British Beet Research Organisation Project 03/13: Report B

The value of the sugar beet crop for birds and the farm environment

[Report B – within-crop management (unplanted plots)]

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Summary

This project examined bird use of sugar beet crops in summer and autumn. Foraging and breeding behaviour, along with data on plant food and vegetation composition, were recorded on a total of 15 sites, eight in 2003 and twelve in 2004.

As many farmland bird species avoid nesting or foraging amongst dense vegetation, the project tested the hypothesis that leaving small (c.4m x 4m) unplanted plots (sometimes known as 'skylark scrapes'), at a density of two plots per hectare within the crop, would increase access for ground nesting or foraging birds. Leaving plots has been demonstrated to increase skylark productivity in winter wheat, at very low cost to the farmer (Morris *et al.*, 2004). On each of the 15 sites, bird use, plant food and vegetation structure were compared between 'Plot' and 'Control' (normal-husbandry sugar beet) treatments. Treatments were normally situated on a single large (>10ha) split field.

Using skylark as an example of a crop-nesting species of Conservation Concern that occurred widely on the study sites, data were collected on territory densities (both years), timing and success of individual nesting attempts (2004 only). Densities of territorial birds were similar to previous estimates from sugar beet and those reported from winter wheat (Browne *et al*., 1999). In sugar beet, there was no indication that territory densities differed between the two treatments. The sample size of nests was small, but breeding success and productivity were similar to a contemporaneous sample of nests from winter wheat. There were too few nests to test for differences between sugar beet treatments. All nests found were instigated during a three-week period, starting in late June. No nests were found within the 4m x 4m plots. However, even in wheat, where the plots have been shown to increase breeding productivity, the main benefit appears to be enhanced access to invertebrate chick-food rather than as nest sites (Morris *et al.*, 2004). The timing of the nesting attempts in beet suggests they were birds which had previously nested elsewhere and which had probably been displaced by changes in habitat at the initial nest site.

As well as benefiting nesting birds, plots have the potential to give greater access to food outside of the breeding season. In sugar beet, this could be especially important as:

(i) it is a relatively weedy crop, in which arable plants and volunteers can readily colonise and produce seed in the plots (where there is no crop competition), thus providing additional sources of food for granivorous birds

(ii) it is later harvested than most other crops, thus providing a relatively rich feeding area for birds well into the autumn or early winter.

Although the vegetation was lower and the amounts of bare ground and seed were greater in the plots than in the surrounding crop, there was no difference in the numbers of birds (granivorous passerines or all species combined) between the Plot and Control treatments during autumn. It is likely that the small area covered by the plots (approximately 0.5% of the cropped area in Plot treatments) meant that any additional food resource (or access to it) the plots provided was insignificant compared to the relative abundance of seed in sugar beet crops as a whole.

Objectives

1. To increase food availability and access for birds in sugar beet fields.
2. To provide additional nesting sites for birds in sugar beet fields.

Methods

In both years, an RSPB Research Assistant was employed from start of June to end October to collect the following data, which gave an indication of the relative value of the two treatments. The data were also used to compare the value of sugar beet to another well-studied arable crop (winter wheat) later in the breeding season, when the developing structure of winter-sown cereals means they became sub-optimal as breeding and feeding habitat.

Treatment design
There were two treatments. (i) 'Control' - conventionally farmed sugar beet and (ii) sugar beet with 'Plots'. Plots (approx. 4m x 4m @ 2/ha) were created by hoeing, but the affected areas were then treated as the rest of the crop, receiving the same pesticide and fertiliser inputs as the Control. All crops were 'conventionally managed', with no trials of GMHT sugar beet being surveyed. Fieldwork was undertaken on eight sites in 2003 and 12 sites in 2004. Five of the sites were surveyed in both years (the remaining three sites surveyed in 2003 were dropped in 2004 due to lack of a suitable crop). All sites were in Cambridgeshire, Norfolk or Suffolk and were chosen from a short list supplied by BBRO and British Sugar.

Each treatment block was chosen to be:
1. at least 5ha in size,
2. relatively unenclosed by tall structures (buildings, pylons, hedgerows or woods), which are known to be negatively related to skylark *Alauda arvensis* density. Fieldworkers confirmed this by calculating a boundary index, based on the methods of (Wilson *et al.*, 1997).

On all but two sites, the two treatments were in a single field split into two halves. The orientation of treatments within split fields was selected to ensure that both had similar surrounding habitats and boundary features. The other two sites each had two 'paired' fields in very close proximity to one another, with similar soil, surrounding habitats etc.

Vegetation
Basic assessments of vegetation type, cover and structure were made on four visits per annum, from late June to mid October. In each treatment, ten 0.5m x 0.5m quadrats were randomly placed in the crop. Additionally, in the plot treatments, one quadrat was placed in each of the unplanted plots.

In each quadrat, the following vegetation characteristics were recorded:
1. Percentage cover (visual estimation) of crop, broad-leaved weeds, grasses and bare soil. Note cover values can sum to more than 100%.
2. The maximum height of vegetation, recorded by touches on a sward-stick, positioned in the four corners of the quadrat.
3. Species/families present. Recorded for flowering or seeding groups, comprising >10% of the vegetation. Identification of seedlings, rare or difficult to identify species/families (e.g. non-fruiting grasses) was not attempted.
4. Reproductive status; the proportion of seeding vegetation in the quadrat.

Bird data

Breeding Season

Assessments of the use of the sugar beet crop and Plots by ground-nesting birds focused on the skylark, which was the only crop-nesting species to occur in sufficient densities on most sites. On each site, the following assessments were made on approximately a biweekly basis from the start of June until early August:

1. Skylark territories

Standardised Area Watches (SAWs) were used to assess the number of birds present and the proportion actively holding territories. Each treatment was watched for a minimum of 30 minutes on at least four occasions from June until early August. Birds seen during the 30 minutes on four watches per site were mapped using standard CBC activity codes (Marchant *et al.* 1990). An estimate of territory density was obtained from the mapped data (based on BTO methods for analysing CBC data). All observations were conducted during the morning in dry weather conditions from a concealed location (most usually a car).

2. Skylark breeding success

In 2004, the above was supplemented by data on breeding success. Such data can only be obtained by finding nests, using visual cues such as nest material or food carrying or the diagnostic flight of incubating females (Donald, 2004) observed during the SAWs. Once located, nests were regularly checked (every 2-4 days) to record clutch/brood size, entire brood loss (through depredation, desertion or agricultural activities) and any brood reduction (through starvation). Estimates (based on nests found at the building stage or with partial clutches, or from back-calculation of nestling age, estimated by studying feather development.) were derived for laying, hatching and fledging dates and used in the calculation of daily survival rates (Johnson, 1979).

Measurements of skylark nestlings were taken when they are between 3-7 days old. Where circumstances allowed, nestling body mass and tarsus length were recorded on two dates, at an interval of one-two days. On the first visit, the tarsi of nestlings were marked with an indelible marker pen, so that individuals could be subsequently recognised and their growth rates calculated. Nestlings were weighed (to the nearest 0.1g) with a Marsden electronic mini balance and the tarsus length (from the depression in the angle of the intertarsal joint to the end of the folded foot) measured with dial callipers (to the nearest 0.1mm).

3. Skylark parental foraging

In 2004, timed foraging watches recorded habitat use by adults provisioning their offspring. The data was collected to determine whether particular habitats (especially the plots) were selected in relation to their availability. During each watch, all flights to the nest were noted and the habitat at and distance to the foraging site (i.e. the location to which a parent flies to obtain food) recorded.

Non-breeding Season

Autumn bird foraging

As sugar beet is not harvested until after most other crops, the presence of certain weeds (e.g. *Polygonaceae*) or seeding crop plants into the autumn or early winter period potentially provides a valuable source of seed for birds at a time when food resources in other arable land are likely to be scarce.

The addition of sparsely vegetated plots into a sugar beet crop may be especially beneficial to ground feeders as:

1. certain invertebrate food taxa, such as *Carabidae*, are often associated with sparse vegetation. This may also be true for some broad-leaved weeds and grasses, which are otherwise unable to compete with the sown crop.
2. the sparse ground cover may improve foraging efficiency by:
   - 2.1. enhancing delectability of food
   - 2.2. enhancing the accessibility of food items.

To monitor use by foraging birds in the critical autumn period, 1km transect walks in each treatment were conducted on five occasions (approximately biweekly) during August-October. All birds flushed from the crop, tramlines and experimental unplanted plots were recorded. Transect distance was measured using a hand-held pedometer. All transect walks were conducted at a constant speed, approximating to normal walking pace. Transects were walked c25m apart, and passed within a maximum distance of 10m to five unplanted plots per treatment (to record foraging within the plots). The direction walked along transect routes was alternated to control for the possibility of observed patterns arising from set patterns of disturbance. For example, following the same route in a preset direction may bias counts (particularly where treatments are situated in close proximity within sub-divided fields) if birds are consistently flushed from one treatment to another, or birds routinely have longer to detect the observer and evade detection. All walks were carried out during dry, calm weather.

Analyses

Skylark nest productivity figures were calculated using data on daily nest survival rates, numbers of eggs laid, numbers of nestlings hatched and numbers of nestlings leaving the nest, as in Donald *et a*l. (2002).

Where sufficient data were available, analyses were performed using General Linear Modelling in SAS Enterprise Guide 2 (SAS Institute Inc.) procedure Genmod. All analyses were conducted using a step-down procedure (in which a full model was constructed and then each variable was deleted and re-added from the model in turn, with the least statistically non-significant variable dropped from the model after each iteration) to establish the minimum adequate model (MAM). All models were constructed with ‘site’ included as a fixed blocking factor. Vegetation quadrat, skylark territory and bird foraging data were modelled using a repeated measures procedure, to account for multiple data collection from the same areas. Overdispersion in the datasets was corrected by SAS procedures.

Vegetation data were modelled using Normal errors, with percentage cover response variables (% broad-leaved weeds, % grass, % bare soil and % seeding) arcsine transformed. Comparisons of vegetation cover between the two treatments were made using a weighted mean for the unplanted plot treatment (WUP) that combined data from both the crop and the unplanted plots, relative to their respective areas. This was achieved by using the resampling with replacement function in Minitab, to randomly select 995 values of the response variable from quadrats within the crop in the Plot treatment and five values from the quadrats within the unplanted plots (to give a total of 1000 iterations). Comparisons of vegetation cover were also made between the actual unplanted plots (PUP) and the crop (CUP) within the Plot treatment.

Bird count data were modelled using Poisson error structures and a log link function. Log treatment area (ha) was included as an offset in the skylark territory model, so that

that the results presented equate to densities (singing males) per ha. For the autumn foraging transects, data on individual species were too sparse to model. To address this, the data were pooled into two suites; the first consisted of all bird species recorded and the second consisted of granivorous passerines (including skylark). Represented in the latter guild were many species of conservation concern. Two separate models were constructed, using the guilds as the response variables.

All response and predictor variables considered in each analysis are listed in Table 1.

Table 1. Variables included in the GLM analyses.

Model	**Vegetation**	**Skylark Territory**	**Autumn Foraging – granivorous passerines**	**Autumn Foraging – all species**
Variable	**Type**	**Type**	**Type**	**Type**
Vegetation height	response			
% bare ground	response			
% vegetation seeding	response			
no. skylark territories		response		
count of granivorous passerines			response	
count of all birds				response
treatment area (ha)		offset		
site (= farm)	fixed blocking factor 15 levels	fixed blocking factor 15 levels	fixed blocking factor 15 levels	fixed blocking factor 15 levels
year	fixed factor 2 levels – 1 = 2003; 2 = 2004	fixed factor 2 levels – 1 = 2003; 2 = 2004	fixed factor 2 levels – 1 = 2003; 2 = 2004	fixed factor 2 levels – 1 = 2003; 2 = 2004
treatment	fixed factor 2 levels – 1 = control; 2 = plot (weighted)	fixed factor 2 levels – 1 = control; 2 = plot	fixed factor 2 levels – 1 = control; 2 = plot	fixed factor 2 levels – 1 = control; 2 = plot
plot	fixed factor 2 levels – 1 = unplanted plot; 2 = crop			
visit no.	continuous variable	continuous variable	continuous variable	continuous variable

Results

Vegetation

MAMs for six vegetation response variables in the comparison of CUP and PUP are given in Table 2.

Table 2. CUP v PUP MAMs for six vegetation response variables. Statistics marked with * remained significant after Bonferroni correction for testing multiple variables. All predictors had 1df. For Visit No.: + = positive relationship (more on later visits); - = negative relationship (less on later visits). Position: means and 95% confidence limits are back-transformed from SAS output. Values equate to cm in the case of height and % cover for all other variables.

Response	Height	% Crop cover	% Broad-leaved weeds	% Grass	% Bare soil	% in Seed
Year	*ns*	*ns*	*ns*	*ns*	*ns*	$P = 0.0175$ 2004>2003
Visit No.	$P = 0.014$ +	*ns*	$P < 0.001$* +	*ns*	$P = 0.002$* -	$P < 0.001$* +
Position:	$P = 0.006$	$P < 0.001$*	$P < 0.001$*	*ns*	$P < 0.001$*	$P < 0.001$*
CUP Mean	34.76	78.41	3.19		17.11	1.55
CUP LCL	31.38	74.29	2.34		13.49	1.01
CUP UCL	38.47	82.43	4.34		21.61	2.39
PUP Mean	19.72	1.51	36.73		49.83	37.80
PUP LCL	12.91	0.65	28.86		41.61	28.91
PUP UCL	30.13	3.51	46.20		59.02	48.69

Vegetation height was lower in the unplanted plots than in the crop (but nor significantly so after Bonferroni correction). Crop cover was significantly greater in the planted areas than in the unplanted plots but broad-leaved weeds. The percentage of bare soil and of the vegetation in seed were significantly greater in the unplanted plots. There were more broad-leaved weeds and vegetation in seed but less bare soil on later visit dates. Year was not significant (after Bonferroni correction) in any of the models.

Comparisons of vegetation on the Control and the weighted Plot (WUP) treatments showed no significant effects of Visit date or Treatment in any of the six models after Bonferroni correction (although height was shorter in the plot treatment, with a negative relationship with visit date, prior to correction). The effect of Year was not tested, as it was non-significant in all of the previous set of models presented in Table 2.

The most commonly occurring broad-leaved plant species on each of the 15 farms are listed in descending rank order in Appendix 1.

Skylark territories

The only predictor retained in the MAM was Visit, with the number of territorial skylarks present on the treatments decreasing from June onwards (Table 3).

Table 3. Parameter Estimates & MAM for skylark territory density (pairs/ha).

Skylark territory density - Analysis Of GEE Parameter Estimates

Empirical Standard Error Estimates

Parameter	Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept	-1.9519	0.2122	-2.3679	-1.5360	-9.20	<.0001
visit	-0.2273	0.0634	-0.3515	-0.1031	-3.59	0.0003

Skylark territory density - Score Statistics For Type 3 GEE Analysis

Source	DF	Chi-Square	Pr > ChiSq
visit	1	6.26	0.0123

Year, Treatment (and Treatment*Visit interactions) were non-significant predictors. For treatment, there was virtually no difference in territory densities, with both recording 0.08 singing males/ha when averaged over the entire survey period and 0.11 singing males in June.

Skylark breeding success

In 2004, eight nests were located on six sites. It is likely that a further two attempts (one on a seventh site) were missed: farm workers reported one nest with eggs, but it presumably failed shortly afterwards, as no signs of activity were seen subsequently; partially fledged young were seen at in a second area, where no nest was located.

Due to the small sample, it was not possible to construct a multivariate model to examine a range of predictors such as the effect of site, treatment and their interactions. Of the eight attempts located, five were in Plot treatments and three in the Controls. All three of the control nests successfully raised one or more young, as did three of the five plot nests. More eggs failed to hatch and more chicks starved (including one nest where the entire brood starved) in the Plot treatments, resulting in more chicks raised per nesting attempt in the Controls (Mean: 4) compared to the Plots (Mean: 2.4) (Table 4).

It was also possible to compare the sugar beet nests with eight contemporaneous nests in winter wheat. Data on the wheat nests were collected from four East Anglian farms as part of the SAFFIE project in 2004. In contrast to sugar beet, Table 4 shows that later wheat nests in Plot treatments appear to be more productive than those in the Controls. When nests in both treatments were combined, there were generally few differences between sugar beet and winter wheat. However, there was some indication that partial brood loss (% brood reduction) due to starvation was greater in winter wheat, leading to slightly lower productivity per nesting attempt (Table 5).

Table 4. Breeding performance of skylarks in control and plot treatments for 16 East Anglian nests in sugar beet and winter wheat during June-July 2004.

Crop	Treat	No. nests	Exposure days	No. Successful	No. eggs laid	No. chicks hatched	No. fledged
S Beet	control	3	39	3	12	12	12
	plot	5	49	3	18	13	12
SB Total		8	88	6	30	25	24
W Wheat	control	2	27	2	7	5	3
	plot	6	88	3	24	20	19
WW Total		8	115	5	31	25	22

Table 5. Comparison of skylark nest productivity and survival from 16 sugar beet and winter wheat nests during June-July 2004.

Crop	Mean clutch size	proportion eggs not hatching	Mean initial brood size	% brood reduction	brood size post-reduction	Mean daily failure rate	Productivity (chicks leaving /nest)
SB	3.75	0.1667	3.13	0.04	3.00	0.0227	1.81
WW	3.88	0.1613	3.25	0.12	2.86	0.0261	1.60

Sugar beet nestlings aged between 5-8 days (n = 22) had a mean weight of 20.37g and a mean tarsus measurement of 25.57mm. There were too few data to calculate growth rates.

For all of these comparisons, it must be stressed that the sample sizes were very small and results should be treated with caution.

Skylark parental foraging

Parental foraging observations were attempted for five nests to which there was reasonable visibility from a concealed nearby watchpoint. The foraging destination was confirmed for only 26 foraging flights out of the 63 flights recorded. Nine out of the 16 flights to nests in control treatments were to habitats other than sugar beet. The corresponding figures for plot nests were six from ten (with two of the flights to unplanted plots). Due to the small sample size, it has not been possible to statistically analyse these data.

Autumn bird foraging

1610 birds (881 granivorous passerines) were recorded during 200 1km transect walks. Separate models were constructed for granivorous passerines and for all bird species. In both cases, the only predictor retained in the MAMs was Visit, with the numbers of both granivorous passerines and all birds present on the treatments increasing through September and into October (Tables 6 & 7).

Table 6. Parameter Estimates & MAM for foraging granivorous passerines.

Analysis Of GEE Parameter Estimates Empirical Standard Error Estimates						
Parameter	Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept	0.5099	0.4672	-0.4059	1.4256	1.09	0.2751
visit	0.3321	0.0796	0.1762	0.4881	4.17	<.0001

Score Statistics For Type 3 GEE Analysis			
Source	DF	Chi-Square	Pr > ChiSq
visit	1	4.69	0.0304

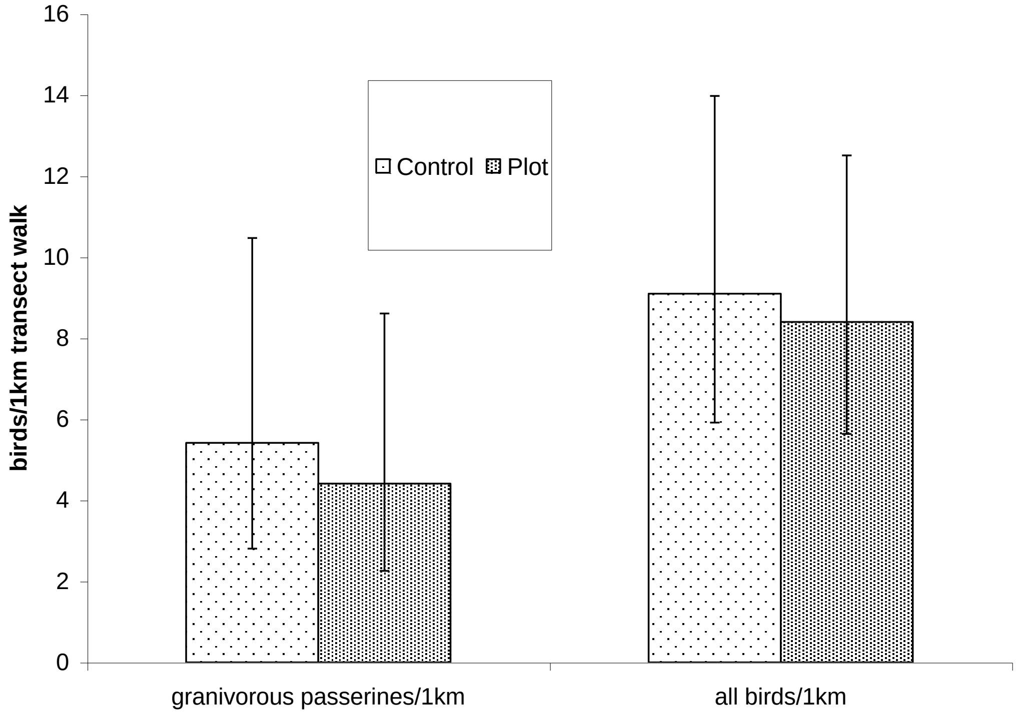
Table 7. Parameter Estimates & MAM for all foraging birds.

All birds - Analysis Of GEE Parameter Estimates Empirical Standard Error Estimates						
Parameter	Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept	1.1889	0.2483	0.7021	1.6756	4.79	<.0001
visit	0.3021	0.0477	0.2086	0.3956	6.33	<.0001

All birds - Score Statistics For Type 3 GEE Analysis			
Source	DF	Chi-Square	Pr > ChiSq
visit	1	7.36	0.0067

In both models, Year was non-significant. For treatment, there were minor non-significant differences between bird abundance in both models, with slightly more granivorous passerines and all species in the Control than in the Plot treatments (Figure 1). Treatment*Visit interactions were not significant in either model.

Figure 1. Mean abundance of birds per 1km transect (with no other terms included in models) and 95% Confidence Intervals. Granivorous passerines model: Treatment *P* = 0.27. All birds model: Treatment *P* = 0.58.



56 out of 772 birds recorded on transect walks in the plot treatments were feeding within the 4m x 4m unplanted plots. As the plots represent less than 0.5% of the entire treatment area, this represents significant selection of the unplanted plots in relation to their availability ($\aleph^2$ = 679; df 1; $P < 0.001$). 31 individuals (constituting ten groups) out of the 56 birds recorded within plots were linnets *Carduelis cannabina*. A list of all bird species recorded on the transect walks is given in Appendix 2.

Discussion

Vegetation composition and structure varied between the unplanted plots and the sugar beet crop. Unsurprisingly, vegetation within the plots was sparser, and to some degree shorter. Despite overspraying of the plots with herbicides, broad-leaved weeds and seeding vegetation (both of which are likely to deliver bird food) were more numerous in the unplanted plots than in the crop, probably due to the lack of crop competition. Grass weed cover did not differ significantly between the unplanted plots and the crop, suggesting that, with appropriate herbicide control and rotation of the plots, the presence in the plots of problem species such as black grass *Alopecurus myosuroides* are unlikely to be a major agronomic concern in sugar beet crops.

The differences in vegetation were not significant at the treatment-scale; i.e. the Plot treatments as a whole did not deliver a significantly more open structure (to enhance access) or more seeding plants (to enhance food abundance) for foraging birds at the field scale. These results agree with those for winter wheat from the SAFFIE project.. SAFFIE also reported less crop cover, more broad-leaved weeds (and also grasses) and a more open vegetation structure in the plots than in the surrounding crop, but the results were not significant at the treatment scale (Morris *et al.*, 2004). Nevertheless, even very small patches of habitat with super-abundant food or good access can provide valuable, well-used foraging habitats in certain circumstances. For example, it is likely that the main benefit to skylarks of plots in wheat crops comes from increased access to invertebrate food (Morris *et al.*, 2004). In sugar beet, it is possible that differences in plant food abundance at the treatment level are less marked than in wheat, as sugar beet tends to be a weedier crop. Therefore, although they contain more seeding and broad-leaved plants than the crop, the provision of unplanted plots in sugar beet may have less effect on foraging birds than in wheat, where food (other than cereal grain) within the crop is now scarce (Potts, 1991).

The relative abundance of plant food within the beet crops may explain the lack of differences in numbers of foraging birds (both breeding skylarks and in autumn) between the two treatments, with the Plots giving little 'added vale' in terms of resource abundance. It might be expected that the sparser vegetation in the unplanted plots would promote access to ground-foraging birds but the influence of access in determining foraging location may be diminished in beet where food is abundant and where the vegetation is more open than in some other arable crops. Linnets did appear to make some use of the plots for foraging, perhaps attracted by the presence of important plant food such as fat-hen *Chenopodium album* (Wilson *et al.,* 1996). However, as fat-hen was also common within the crop, it is possible that linnets were foraging on the barer ground for dropped seed, or were feeding on plants less tolerant of crop competition e.g.*Cruciferae*. Despite overall significant selection in relation to their availability, records of other species (granivorous or insectivorous) in the unplanted areas were sparse. In the UK, comparative studies of bird numbers in different arable crops are lacking for the autumn period. Those reported here look to be only moderate. However, in the case of the suite of granivorous passerine species, a figure of one bird every 200m is low given the abundance of seed of favoured bird food such as *Chenopodium, Cruciferae and Polygonaceae* (Wilson *et al.,* 1996). Given that bird use significantly increased with survey date, it is possible that late-harvested weedy beet crops will be of benefit, both to granivores and to birds feeding on seed-eating insects.

As this study did not have the resource to collect data on invertebrate abundance within the crop, it has not been possible to relate the foraging behaviour of breeding skylarks or insectivorous species during the autumn to the abundance or distribution of their food. The finding that the unplanted plots in sugar beet were little used for foraging by any insectivores during the autumn or by breeding skylarks (although in the latter case the sample size was small) suggests that they are likely to be of limited value in enhancing invertebrate food availability in this crop. In winter wheat, the SAFFIE project found that foraging skylarks significantly selected the plots in relation to their availability (unpublished data). SAFFIE research indicates the main benefits of the plots are to linked with the increased delectability of and/or access to invertebrates in short, sparse swards rather than increased invertebrate abundance (Morris *et al.*, 2004). Although the sample size was small, this study found that over half the skylark parental foraging flights were to habitats outside the sugar beet crop (most frequently to barley or field-margins). This suggests that sugar beet may not be a particularly good foraging habitat for invertebrate-feeders. Indeed, late summer numbers of epigeic invertebrates, bees and butterflies are all reported to be low in beet crops (Booij & Noorlander, 1992; Haughton *et al.*, 2003). As molluscs can be abundant, it is surprising that thrushes were not more frequently recorded in autumn.

For breeding skylarks, there was no indication that the provision of unplanted plots in sugar beet had an influence on the numbers of territorial males. As most of the treatments in this study were split-field plots, it is possible that the lack of a significant difference was due to territories overlapping the plot boundaries. However, some sites in wheat with the two treatments in a split field show aggregation of nesting skylarks around the plots (unpublished SAFFIE data). June territory densities of 11 males/km^2 agree well with the figure of 10.82 reported by Browne *et al.* (2000) for root crops during April-June. Territory densities in this study were also similar to those reported from winter cereals by Browne *et al.* (2000) and the SAFFIE project. Densities in beet are higher than for agricultural grassland and some other arable crops (e.g. oilseed rape) but lower than in many semi-natural habitats, set-aside and spring cereals (Browne *et al.*, 2000; Donald *et al.*, 2001b). After the end of June, territory densities decreased rapidly, so that over the whole survey period (June – early August), densities averaged eight males/km^2. This was reflected by the fact that, despite intensive observations in 2004, no renesting was reported after the initiation of clutches in late June or early July. These late first-egg dates suggest that skylarks had probably moved into the beet crop after having earlier attempts in other habitats. The eight nests found in sugar beet had first-egg dates within 17 days of each other, perhaps suggesting the crop is only suitable as a breeding habitat during a fairly narrow window of its development. However, as the sample was small, and from only one year, further investigation is needed to verify this conclusion. Weight and tarsus measurements from the sample of sugar beet nestlings were similar to those reported by Donald (2004).

The small sample size from this study means that measures of breeding performance will be imprecise. There was no indication that unplanted patches in sugar beet lead to more nestling being raised than in the Control. This is contrary to SAFFIE, where a combination of a longer nesting season, larger clutches and greater post-May nest survival rates resulted in significantly more nestlings per breeding attempt in the Plot treatments (Morris *et al.*, 2004). Productivity per nesting attempt in sugar beet did appear to be slightly higher (0.2 chick/nest) than for a contemporaneous set of wheat nests, with the main difference relating to the greater amount of partial brood loss due to starvation in wheat. However, one entire brood (in a plot treatment) in sugar beet also starved (compared to no entire brood starvation in wheat) and further research will be needed to determine whether productivity figures really do vary significantly between the two crops. The only other nest failure in beet was due to predation of nestlings (witnessed by the Research Assistant) by a marsh harrier *Circus aeruginosus*.

Conclusion

This study found that:

1. At the micro scale, unplanted plots in sugar beet increased plant food abundance for birds.
2. At the micro scale, plots also increased accessibility for foraging birds, as their swards were shorter and sparser.
3. The relatively small area occupied by the plots and the weediness of the crop meant that vegetation structure and seed abundance did not differ between the Control treatments and the Plot treatments as a whole.
4. Probably as a result of point 3 above, the numbers of birds (including a suite of granivorous passerine species, many of which are red or amber-listed) did not vary significantly between the two treatments.
5. Despite overall significant selection in relation to their availability, few birds, other than linnets, were recorded foraging within the plots.
6. There were moderate numbers of birds foraging in the crop during the autumn months, although numbers of granivorous passerines were relatively low given the ready availability of seed.
7. Estimates of skylark territory density agree well with those previously published for root crops and match those in winter cereals. They are greater than those for agricultural grassland and several other arable crops, but less than those for set-aside, spring cereals and many semi-natural habitats.
8. There was no evidence of differences in skylark territory density between the two treatments.
9. Small sample sizes meant that it was not possible to make precise comparisons of nesting success and productivity between the two sugar beet treatments or between sugar beet and wheat. There was no indication that success or productivity varied with treatment. It is possible that productivity per nesting attempt in sugar beet is greater than in wheat crops. This may be worthy of further investigation.

The vegetation structure and food resource results agreed with those from the SAFFIE project. However, contrary to the results from SAFFIE, this research found no measurable benefit to birds (either nesting skylarks for foraging post-breeding season) from the provision of unplanted plots in sugar beet. This may be due to the differences in structure, development and weediness of the two crops, which, in the case of sugar beet, results in less of a difference in food availability between the crop and unplanted plots.

This study also provided an opportunity to review and extend our knowledge of bird use of sugar beet crops as a whole during the summer and autumn months.

Although previous research shows that sugar beet stubbles may provide valuable winter foraging resources for species such as pink-footed goose *Anser brachyrhynchus* and skylark (Gill, *et al*., 1996; Donald *et al.*, 2001a), there was little indication from this study that numbers of birds feeding in the crop were particularly high during summer or autumn. Given the amount of seed available, it is a little surprising that numbers of granivorous passerines were low. Although the sample size was small, more than half the foraging observations of adult skylarks provisioning nestlings were of flights to habitats outside of sugar beet, including several to other arable crops.

Prepared seedbeds and germinating sugar beet crops may also be a valuable habitat for renesting lapwings and stone curlews. This study suggests beet probably also provides an adequate, but not an exceptionally good quality, breeding habitat for skylarks, with territory densities akin to those found in conventionally managed winter wheat. In arable areas where crop rotations are based on winter sowing, sugar beet may provide a renesting opportunity for skylarks forced out of the winter-sown crops by the development of tall, dense swards. However, this study suggests the window for renesting in beet crops may be narrow and no second nesting attempts in beet were reported. This study found some indication that skylark nest productivity was slightly higher than for a contemporaneous sample of nests in winter wheat. However, as sample sizes were small and confined to one year, this result will need to be verified by further studies.

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Appendix 1. Plants recorded during quadrat surveys by site & year.

Rougham Estate, Rougham, Suffolk 2003

1. Black Bindweed
2. Fat Hen
3. Groundsel
4. Knotgrass
5. Perennial Sow Thistle
6. White Campion
7. Wild Cabbage

Colveston Manor, Mundford, Thetford, Norfolk 2003

1. Black Bindweed
2. Bugloss
3. Cleavers
4. Common Sorrel
5. Creeping Thistle
6. Fat Hen
7. Field Pansy
8. Groundsel
9. Hoary Plantain
10. Knotgrass
11. Nettle
12. Perennial Sow Thistle
13. Potato
14. Redshank
15. Slender Speedwell
16. Spring Rape
17. Wild Mignonette
18. Poppy
19. Fool's Parsley
20. Scarlet Pimpernel
21. Common Mallow
22. White Campion

Newton Farms, Newton, Cambridge 2003

1. Black Bindweed
2. Creeping Thistle
3. Fat Hen
4. Field Pansy
5. Fool's Parsley
6. Groundsel
7. Knotgrass
8. Petty Spurge
9. Redshank
10. Rye Grass
11. Scarlet Pimpernel
12. Slender Speedwell
13. White Campion
14. Wild Mignonette

Thorn Hall Farms, Wicken, Ely, Cambridge 2003

1. **Field Pansy**
2. **Fool's Parsley**
3. **Redshank**
4. **Slender Speedwell**
5. **Wild Mignonette**
6. **Knotgrass**
7. **Fat Hen**
8. **Poppy**
9. **Scarlet Pimpernell**
10. **Potato**

Rowley Farm, Hilborough, Thetford, Norfolk 2003

1. **Wild Mignonette**
2. **Black Bindweed**
3. **Bugloss**
4. **Cranesbill spp**
5. **Field Pansy**
6. **Flixweed**
7. **Fool's Parsley**
8. **Groundsel**
9. **Perennial Sow Thistle**
10. **Redshank**
11. **Scentless Mayweed**
12. **Slender Speedwell**
13. **Treacle Mustard**
14. **White Campion**

Exning Estate, Exning, Newmarket, Suffolk 2003

1. Black Bindweed
2. Cleavers
3. Fat Hen
4. Field Pansy
5. Groundsel
6. Knotgrass
7. Perennial Sow Thistle
8. Redshank
9. Slender Speedwell
10. White Campion

Bartlow Estate, Bartlow, Cambridge 2003

1. Fat Hen
2. Black Bindweed
3. Slender Speedwell
4. Fool's Parsley
5. Maple-leaved Goose Foot
6. Creeping Thistle
7. Redshank
8. Field Pansy
9. Knotgrass
10. Groundsel
11. Wild Mignonette

College Farm, Duxford, Cambridge 2003

1. Black Bindweed
2. Cleavers
3. Creeping Thistle
4. Fat Hen
5. Field Pansy
6. Groundsel
7. Perennial Sow Thistle
8. Petty Spurge
9. Scarlet Pimpernel
10. Scentless Mayweed
11. Slender Speedwell
12. Treacle Mustard
13. Wheat
14. White Mustard
15. Wild Cabbage

Pond Farm, Carleton St Peter, Norfolk 2004

1. Field Pansy
2. Fat Hen
3. Black Bindweed
4. Speedwell spp
5. Scarlet Pimpernel
6. Knotgrass
7. Potato
8. Thistle
9. Cabbage Thistle
10. Groundsel

W Martin Littleport Ltd., Littleport, Cambridgeshire 2004

1. Speedwell spp
2. Common Chickweed
3. Fat Hen
4. Dandelion
5. Redshank
6. Thistle spp
7. Pale Persicaria
8. Water Forget Me Not
9. Black Bindweed
10. Shepherds Purse
11. Red Dead Nettle
12. Potato
13. Field Pansy
14. Stinging Nettle
15. Marsh Mallow
16. Groundsel
17. Dead Nettle
18. Cleavers
19. White Dead Nettle
20. Wall Speedwell

College Farm, Duxford, Cambridgeshire 2004

1. Potato
2. Field Pansy
3. Speedwell
4. Wild Cabbage
5. Lesser Chickweed
6. Groundsel
7. Fat Hen

Teversham Hall, Teversham, Cambridge 2004

1. Fat Hen.
2. Orache (Common And Frosted)
3. Field Pansy
4. Thistles
5. Black Bindweed
6. Scarlet Pimpernel
7. Cleavers
8. Wild Cabbage
9. Speedwell
10. Redshank
11. Fools Parsley
12. Dandelion
13. Black Nightshade

Bartlow Estate, Bartlow, Cambridge 2004

1. Black Bindweed.
2. Fat Hen
3. Fools Parsley
4. Field Pansy
5. Rough Chervil
6. Speedwell
7. Orache
8. Scentless Mayweed
9. Wild Mignonette
10. Thistle spp
11. Hawkweed
12. Groundsel
13. Dandelion
14. Cleavers
15. Chickweed
16. Bugloss

Rowley Farm, Hilborough, Norfolk 2004

1. Black Bindweed
2. Field Pansy
3. Speedwell
4. Nettles
5. Wild Mignonette
6. White Campion
7. Groundsel
8. Cleavers
9. Thistle spp
10. Scarlet Pimpernel
11. Knotgrass
12. Shepherds Purse
13. Hedge Mustard
14. Trefoil
15. Herb Robert
16. Hedge Cranes Bill
17. Fat Hen
18. Dandelion
19. Common Toadflax
20. Chickweed

Rougham Estates, Rougham, Suffolk 2004

1. Field Pansy
2. Speedwell spp
3. Common Chickweed
4. Black Bindweed
5. Fat Hen
6. Groundsel
7. Dandelion
8. Thistle

Croxton Hall Farm, Croxton, Norfolk 2004

1. Black Bindweed
2. Field Pansy
3. Wild Mignonette
4. Nettles
5. Fat Hen
6. Rough Chervil
7. Knotgrass
8. Thistle spp
9. Groundsel
10. Shepherds Purse
11. Sugar Beet
12. Dandelion
13. Common Field Speedwell
14. Black Nightshade
15. Horseradish
16. Charlock

Brettenham Manor, Thetford, Norfolk 2004

1. Field Pansy
2. Speedwell spp
3. Fat Hen
4. Wild Mignonette
5. Nettles
6. Groundsel
7. Black Bindweed
8. Knotgrass
9. Fool's Parsley
10. Flixweed
11. Spear Thistle
12. Redshank
13. Pale Persicaria
14. Black Nightshade
15. Potato
16. Fat Hen
17. Dove's Foot Cranesbill
18. Common Fumitory
19. Cleavers

H Thompson Farms Ltd, Littleport, Cambridgeshire 2004

1. Speedwell spp
2. Field Pansy
3. Fat Hen
4. Bistort
5. Pale Persicaria
6. Redshank
7. Stinging Nettle
8. Black Bindweed
9. Cleavers
10. Chickweed
11. Sugar Beet
12. Fools Parsley
13. Woundwort
14. Rough Chervil
15. Goosefoot
16. Black Horehound

Newton Farms, Newton, Cambridge 2004

1. Speedwell spp
2. Knotgrass
3. Field Pansy
4. Black Bindweed
5. Thistle spp
6. Cleavers
7. Potato
8. Dandelion
9. Scarlet Pimpernel
10. Redshank
11. Petty Spurge
12. Groundsel
13. Wild Cabbage
14. Ragwort
15. Pineapple Weed
16. Common Orache
17. Chickweed

South Lopham Hall, South Lopham, Norfolk 2004

1. Black Bindweed
2. Scentless Mayweed
3. Cleavers
4. Speedwell (Common Field And Slender)
5. Dandelion
6. Fat Hen
7. Spear Thistle
8. Knotgrass
9. Black Nightshade
10. Dead Nettle
11. Field Pansy
12. Groundsel
13. Redshank
14. Chervil
15. Common Orache
16. Fools Parsley
17. Potato
18. Scarlet Pimpernel
19. Cabbage Family
20. Cabbage Thistle
21. Cranesbill spp
22. Pale Persicaria
23. Pineapple Weed

Appendix 2. Bird species recorded feeding in the plots during transect walks 2003-2004.

Species
blackbird
corn bunting
dunnock
golden plover
goldfinch
greenfinch
house sparrow
kestrel
linnet
meadow pipit
pheasant
pied wagtail
red-legged partridge
reed warbler
sedge warbler
skylark
snipe
sparrowhawk
swallow
whinchat
whitethroat
woodpigeon
wren
yellow wagtail
yellowhammer