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# HABITAT SELECTION AND BREEDING SUCCESS OF SKYLARKS *Alauda arvensis* ON ORGANIC AND CONVENTIONAL FARMLAND

by

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## SUMMARY

1. The habitat selection, territory density, nesting success and diet of Skylarks breeding on one organic and one conventional farm in north Suffolk were investigated as a pilot study to examine 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, and organic cereals were the most attractive field types to Skylarks.

3. Densities of territorial male Skylarks remained constant throughout the breeding season on all field types except conventional winter cereals. Here, most territories were abandoned in late April and early May when birds were expected to lay their first clutches.

4. Nesting success was highest on set-aside and in organic cereals. Nesting attempts in conventional winter cereals were rare, and all were unsuccessful. Crop structure and growth rate, a cool, damp nest microclimate and low food availability may all have contributed to breeding failures of Skylarks in conventional cereal fields. Furthermore, the breeding season in arable habitats may be curtailed by crop growth, and cutting and harvesting operations.

5. 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.

6. Recommendations are made for further research on the ecology of Skylarks on arable farmland, both during and after the BTO's Birds and Organic Farming Project.

# 1. INTRODUCTION

## 1.1. Skylark Ecology

The Skylark is a characteristic species of lowland farmland, and other open habitats. It is ground-nesting, and shuns tall structures, so virtually all activity is carried out in open habitats. The nest is a simple cup constructed from woven grass in a shallow scrape in the soil. The female is responsible for nest-building and incubation, but both sexes feed the young. Incubation lasts 11 days, and clutch size is usually three or four (exceptionally two or five), with later clutches tending to be larger. Young leave the nest at 8-11 days old, and fledge at 15 days. Most are independent of their parents at 30 days old. Individual pairs make up to three, or exceptionally four, nesting attempts in one year. The first pairs may have eggs by early April, with the last broods still being fed in late July. Territory size varies greatly, but most territories cover 0.25 - 2 hectares. Pairs will shift or abandon their territories during the course of the season if vegetation structure becomes unsuitable. The above information is summarised from Cramp (1988).

Research on Skylarks nesting on arable farmland in Switzerland (Schlapfer 1988; Jenny 1990a,b,c) suggests that highest densities are reached where crop diversity is high so that different crop types provide suitable nesting habitat throughout the season. Where habitat is homogeneous over large areas, the distribution of territories is often clumped. Schlapfer (1988) found that dense vegetation exceeding 30-35cm 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 (<0.1 per ha) with higher densities on spring cereals and grassland (0.1-0.2 per ha), and the greatest concentrations on five-year set-aside land (0.2-0.5 per ha). Estimates of territory density according to crop type must always take into account field boundary structure since tall structures such as hedgerows and woodland edge reduce the area of a field that Skylarks will use. Much higher densities may often be found in other habitats, such as saltmarshes, coastal grazing marsh, and dune systems; for example, 1.62 territories per hectare on marshland in Germany (Gloe 1979), and 0.70 per hectare on dunes in England (Delius 1965).

Diet varies greatly throughout the year. In winter, Skylarks are largely herbivorous and take a variety of weed seeds and leaves, as well as cereal grain. In the breeding season, invertebrates, notably adult elaterid, chrysomelid, curculionid and carabid beetles, predominate in the diet (Green 1978). Large chicks are also fed beetles, but younger chicks are fed lepidopteran and hymenopteran larvae, and spiders (Poulsen 1993). On arable farmland, Poulsen (1993) found that set-aside fields provided the highest concentrations of these nestling food items, with winter cereals the least suitable crop type for brood provisioning.

The wide dietary range of Skylarks may make them valuable indicators of resource availability for a wide variety of other bird species utilizing farmland for nesting and feeding.

## 1.2. Previous Research on Skylarks

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), followed by studies of diet and food selection (Green 1978, 1980) on East Anglian farmland. However, the most detailed studies of the breeding biology and ecology of Skylarks on farmland took place in Switzerland in the 1980s (Schlapfer 1988; Jenny 1990a,b,c). Schlapfer produced a valuable graphical model explaining the influence of crop distribution patterns on the abundance, distribution and stability of Skylark territories. Busche (1989) describes severe declines of Skylark populations in Germany as a consequence of intensification of grazing, mowing, and fertilizing regimes on grassland farms. The most recent research has been carried out by the Game Conservancy Trust on cereal farmland in Hampshire and Dorset (Poulsen & Sotherton 1992; Poulsen 1993). The main findings of this last work are discussed alongside those of the present study.

## 1.3. Skylark Population Trends

Common Birds Census data indicate a 54.3% decline of the breeding population of Skylarks on British farmland between 1968 and 1991 (BTO unpublished data). 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. Even assuming no declines in other habitats, these figures mean that more breeding Skylarks than any other species have been lost in Britain over this period. 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, though the mechanisms remain unknown.

## 1.4. Skylarks and the BTO Birds and Organic Farming Project

Census work during the 1992 breeding season 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 cereals and grass fields, in comparison with their conventional counterparts (Wilson 1993). Possible explanations for this difference include:

i) Vegetation structure. Organic cereals are less heavily fertilized and are often sown later and less densely than conventional cereals (Lampkin 1990) so that they provide a more suitable nesting habitat for Skylarks (see Schlapfer 1988). Similarly, organic grass is often short-term ley, perhaps again providing a more suitable vegetation structure for nesting than lush, heavily fertilized swards of herbage seed, silage or permanent grass on conventional farms.

ii) Food availability. This may be greater on organic farms due to the withdrawal of pesticide inputs, and the retention of rotational practices such as undersowing, which favours invertebrates that only overwinter successfully in undisturbed soils (e.g. sawfly larvae).

iii) Greater crop diversity. This is associated with organic rotations which 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 better understand the apparent benefits of organic farming systems for breeding Skylarks. This work began in 1993, on one pair of farms in East Anglia.
This report documents the results of the 1993 pilot work, and makes recommendations for extension of this research both as part of the Birds and Organic Farming Project, and as an integral part of future BTO research on the ecology of bird populations in agricultural environments.

## 2. METHODS

### 2.1. Study Area

The study area comprised the arable sections of Village Farm, Market Weston (12 fields totalling 46ha) and Hall Farm, Coney Weston (13 fields totalling 133ha). 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. The whole area has been at Soil Association organic standards for over 20 years. Hall Farm grew winter cereals, sugar beet and peas, under an intensive pesticide and fertilizer application regime. One field was sown with perennial ryegrass *Lolium perenne* under RSA regulations.

### 2.2. Territory Mapping

Both the organic and conventional study areas were visited on 12 occasions between mid-March and mid-June 1993. On each occasion the location of all singing male Skylarks was recorded and, where possible, the start and end points of a song-flight were also noted. Details of territorial skirmishes between neighbouring males, and any behaviour indicating the presence of a mated pair were also recorded. This methodology allowed the approximate location of each occupied territory to be recorded at each visit. Territory mapping is best carried out between 6am and midday when most males are singing, and the exercise can be completed quickly. However, males continue to sing all day, and adequate territory mapping could probably be accomplished at any time of day. In areas of high territory density, a mapping rate of 20ha per hour is possible, speeding up as the density of birds falls.

### 2.3. Field Characteristics

Vegetation height and percentage ground cover were recorded at the same ten equidistant locations on a diagonal transect across each field, 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 50x50cm quadrat divided into a 5x5cm grid. 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). Details of farm type and of the area, perimeter, crop type, boundary index and shape for each field are given in Table 1, and details of cultivations on fields during the fieldwork period are listed in Table 2.

### 2.4. Location of Nests

Several techniques for locating Skylark nests were tested. Rope dragging with two fieldworkers was labour-intensive and of limited value. A few nests were located using this method, especially during the early morning and evening when a greater proportion of the females were on the nest. However, on fields with high densities of nesting birds this operation caused sufficient disturbance that other sitting females elsewhere on the field were likely to fly, whilst in tall crops we suspected that some females 'sat tight' even as the rope passed over them. A lone observer slowly and quietly walking the field is probably more likely to be successful, but this technique is extremely time consuming.

By far the most productive technique for finding nests was simply 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. A few nests were located by watching adults carrying nesting material, and subsequently discovering a partially completed nest cup. During the incubation period, nests were very difficult to find, but a few were located by watching the female leave the nest at the start of a break in incubation. If a bird leaves the crop in a low, direct flight to a nearby area where it feeds and preens intensively for 10-15 minutes, then returns in the same manner, and lands a few metres away from where it left the crop, and subsequently repeats this behaviour at 30-60 minute intervals, then the bird is probably an incubating female. Once the eggs have hatched, nests are much easier to find as both adults visit the nest regularly with food for the nestlings. With practice, food in the bill of adults can be distinguished at considerable distances with the aid of binoculars. As when incubating, a bird visiting the nest always landed a few metres away and walked in, but left directly from the nest, often carrying a faecal sac from one of the chicks. Once the point from which the birds left the crop had been located, it was then usually a straightforward matter to walk out into the field and find the nest, providing that the distance was not great and that there was an obvious crop plant or weed near to the estimated nest location to use as a reference. In very large fields with weed-free, homogeneous crops, and especially where the nest was very distant, triangulation was often necessary.

After noting the first definite evidence of nesting behaviour, most nests were located within one-two hours. Distant nests in large fields with homogeneous vegetation cover sometimes required three-five hours. Nest searching can be carried out at any time of day, but if the expected cue is adults carrying food, then mornings are better as this tends to be the time of day when provisioning rate is at its highest.

### 2.5. Nest Checks

Once located, nests were visited on a daily basis to record clutch or brood size and ring and measure chicks. Chicks were ringed between five and nine days of age. Younger chicks were too small to ring, and handling older chicks risked inducing them to leave the nest prematurely. 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. From four-nine days old, tarsus length of each chick was measured daily to an accuracy of 0.1mm using vernier calipers, and mass was recorded to an accuracy of 0.1g using a Pesola balance. The same observer (JDW) recorded all measurements.

Each chick usually produced at least one faecal sac during each handling. These sacs were collected and preserved in 70% ethanol. Over the course of the breeding season, several hundred such samples were collected and will be analysed at the Institute of Arable Crops Research at Rothamsted, to investigate variation in diet with chick age, season, crop type and farm type.

With such regular visits to nests, great care was taken to minimise the degree of trampling near to nests. Often this necessitated taking chicks some distance from the nest for ringing and measuring. In these instances, a tall cane was placed by the nest to discourage the parents from visiting the nest whilst it was empty.

## 2.6. Data Analysis

All analyses were carried out using Release 8 of the MINITAB statistical package.

# 3. RESULTS

## 3.1. Seasonal Changes in Territory Density

Figure 1 shows the mean density of territorial males on four different field types for each of 12 mapping visits between mid-March and mid-June. Throughout the season, densities on grass fields (set-aside and grass-clover ley) and organic cereals were much higher than those on conventional cereals and sugar beet, and were therefore consistently higher on the organic farm (Mann-Whitney $p < 0.05$ for seven visits, and $< 0.01$ for five visits). The conventional fields were also larger than the organic fields (Mann-Whitney $p < 0.001$). An ordination of field type (organic = 1, conventional = 2), boundary index, shape index, and field area by principal components analysis over all 25 fields confirmed this. The first three principal components (PCs) together explained 96.2% of total variance (54.1%, 26.3% and 15.8% respectively). PC1 was positively correlated with all four variables, and reflects a gradient from small, open organic fields with relatively short boundaries, to larger, more enclosed conventional fields with relatively long boundaries. 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 to enclosed fields with relatively short boundaries. PC2 had no obvious interpretation. We included the scores for all three PCs along with percentage vegetation cover (arcsine-square root transformed) and vegetation height in at least-squares multiple linear regression analysis 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). 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 -0.483. PC2 was uncorrelated with Skylark density.

On organic cereal fields territory densities remained almost constant throughout the breeding season, whereas on conventional cereals densities fell to almost zero after late April/early May. Densities on set-aside fields remained constant until June when all were cut severely and, in one case, ploughed. On sugar beet fields, territories were at a low, but constant density throughout the spring, with the few nesting attempts all occurring in June when the beet was sufficiently well grown to provide good nesting cover.

### 3.2. Seasonal Changes in Vegetation Structure

Figures 2(a) - 2(c) plot vegetation height against density for each field in the study area in (a) mid-April, (b) mid-May and (c) late June. The solid line shows the stage at which Schlapfer (1988) suggests crop becomes unsuitable for nesting Skylarks. We have extrapolated this line back (hatched), assuming that even the tallest cereal crops (c100 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' or 'unsuitable' for nesting Skylarks according to their position with respect to this threshold lines.

By mid-April, all winter cereal fields were suitable for initiation of nesting attempts by Skylarks, as were the three long-term set-aside fields and single grass ley on Village Farm. The spreading growth habit of young barley plants provides a much greater ground coverage than occurs on wheat and oat fields at this stage. Growth was very sparse on the rotational RSA field on Hall Farm, and the peas and spring cereals were only just germinating. The sugar beet on Hall Farm had not germinated.

By mid-May, the winter barley fields were already too tall and dense for nesting Skylarks, and the remaining conventional wheat and oat fields were only just suitable. The three long-term set-aside fields also appeared to be almost unsuitable, but continued to harbour many nesting attempts by Skylarks (see 4.3.). All the organic cereals and the RSA were suitable for nesting by mid-May, but cover remained very sparse on the newly germinated sugar beet.

By late June, all conventional winter cereals were unsuitable for nesting Skylarks, whilst the organic cereals remained suitable by virtue of their lower ground coverage. The rapidly growing beet and peas were becoming unsuitable, having been ideal throughout the second half of May and early June. The RSA field was 'topped' on 25 May, and the sward was lower than would have been the case if growth had been uninterrupted. The three long-term set-aside fields and grass ley on Village Farm were measured on 8 June, after which they were cut, and all territories were abandoned.

A slight decrease in percentage cover of vegetation on organic cereal fields between May and June is attributable to a higher weed burden in these fields which was eventually shaded out by the relatively sparse crop, resulting in a net decrease in cover.

### 3.3. Breeding Season

A total of 41 nests was recorded, with the first clutch initiated on 31 March, and the last two on 11 June. Figure 3 shows the seasonal distribution of clutches. For nesting attempts where clutch initiation was not observed, its date has been 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. Most clutches were laid in the last two weeks of April and first two weeks of May, with some laid in late May and early June being second (and in one case third) clutches.

Of 29 nesting attempts with known clutch size, one had two eggs, 16 had three and 12 had four (mean = 3.38$\pm$0.56SD). Larger clutches were laid later in the season (Mann-Whitney $p$=0.0023 for a comparison of initiation dates for clutches of three and four). The overall mean clutch size in this study is very similar to the 3.61$\pm$0.59 (n=32) recorded by Poulsen (1993), 3.69$\pm$0.58 recorded by Delius (1965), and 3.22$\pm$0.69 (arable) and 3.36$\pm$0.66 (grassland) calculated from BTO Nest Record Cards by O'Connor & Shrubb (1986).

Figure 4 shows the mean clutch initiation date ($\pm$SE) on five field types. Clutches tended to be laid early in the season on winter cereals, and late in the season on spring cereals and beet, with a much wider spread of dates on set-aside fields.

### 3.4. Productivity

Figure 5 shows the total area occupied by seven different field types, the number of nesting attempts on each, and the number of chicks leaving the nests. The most striking result is the high productivity of Skylarks organic cereals and all set-aside fields, contrasting with the rarity of nesting attempts and failure to fledge any chicks on conventional cereal fields. Of the four nests in conventional cereals, one failed before laying, one failed during incubation, and two failed before fledging. We suspect starvation in both the latter cases. The few, late-season nesting attempts in sugar beet fields were all successful.

### 3.5. Chick Condition

An index of condition of individual chicks can be derived by examining residuals from the regression of mass on a measure of intrinsic body size (e.g. tarsus length) at a given age (e.g. Ormerod & Tyler 1990). Chicks with a higher than expected mass for their size are interpreted as being in good condition, and chicks with unexpectedly low masses as being in poor condition. Thus, for each age from four-nine days inclusive, the logarithm of mass was regressed on the logarithm of 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

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

was rearranged to give

$$\text{mass} = a \text{ x tarsus}^{b}$$

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

The regression lines for each age explained between 58.3% (day nine - small sample size) and 83.7% (day four) of the variation in mass (Table 4). The condition indices derived from these regressions ranged from -9.1g (day eight) to +6.0g (day seven), but were not consistently correlated with the organic or conventional status of the farmland on which the chicks were being reared (Figure 6). This result may be confounded by the fact that most of the successful nests on Hall Farm were on a field of rotational set-aside which received no fertilizer or pesticide inputs during the breeding season. When the same data are re-cast according to the two dominant vegetation types (set-aside grass versus organic and conventional cereals), there is a suggestion that chicks reared on set-aside may be in better condition than those reared in cereal fields (Figure 7), although small sample sizes and considerable variation between individual chicks within broods means that there is no statistically significant difference at any age.

## 3.6. Causes of Nest Loss

There were 13 complete nest losses during the course of the study, out of the total of 41 found. Six were due to predation of either the complete clutch or brood (probably by corvids or mustelids), five were due to field operations (three crushed by tractor during cutting of set-aside, one destroyed by harrowing on organic cereal field, and one trampled by farm workers hand-weeding an organic cereal field) , one clutch was abandoned (in conventional winter wheat), and one brood starved (in conventional winter oats). Nest losses on the RSA field on Hall Farm were considerably reduced as a result of discussions with the farmer. His initial intention was to plough in the green cover in mid-May to ensure control of grass weeds. However, on hearing of the numbers of breeding Skylarks on this field he undertook only a light cut of the field on 25 May, and delayed cultivation until 15 June. Assuming that ploughing would have destroyed all nests, this decision resulted in nine out of 12 nesting attempts being successful, as opposed to only one out of 12 (a very early nest) had ploughing taken place in May as originally intended.

# 4. DISCUSSION

## 4.1. Landscape Effects on Territory Density

Multivariate analyses indicate that field area, field shape and the physical structure of the field boundary all have important effects on Skylark density which can confound any attempt to examine the impact of differences between farming regimes. In this study, the organic farm held higher densities of breeding Skylarks, and also had smaller, more open fields leading to a high vegetation diversity in a relatively small area; exactly the characteristics which Schlapfer (1988) predicted would favour breeding Skylarks. An ideal study comparing the effects of organic and conventional farming systems would compare farms with very similar field sizes, shapes, and field boundary structures. In reality, this ideal may be almost impossible to achieve, but it is important to know whether organic farms tend to possess those characteristics at the landscape scale that we would expect to benefit breeding Skylarks.

## 4.2. Territory Density and Nesting Success in Cereal Crops

Today, much lowland farmland in Britain is covered by winter cereal crops for most of each year. In England & Wales in 1989-1990, autumn and winter-sown cereals occupied 67% of the arable area, and over 30% of the total area of lowland farmland (Davis *et al* 1989, 1990). Recent research, however, indicates that winter cereals are a poor habitat for breeding Skylarks (Poulsen 1993; this study).

In this study, the dramatic fall in the number of Skylark territories on conventional winter cereals from late April onwards was not matched on any other field type. Poulsen (1993) also recorded very low territory densities on winter cereals in Hampshire and Dorset, but his study period did not begin until late April and does not reveal the higher densities that may have been present during the phase of territory establishment earlier in the spring. Both this study and Poulsen's also found that productivity of nests that were built in winter cereal fields was very low. Poulsen found no nests in 580ha of winter cereals even though territories were present at a density of 0.035/ha in late April and May, while this study recorded four nesting attempts in 76ha of conventional winter cereals (the lowest frequency of nesting attempts per unit area of any cover type), from which no chicks fledged.

Three causes may have contributed to the breeding failures of Skylarks in winter cereals in these studies. Firstly, Schlapfer (1988) suggested that Skylarks avoid vegetation which becomes too tall and dense to permit easy access to the ground, and restricts mobility once on the ground. Modern, heavily fertilized winter cereals 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. Secondly, the microclimate of nests in cereal crops may be cooler and wetter than in grass fields. In grass the shorter, thinner stems allow morning dew to evaporate more quickly (pers.obs.), and the mat of stems and dead vegetation at ground level may provide better nest insulation than the bare earth which usually separates individual crop plants in cereal fields (e.g. Royama 1966). 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, so that brood provisioning may be more difficult.

Organic management produces a slower growing, shorter, sparser crop (Figure 3), and there is evidence from other studies (e.g. Hald & Reddersen 1990) that organic cereal fields hold higher densities 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. Accordingly, the present study found that Skylark territory densities and breeding success remained high throughout the breeding season on organic cereal fields, and the BTO Birds and Organic Farming Project, and a similar Danish study both provide more general indications that Skylarks are present at higher densities on organic than on nearby conventional farms (Wilson 1993; Braae *et al* 1988).

### 4.3. Territory Density and Nesting Success on Grassland

Both Poulsen's and this study found high territory densities and breeding success on set-aside fields. On Hall Farm, 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 Village 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. This occurred although the height and ground coverage of set-aside grass did exceed the thresholds which Schlapfer (1988) suggested would lead to territory abandonment. A possible explanation is that, although tall, grass stems are much less substantial than cereal stems and present far less of a barrier to access to the ground surface. Secondly, although ground coverage may be almost complete the sward is often tussocky and there may be many patches which are only covered by a mat of dead grass, again making access to ground level easy for Skylarks.

Set-aside will occupy 15-20% (0.6-0.8 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,* and also to provide important invertebrate and seed food resources for a much greater range of farmland birds throughout the year. Vegetation structure of set-aside fields under the new rotational and non-rotational set-aside schemes seems likely to be ideal for breeding Skylarks, especially if the availability of invertebrate food resources is higher than on surrounding cropped land. However, many of these potential benefits will only be realised if appropriate management techniques are adopted. Management rules in the first year of RSA (MAFF 1992) resulted in the cutting or ploughing in of most set-aside fields in May-June 1993, at the peak of the Skylarks' breeding season, and many nests are likely to have been destroyed (Mead & Wilson 1993). These operations were conducted both to control weeds and to prevent fraudulent production of a crop on set-aside land where the farmer allows natural regeneration of weeds and crop volunteers from the previous cropping year. After widespread expression of concern at the lack of consideration given to the consequences for wildlife of different management options (e.g. Andrews 1992; Wilson & Fuller 1992), changes were made. From 1994, farmers will be permitted to delay cutting and cultivation until July, and to employ selective herbicides to control pernicious weeds at an earlier date. Further, derogations from management regulations may be granted to farmers who wish to protect the interests of ground-nesting birds and other wildlife on their set-aside land.

This study did not include areas of permanent grassland or silage. Poulsen (1993) found that these fields held high densities of Skylarks and that nests in permanent grassland were often successful. Many nests were lost in silage fields, however, because the interval between cuts was too short for the birds to rear a brood to independence, and the only successful nests in silage were late in the season after the last cut.

### 4.4. Territory Density and Nesting Success in Sugar Beet

Nests were only found in sugar beet fields late in the season when the crop had grown sufficiently to provide cover, but all three were successful. The importance of sugar beet and other late-sown root crops as nesting habitats when other crops have grown too tall and dense is worthy of further investigation.

### 4.5. Length of Breeding Season

In the present study, the last clutch was initiated on 11 June. Poulsen (1993) records successful nests into July, but it is unclear what stage these nests had reached when they were recorded. In the only other published breeding season study of Skylarks in Britain, Delius (1965) recorded new clutches being laid in early July on a dune system at Ravenglass, Cumbria, but also noted that Skylarks nesting on adjacent arable land abandoned their territories in early June. In East Anglia in 1993, we observed Skylarks carrying food to nestlings or fledged young throughout July on coastal grazing marshes and in forestry clear-fells in Breckland. It would be interesting to know whether termination of the breeding season in agricultural habitats earlier than in other habitats (due to crop growth and cutting operations) is a general phenomenon. If it is, then it may have a considerable effect on the overall productivity of Skylarks nesting on arable land by reducing the opportunity for repeat nesting attempts, and because the latter part of the breeding season is when clutch sizes tend to be largest.

### 4.6. Chick Condition

This study found no clear evidence of a strong correlation between chick condition and either field or farm type, although more data may demonstrate that chicks hatched on set-aside fields tend to be in better condition than those hatched in cereal fields. However, hatching of Skylark chicks is asynchronous with many broods having an obvious 'runt', and correlations between chick condition and field type may have been masked by intra-brood variation in chick condition. More data are necessary to allow the possible influence of field type and farming regime on chick condition to be examined at the level of brood means rather than, as in this study, at the level of individual chicks. The latter approach is also preferable since it solves the problem of statistical non-independence of chicks in the same brood being fed by the same adults on the same field.

### 4.7. Causes of Nest Losses

The three nests that were lost to cutting of the rotational set-aside on 25 May were crushed by the tractor, rather than being destroyed by the cutting blade. Furthermore, no nests were lost subsequently through being exposed to predators (*contra* Poulsen 1993). It follows that cutting of set-aside fields is likely to be far less damaging to nesting Skylarks than cultivation, especially if the cover is only 'topped' (to reduce exposure), and the cutting blade is long to reduce the number of tractor passes across the field.

Mechanical weed control in organic cereal fields (largely by harrowing) could destroy many nests if it takes place in May and June.

The effects of selective herbicide spraying as a means of weed control on set-aside are unknown. This management option for RSA comes into effect in 1994, and its effects on Skylarks breeding on RSA will be worthy of further investigation.

## 5. RECOMMENDATIONS

1. Existing work on the ecology of Skylarks on arable land should continue in the 1994 breeding season as part of the BTO's Birds and Organic Farming Project. Work on territory distributions, breeding success (and perhaps diet) should continue on Village and Hall Farms, and should be extended to Hawstead Place Farm, Bury St Edmunds (organic), and the Westacre Estate near Swaffham (mixed organic and conventional fields) if time and financial resources permit. Valuable additions to data collection might include, i) a study of the foraging locations of adult Skylarks during nest provisioning. This might yield valuable information about the availability of food resources for chicks in different crop types, ii) collection of data on temperature, humidity and air movement at ground level in different crop types throughout the breeding season. JDW also plans to add to the existing database by undertaking studies similar to this on one or more pairs of organic and conventional farm plots in Oxfordshire, commencing in 1994.

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 of territory abandonment on winter cereals. 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 (1km or tetrad), roadside transects, or could use the existing network of Breeding Bird Survey 1km transects.

3. Establishment of an intensive population study with colour-marked individuals on one large study area (perhaps a single, large East Anglian estate - e.g. Gooderstone, Elveden, Euston) is desirable in order to examine the fates of individual birds of differing status (age, sex, pairing, physical condition, prior breeding history) in relation to cropping patterns and crop phenologies. In particular it will be important to investigate whether there are differences between the attributes of birds nesting in different crop types, and to know the fates of those birds which attempt to establish breeding territories in fields of winter cereals.

4. In the longer term, an ambitious but important experimental study would be to manipulate the density, height and growth rate of winter cereals (through alteration of sowing and input regimes) at the farm scale, coupled with monitoring of territory

establishment and nesting success of Skylarks in the same areas. Clearly, this would need a farm-scale approach, and require baseline monitoring of populations before manipulations began.

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**TABLE 1**

**Field Characteristics**

| Farm Type | Crop | Area (ha) | Perim. (m) | B.Index | Shape |
|---|---|---|---|---|---|
| Conventional: | Winter Barley | 9.50 | 1187.5 | 0.31 | 1.09 |
| Conventional: | Rotational Set-aside | 11.00 | 1320.0 | 0.13 | 1.12 |
| Conventional: | Winter Oats | 14.50 | 1712.5 | 1.34 | 1.27 |
| Conventional: | Peas | 9.75 | 1640.0 | 3.27 | 1.48 |
| Conventional: | Winter Wheat | 12.75 | 1627.5 | 2.45 | 1.29 |
| Conventional: | Winter Barley | 7.00 | 1105.0 | 2.26 | 1.18 |
| Conventional: | Winter Barley | 9.00 | 1430.0 | 1.80 | 1.34 |
| Conventional: | Sugar Beet | 10.50 | 1600.0 | 0.81 | 1.39 |
| Conventional: | Winter Wheat | 15.50 | 1735.0 | 1.00 | 1.24 |
| Conventional: | Sugar Beet | 10.75 | 1670.0 | 0.86 | 1.44 |
| Conventional: | Sugar Beet | 6.00 | 1565.0 | 1.87 | 1.80 |
| Conventional: | Sugar Beet | 9.00 | 1117.5 | 1.41 | 1.05 |
| Conventional: | Winter Wheat | 7.50 | 1230.0 | 1.08 | 1.27 |
| Organic: | Spring Barley | 3.25 | 722.5 | 0.63 | 1.13 |
| Organic: | Winter Triticale | 2.00 | 635.0 | 0.00 | 1.27 |
| Organic: | Grass/Clover Ley | 3.50 | 760.0 | 0.00 | 1.15 |
| Organic: | 5-Year Set-aside | 4.50 | 827.5 | 1.10 | 1.10 |
| Organic: | 5-year Set-aside | 6.00 | 1117.5 | 1.59 | 1.29 |
| Organic: | 5-year Set-aside | 5.25 | 1240.0 | 1.88 | 1.53 |
| Organic: | Winter Wheat | 3.00 | 782.5 | 0.94 | 1.27 |
| Organic: | Spring Wheat | 2.75 | 632.5 | 1.30 | 1.08 |
| Organic: | Winter Wheat | 4.75 | 780.0 | 1.47 | 1.01 |
| Organic: | Spring Wheat | 2.25 | 590.0 | 0.00 | 1.11 |
| Organic: | Spring Oats | 4.50 | 917.5 | 1.20 | 1.22 |
| Organic: | Rotational Set-aside | 4.75 | 865.0 | 2.18 | 1.12 |

**TABLE 2**

**Timing of cultivations on fields**

| Field | Operation | Date |
|---|---|---|
| Conventional: Rotational Set-aside | Rolling | 15 April |
| Organic: Winter Triticale | Harrowing | 16 April |
| Organic: ALL CEREALS | Harrowing | 3 May |
| Organic: ALL CEREALS | Harrowing | 11 May |
| Organic: Rotational Set-aside | Green cover ploughed in | 23 May |
| Conventional: Rotational Set-aside | 'Topped' (a high cut) | 25 May |
| Organic: ALL 5-YEAR SET-ASIDE | Started cutting | 8 June |
| Conventional: Rotational Set-aside | Started ploughing in | 15 June |
| Organic: ALL 5-YEAR SET-ASIDE | Completed cutting | 21 June |
| Conventional: Rotational Set-aside | Completed ploughing in | 21 June |
| Organic: Grass/clover ley | Cut | 23 June |

## TABLE 3

**Total variance explained, and statistically significant (at $p<0.05$) predictors of the density of singing male Skylarks on 25 fields, Village & Hall Farms, March-June 1993. See text for explanation of analysis and principal components.**

| Source | % Variance Explained | 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 |