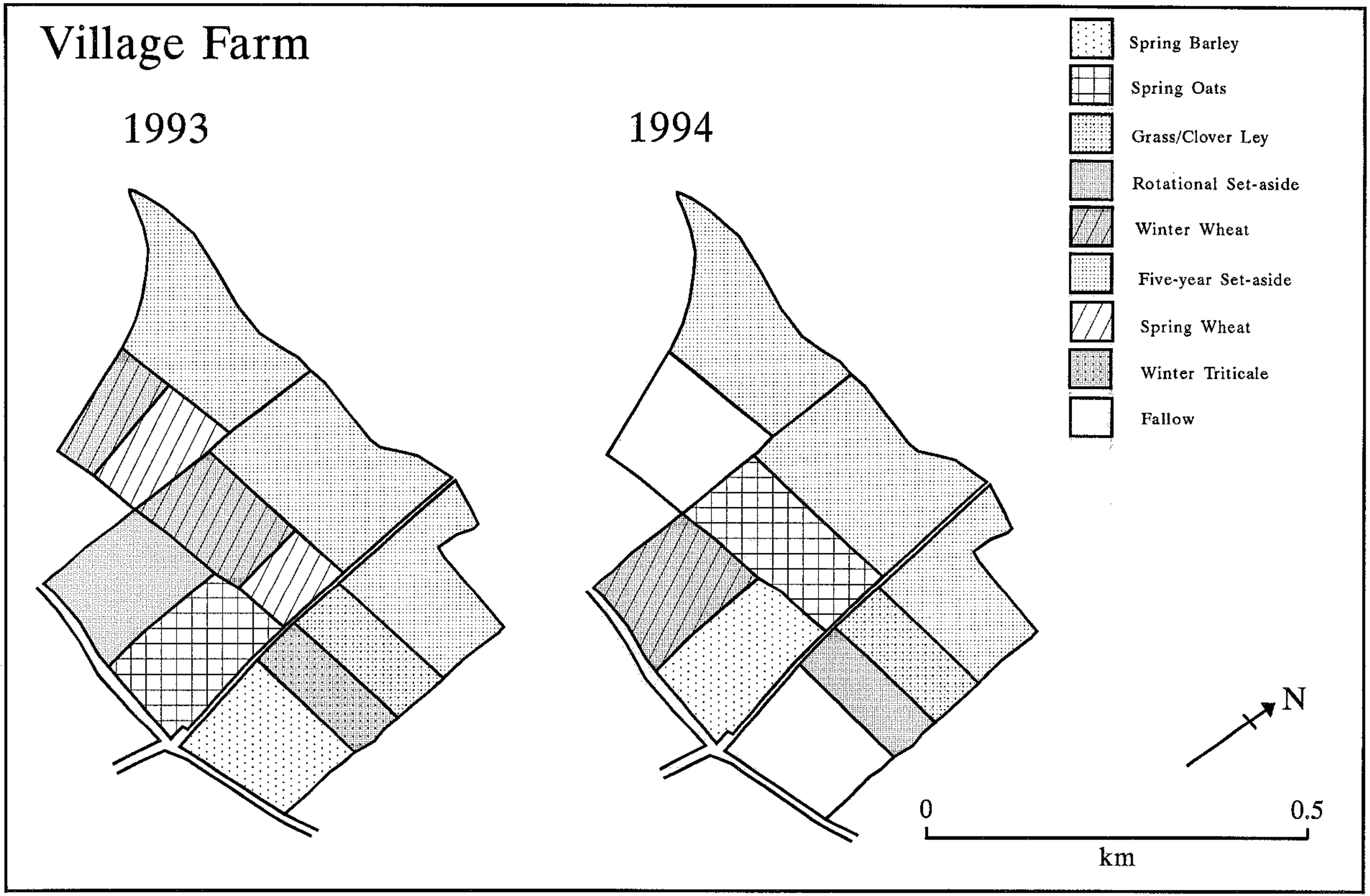

Figure 1 Map of the organic study site showing the differences in cropping patterns between the two years.

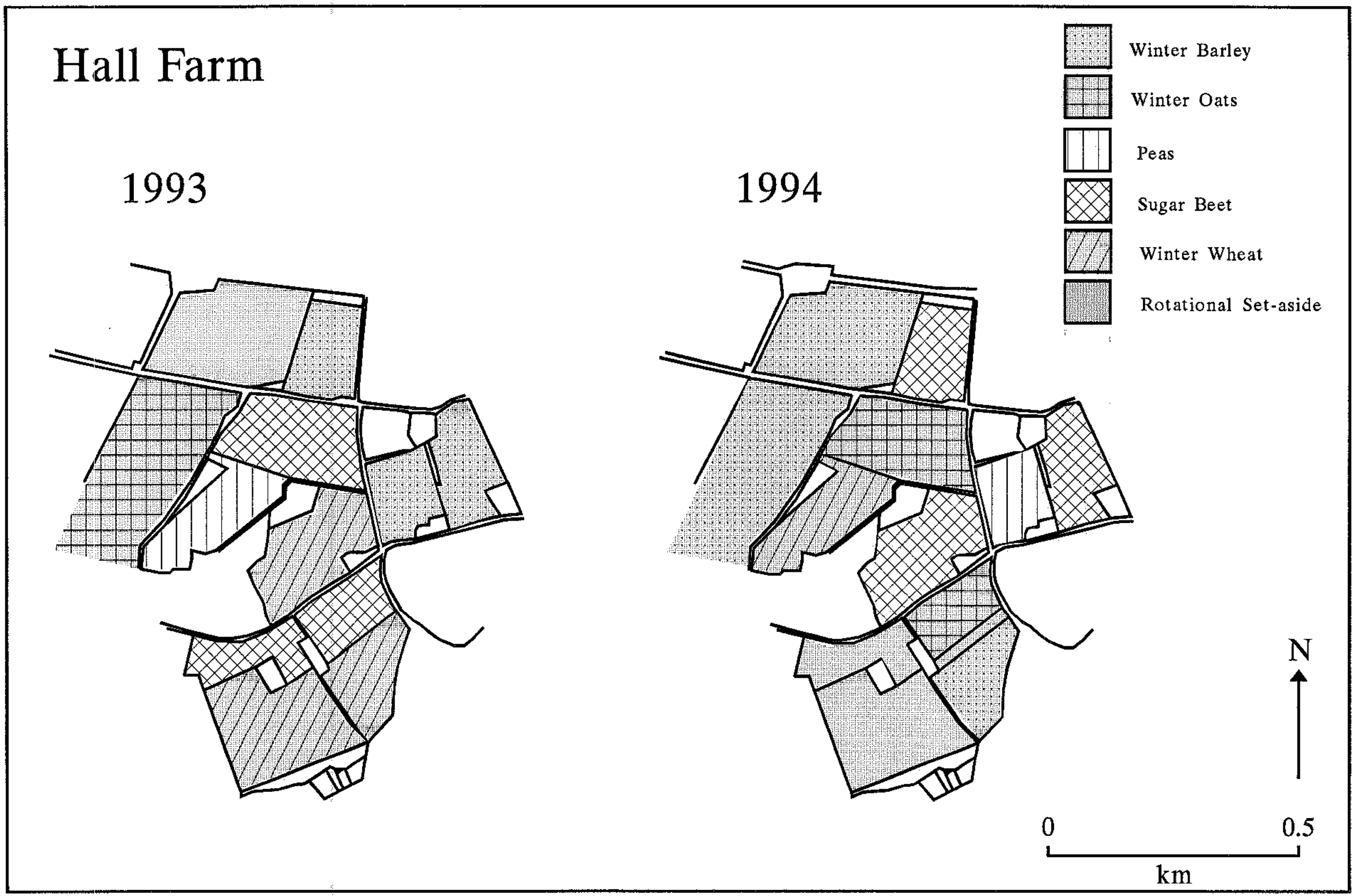

Figure 2 Map of the conventional study site showing the differences in cropping patterns between th two years.

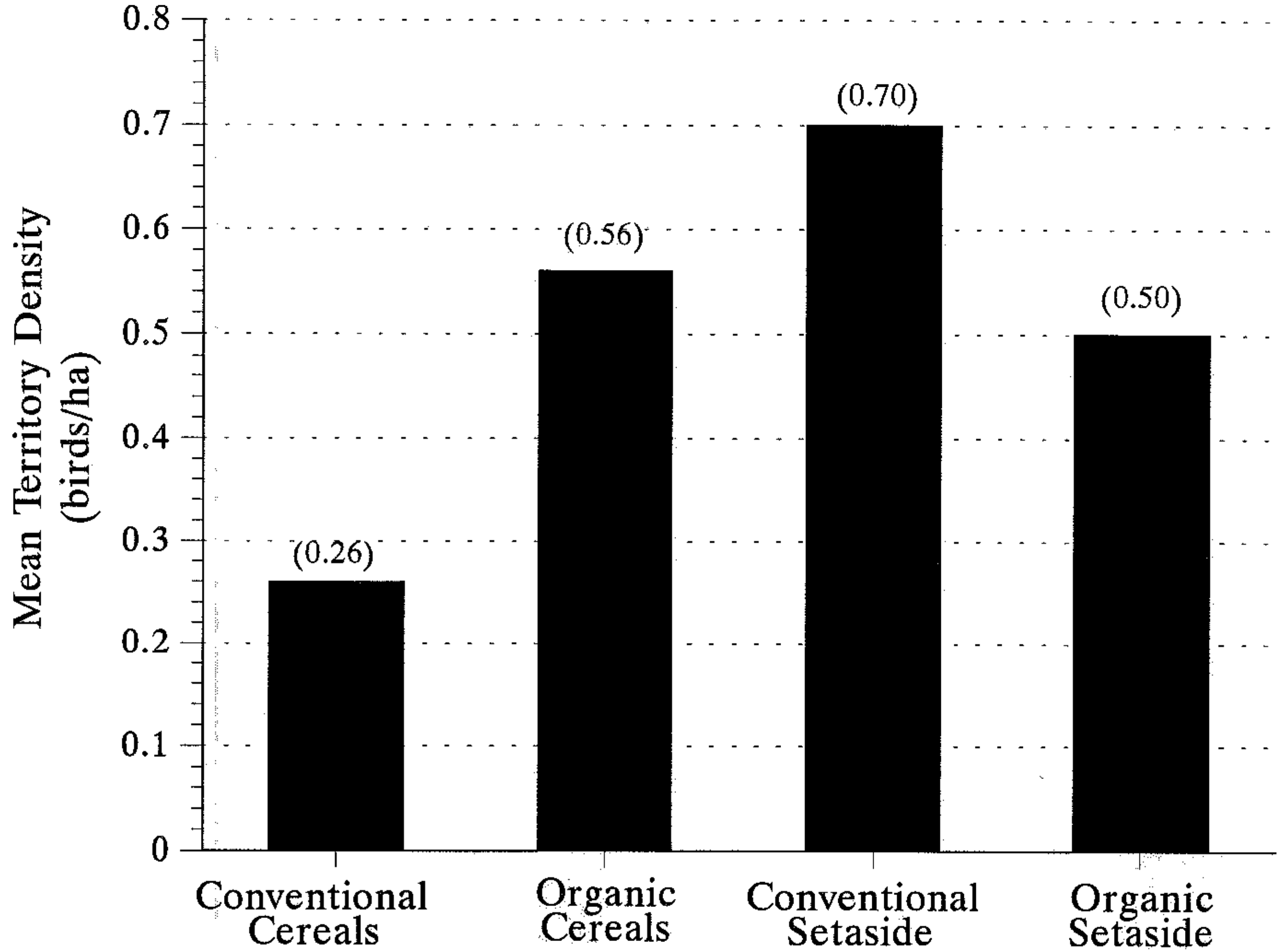

Figure 3 Skylark territory density (mean of two years) on different field types.

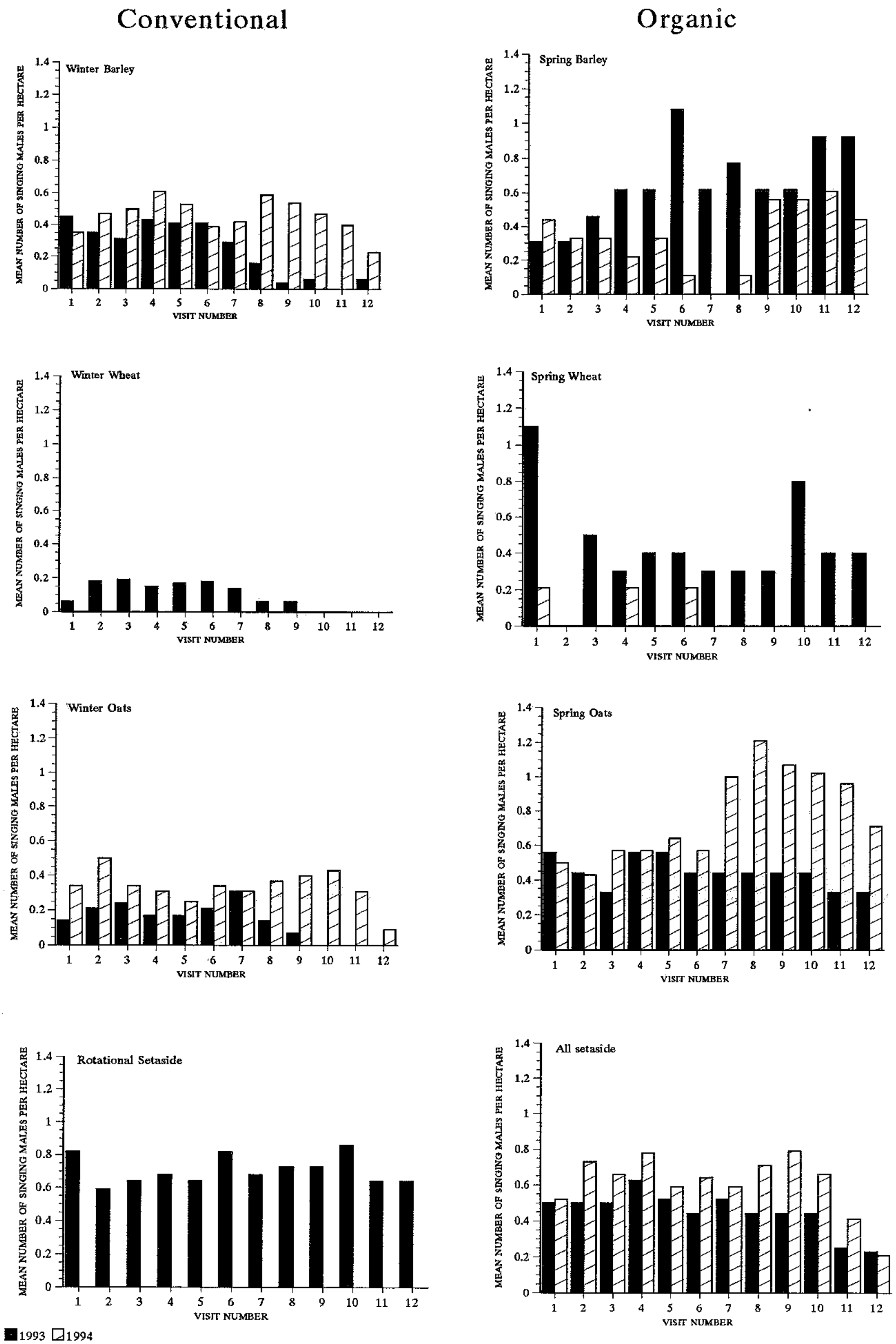

Figure 4 Seasonal change (mid March – mid June) in the densities of singing male skylarks on eight different field types (four organic, four conventional) during 1993 (solid bars) and 1994 (hatched bars). Note: there was no conventional rotational set-aside within the study area in 1994. Conventional winter wheat was present in 1994 but was unoccupied by skylarks.

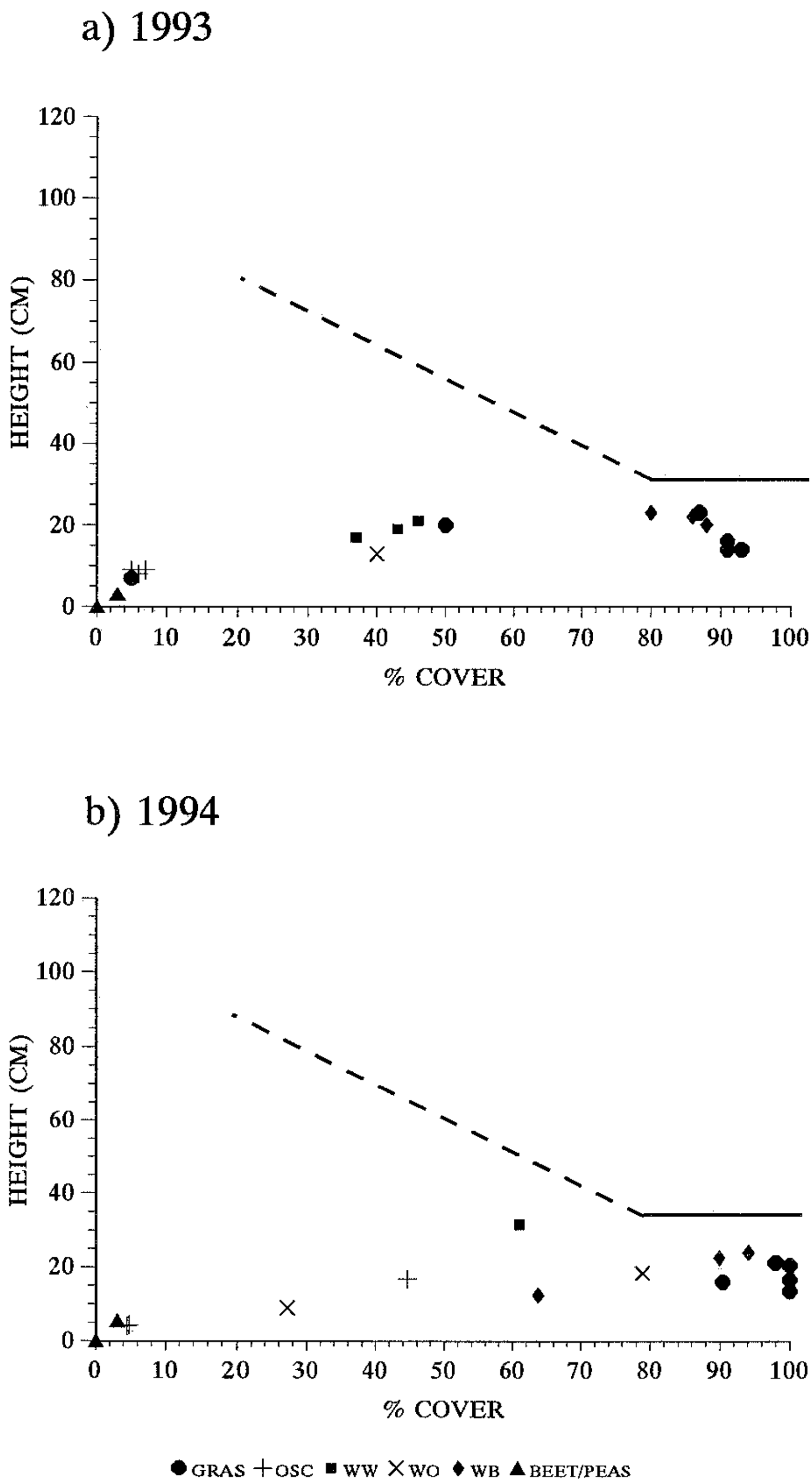

Figure 5 Height and ground cover on fields on Village (organic) and Hall (conventional) Farms, April 1993 and 1994. (GRAS = all ley and rotational set-aside; OSC = organic spring cereals; CWW = conventional winter wheat; CWO = conventional winter oats; CWB = conventional winter barley; BEET/PEAS = conventional sugarbeet/peas). The line shows the threshold above which crops are considered unsuitable for Skylarks (see text).

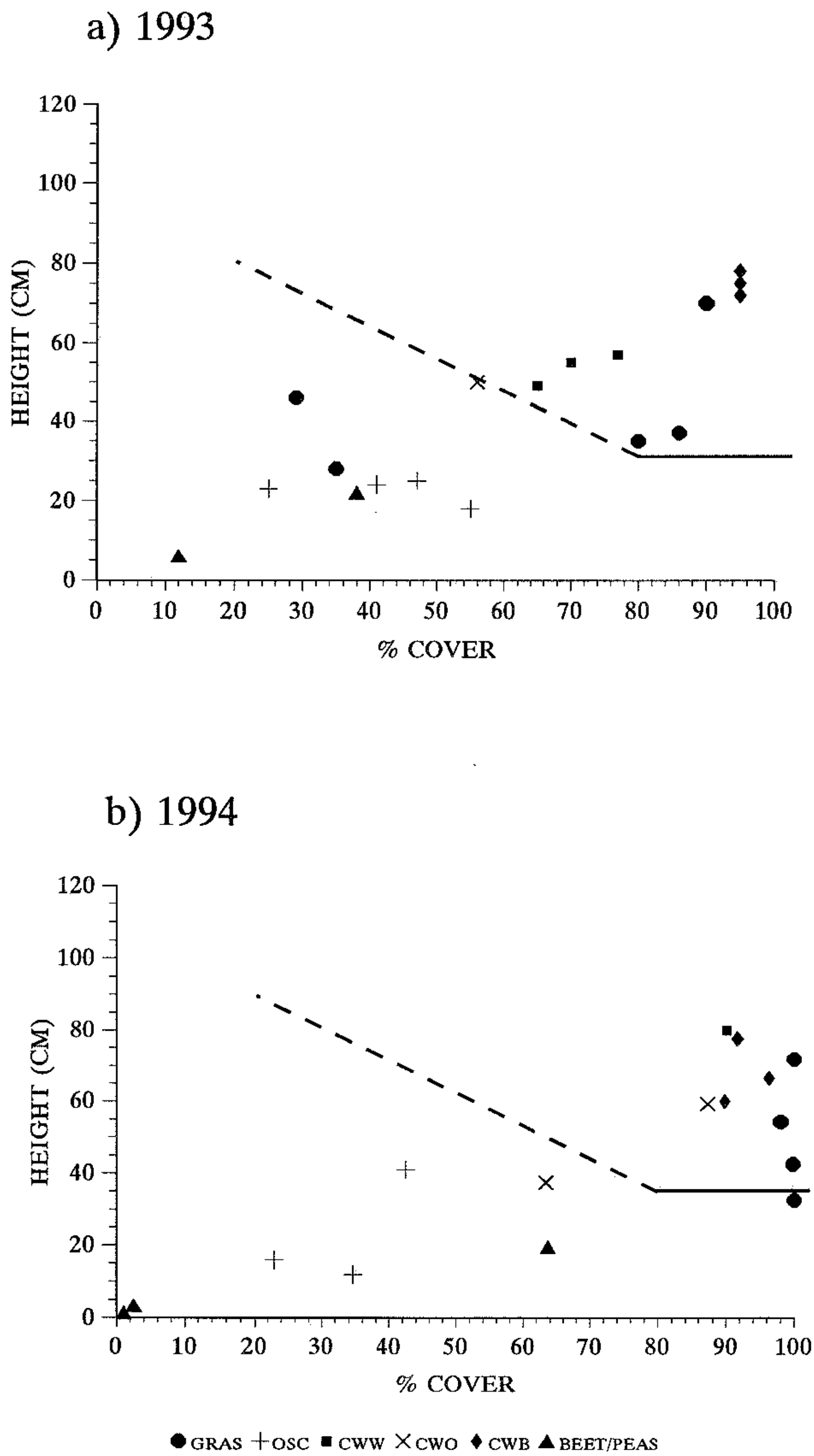

Figure 6 Height and ground cover on fields on Village (organic) and Hall (conventional) Farms, May 1993 and 1994 (GRAS = all ley and rotational set-aside; OSC = organic spring cereals; CWW = conventional winter wheat; CWO = conventional winter oats; CWB = conventional winter barley; BEET/PEAS = conventional sugarbeet/peas). The line shows the threshold above which crops are considered unsuitable for Skylarks (see text).

a) 1993

b) 1994

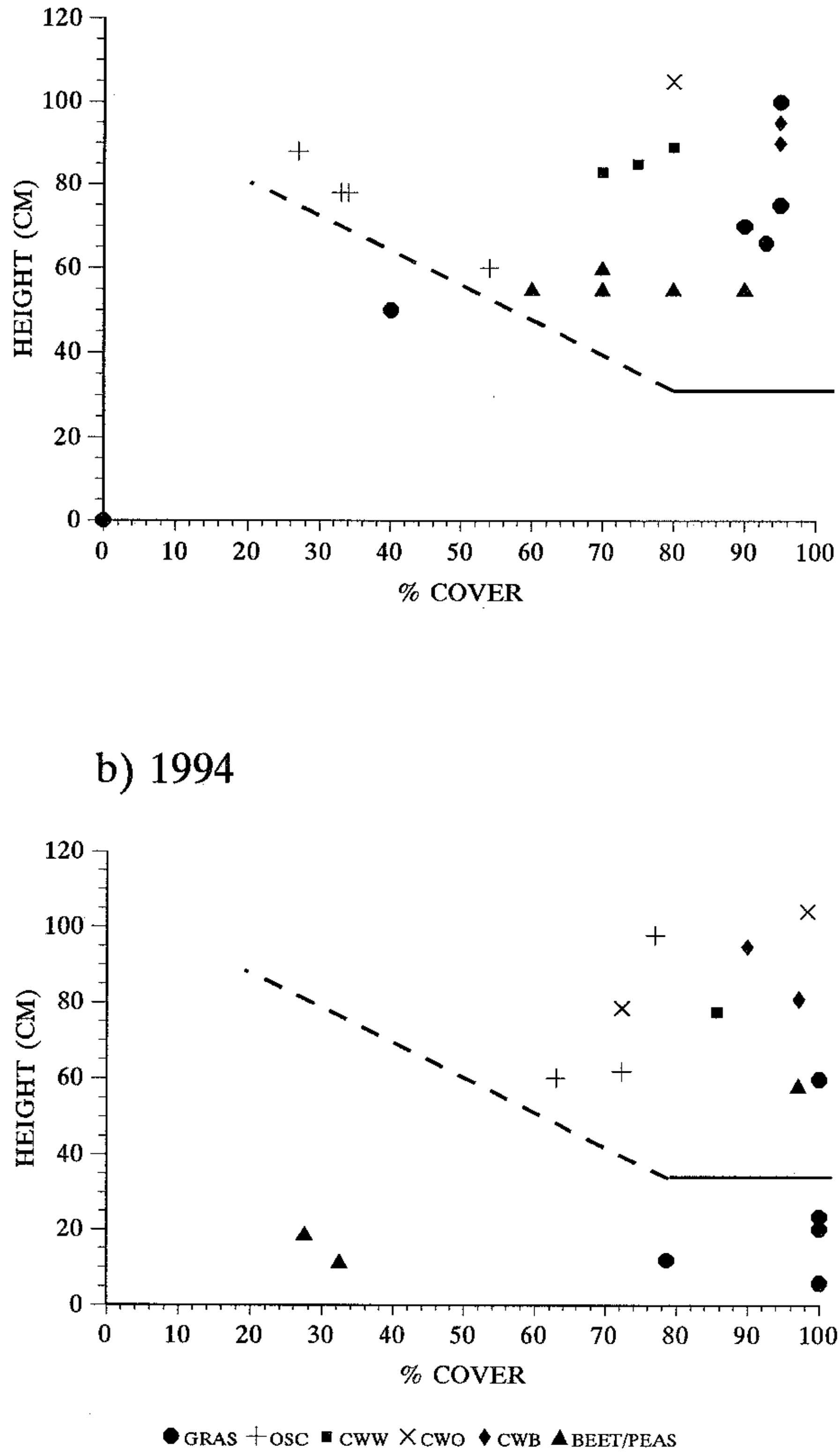

Figure 7 Height and ground cover on fields on Village (organic) and Hall (conventional) Farms, June 1993 and 1994 (GRAS = all ley and rotational set-aside; OSC = organic spring cereals; CWW = conventional winter wheat; CWO = conventional winter oats; CWB = conventional winter barley; BEET/PEAS = conventional sugarbeet/peas). The line shows the threshold above which crops are considered unsuitable for Skylarks (see text).

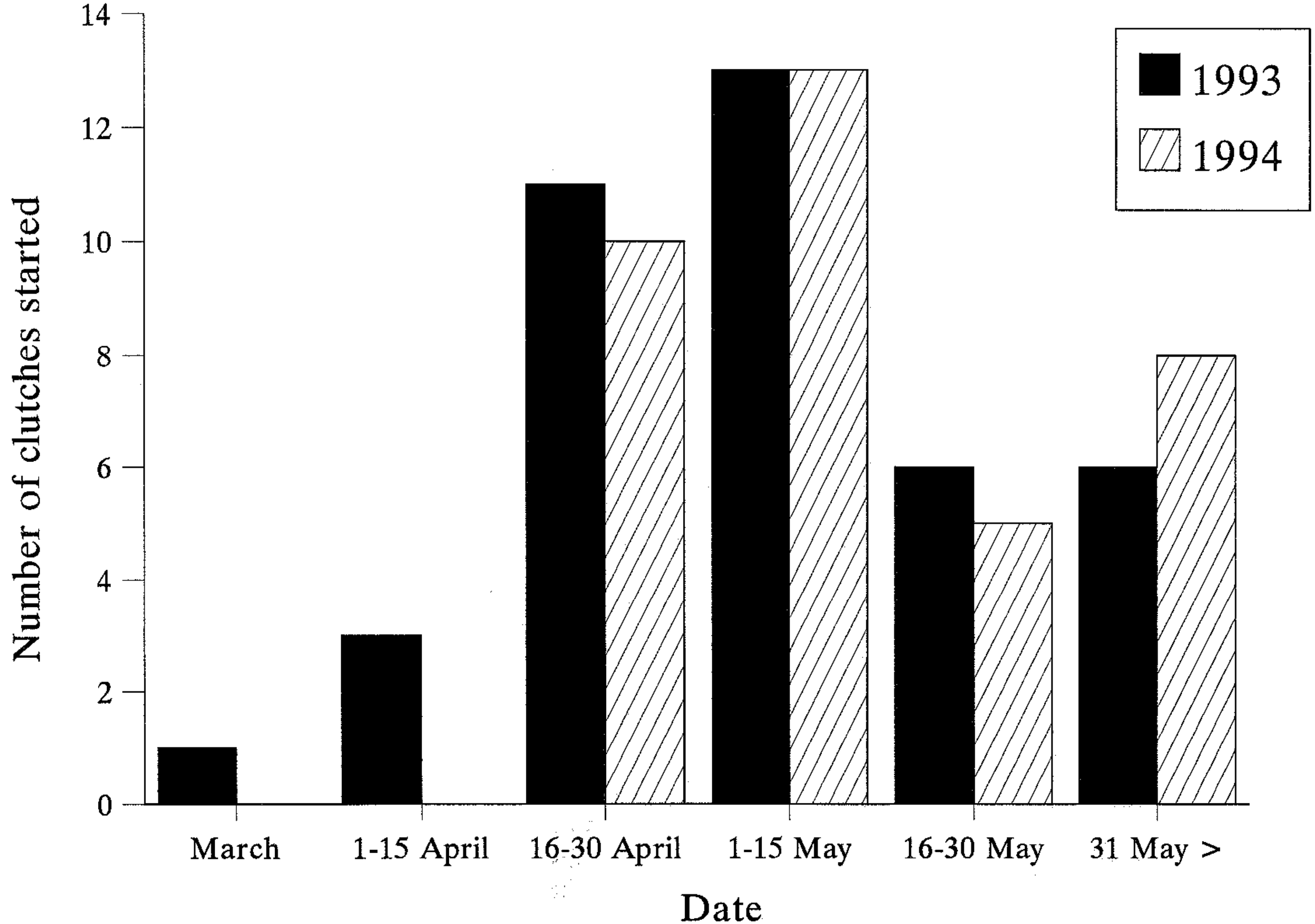

Figure 8 Seasonal distribution of clutch initiation of Skylarks on Village (organic) and Hall (conventional) Farms, 1993 (n=40) and 1994 (n = 36).

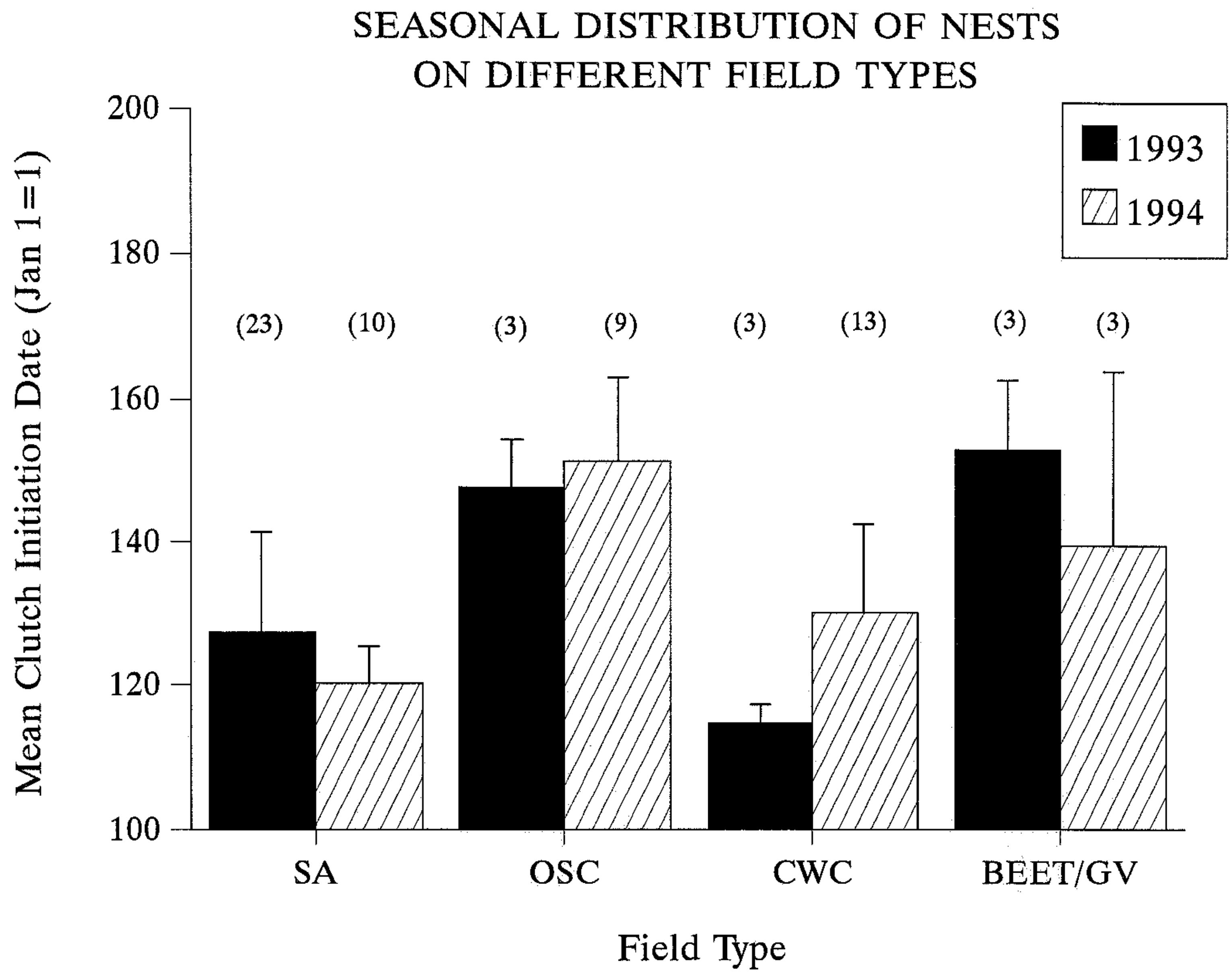

Figure 9 Mean clutch initiation date (±SE) by field type, Hall (organic) and Village (conventional) Farms, 1993 and 1994. (SA = all set-aside; OSC = organic spring cereals; CWC = conventional winter cereals; BEET/GV = conventional sugarbeet/grass verges).

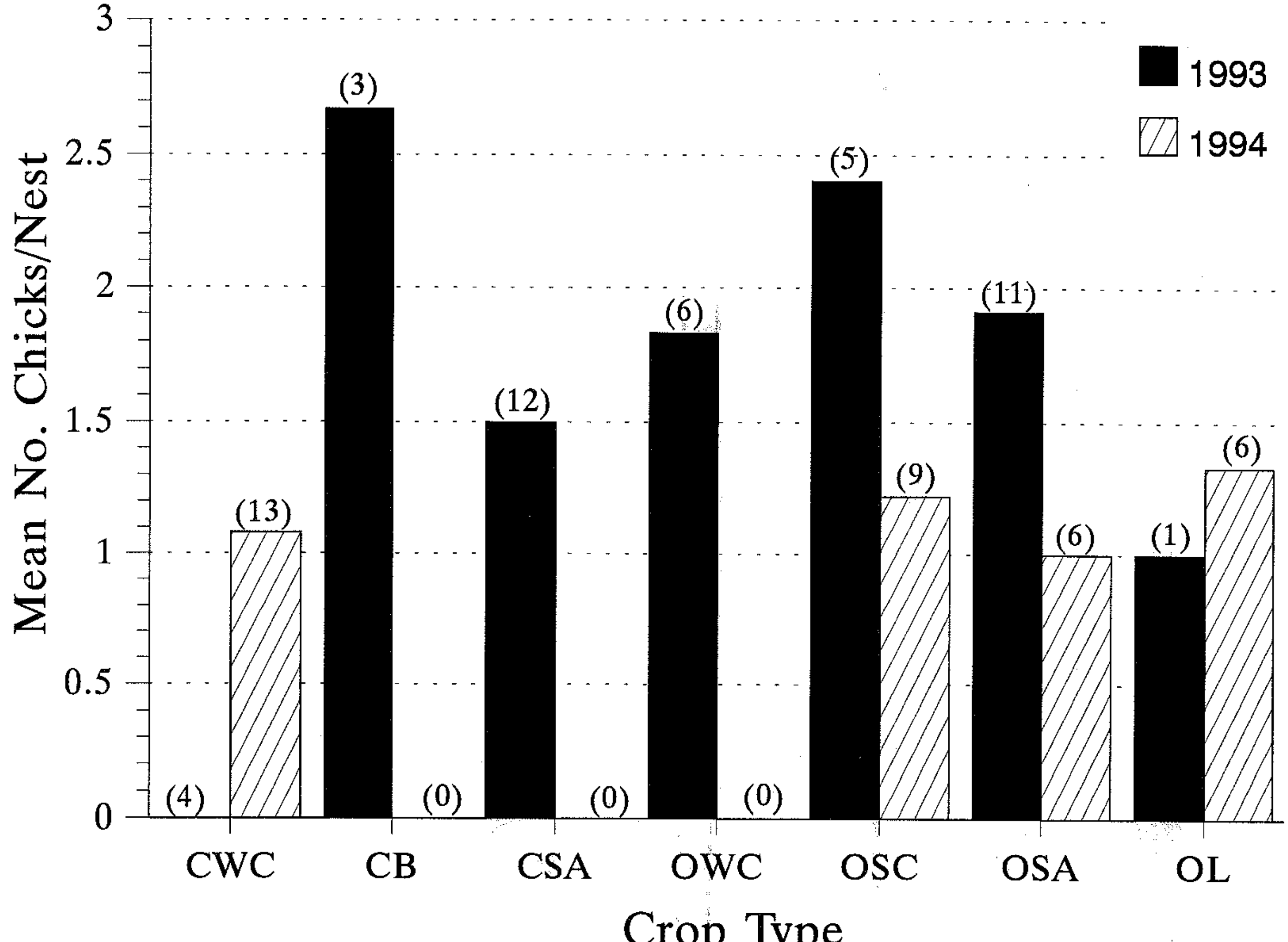

Figure 10 Mean number of chicks fledged per nest on seven different field types, Village (organic) and Hall (conventional) Farms, 1993 and 1994. (CWC = conventional winter cerreals; CB = conventional sugarbeet; CSA = conventional set-aside; OWC = organic winter cereals; OSC = organic spring cereals; OSA = organic set-aside; OL = organic grass ley). Number of nests in each habitat given in parentheses.

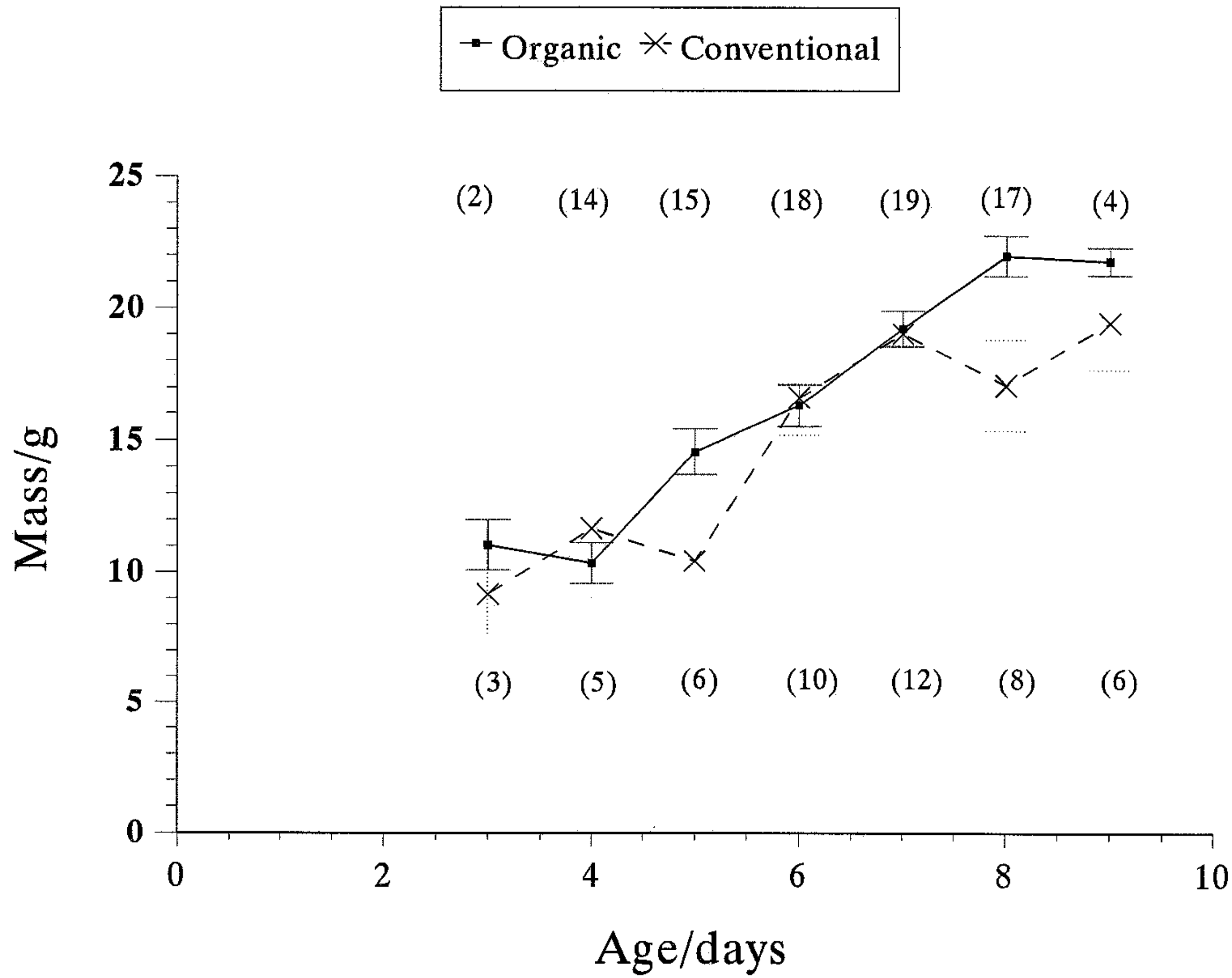

Figure 11 Relationship between mean chick mass per brood (±SE) and age on the organic (Village) and the conventional (Hall) farms. Sample sizes given in parentheses, Organic above, Conventional below.

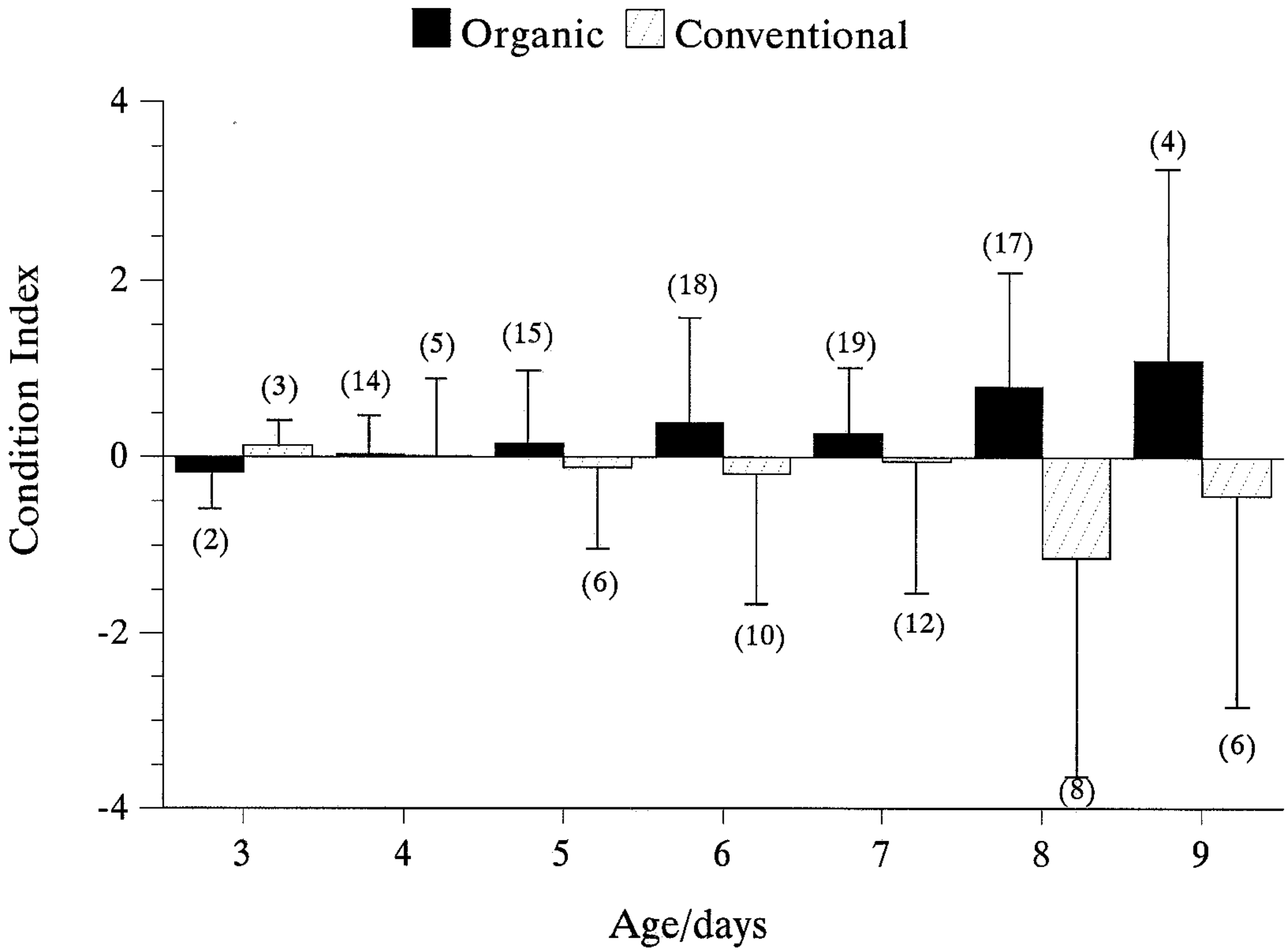

Figure 12 Effect of age and farm type on mean chick condition index (±SE) of Skylark brood on the organic (Village) and the conventional (Hall) farms, both years combined. Sample sizes given in parentheses.

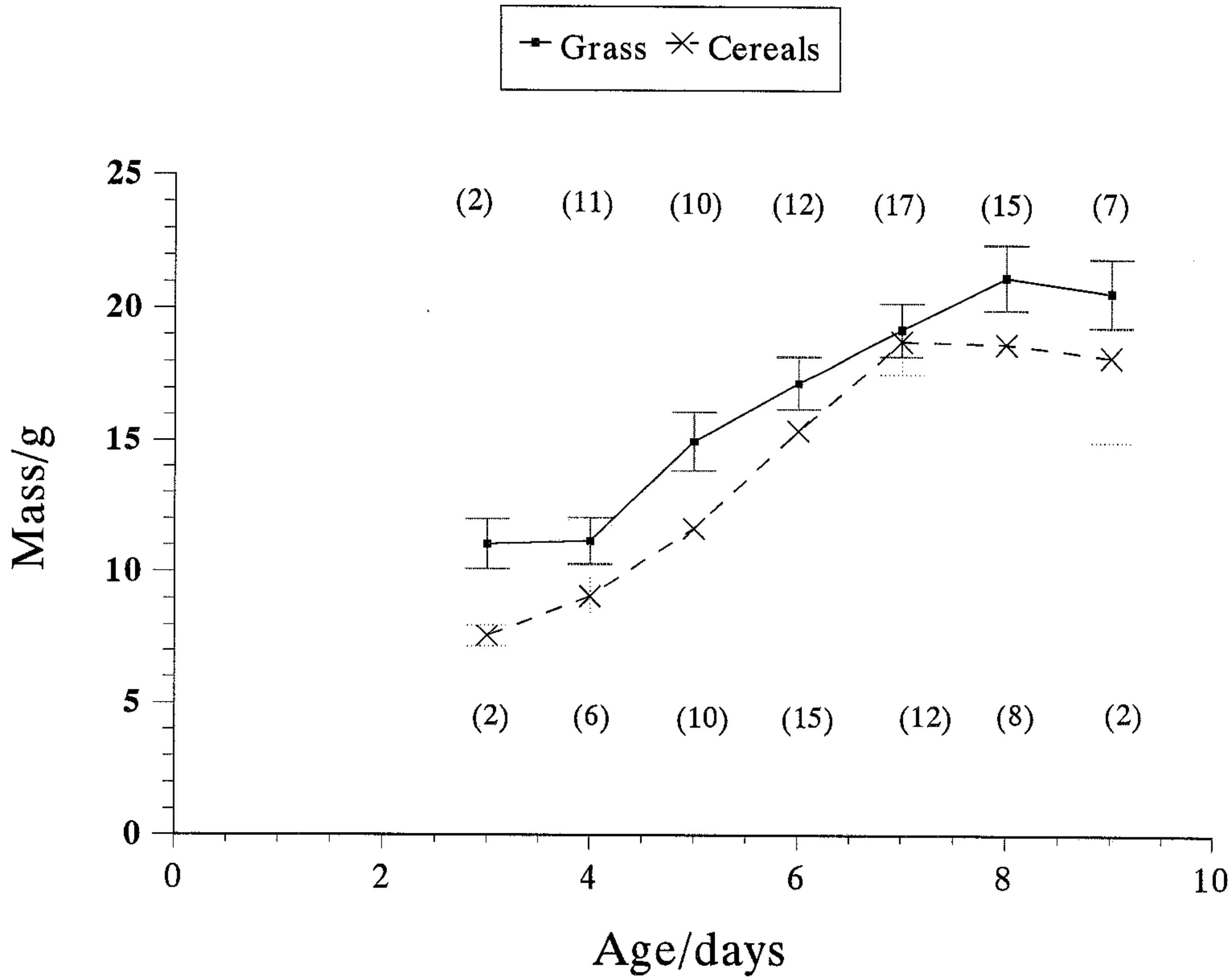

Figure 13 Relationship between mean chick mass per brood (±SE) and age on grass and cereall fields (Grass = organic grass ley and organic and conventional set-aside; Cereals = organic and conventional cereals). Sample sizes given in parentheses. Grass above, Cereal below.

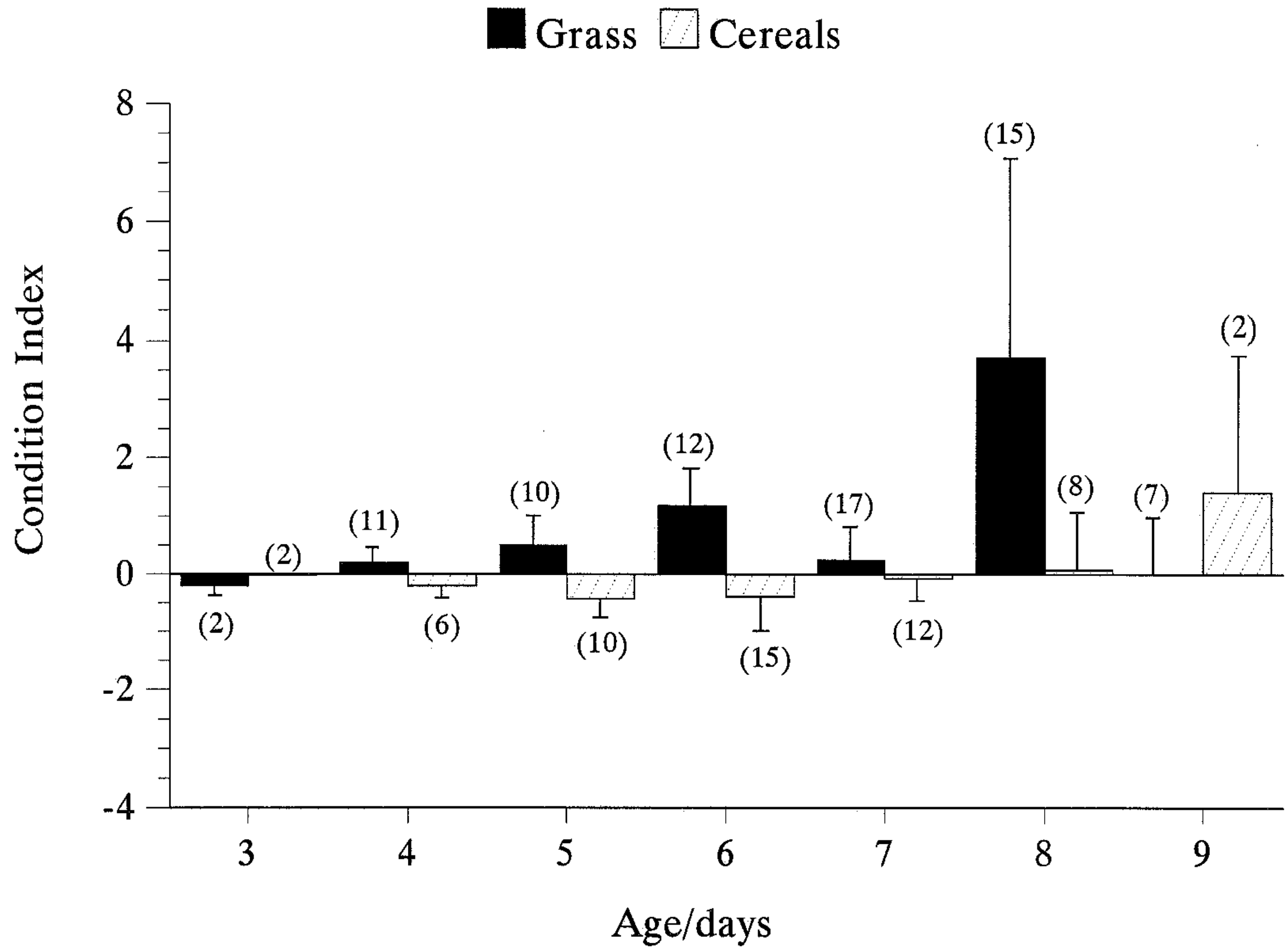

Figure 14 Effect of age and field type on mean chick condition index (±SE) of Skylark broods on grass and cereal fields. (Grass = organic grass ley and organic and conventional set-aside; Cereals = organic and conventional cereals). Sample sizes given in parentheses.