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The Use of Pea Crops by Farmland Birds; Evidence for an Extended Breeding and Enhanced Feeding Opportunities in Crop Mosaics

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Executive Summary

1. A comparison of the usage by bird species of vining peas (as a spring sown crop) compared to neighbouring crops of winter cereals or oilseed rape, or for Lapwings compared to sugar beet and spring cereals.

2. Bird densities on crops were calculated from birds recorded by volunteer ornithologists on surveyed pairs of fields (one pea field and one cereal/rape field per pair), with each field-pair located on a different farm. On six visits to a farm plot between March and August, observers walked the perimeter of each field recording all birds seen or heard, and whether the birds were singing (indicative of territoriality) or not. Intensive studies were used to record the activities of breeding and foraging Skylarks and Lapwings, needed to ascertain the purpose and seasonal timing of their association with different crop types.

3. A higher mean density of Lapwing, Grey Partridge, Skylarks, thrushes, wagtails was recorded on pea fields compared to cereal fields or rape, but seed-eating passerines were most abundant in rapes. In general, the densities recorded on crops were low compared to non-cropped habitats such as set-aside. From intensive observations and time budgets, Skylarks breeding on peas peaked through appeared to continue into June and possibly July, thereby potentially raising more offspring than on cereals.

4. On farms with breeding Lapwings, 88% of pea fields supported at least one pair, compared to 36.4% of sugar beet fields, 5.6% of winter cereals. Peas, then sugar beet, had highest breeding densities of Lapwings, spring and winter cereals were one to two orders of magnitude lower. The timing of crop cultivation explained the different use of crops by Lapwings. In eastern England, peas appear to be particularly suitable for incubating birds that rarely settled in vegetation over 5cm tall. Also, where four weeks or more was available between management activities (e.g. cultivation, rolling, drilling) in April and May, then clutch losses were low and most broods hatched. For Lapwings, not all spring crops were equally successful in attracting breeding pairs, thus peas or sugar beet were a significant improvement on spring cereals. Also, since chicks tended to be escorted off their natal crops, onto nearby fallow areas to forage, adjacent non-cropped habitats may be an important part of successful rotations for this species.

5. Overall, the mosaic created by pea crops, in mixed rotations may help to create foraging and breeding opportunities for birds in summer.

6. Future work will investigate the progress of Lapwing chicks in pea crops and their potential to survival to independence during the pea growing season.

1. INTRODUCTION

For birds using arable farmland one of the most important changes in the pattern of land-use in Britain in the last 30 years, has been a general loss of spring-sown crops with winter-sown cereals. This has gone hand-in-hand with an increased reliance on chemical pest and weed control, allowing for simplified crop rotations and a progression towards cereal monocultures. Simplified cropping patterns have led to a loss of structural variety in the landscape so that crop development severely reduces the opportunities for birds to nest and forage. This is especially likely in winter cereal dominated landscapes where crops in the UK at least, generally, grow too tall and dense to allow suitable access for birds such as Skylarks *Alauda arvensis* (in contrast to their performance sparser vegetation) and Lapwings *Vanellus vanellus*, that nest on patchy or bare ground and use unimproved fallows or grassland for chicks. Neither of these generally provided by winter cereals.

At present in the UK, so called "agri-environment" schemes are having an increasing role in restoration of habitats for birds and other wildlife. Typically these focus on spatially marginal habitats such as field boundaries. There are whole-field options available as spring crops or fallows (Countryside Stewardship Scheme (CSS)) but their likely rate of uptake amongst farmers is unknown. Many would therefore argue that commercially viable crops must make a contribution if measurable increases in the wildlife value of arable land is to be achieved on a national scale. This is especially likely to be the case for open nesting bird species. A complimentary approach to agri-environment schemes would be to attempt to maximise the potential of particular commercial crops to support specific species or communities of birds within any national or regional context. Greater diversification of crop rotations can sometimes help in crop management, for example to control pernicious weeds, such as blackgrass. A significant potential benefit would be the convergence of agronomic and environmental viability ('sustainability'), perhaps the 'Holy Grail' of British agriculture.

Break crops such as legumes or oilseed rape are a legitimate source of heterogeneity within a rotation, typically used to break the sequential use of fields by the same crop type between years. They can help reduce accumulations of weeds or disease resistance and can prevent losses of soil fertility. Theoretically, they could present birds with a greater variety of breeding and foraging opportunities due to differences in cultivation, management, crop structure and development. The need to understand the association between crops and the bird communities that they support is important as is an understanding of the flexibility in management of particular crops, so that informed decisions can be made on how best to manage crop rotations and farmland wildlife.

The focus of this study is on vining peas since the initial concept was to determine the potential biodiversity value of peas within the context of a typical arable rotation. Several studies have indicated that spring crops in general may allow Skylarks opportunities to breed for longer over the summer period than winter cereals would allow (Wilson *et al.* 1997, Chamberlain *et al.* 1999). In England, vining peas are typically drilled over a protracted period from mid March to early June (thus, mainly April and May). Cultivation and drilling is between March and late May, and harvest, between June and early August. As a fully commercial spring crop vining peas contrast with winter crops, in providing bare ground in spring. The crop is also relatively low growing and produces flowers in mid-summer (June/July). But we compare the bird community associated with peas to major and representative winter sown crop types, especially winter cereals but also oilseed rape. For Lapwings, the focus of the study alters towards comparing peas to sugar beet since this crop is also a widely grown crop that is drilled typically earlier than peas, in March and early April (M. May pers. comm.) but provides structural contrast to winter crops.

This study provides a general comparison of bird composition on crops followed by a more detailed analyses of two open-nesting species, Lapwing and Skylark.

2. METHODS

2.1 Comparing Bird Densities Between Crops and Treatments – All Species

The relative densities of bird species using peas, was assessed from 56 pea crops (each a different field) from a total of 21 farms over four years (1999-2002), although with a variable number of farms involved from year to year. The selection of farms was arbitrary, relying on access being granted by the farmer. On farms, however, one pea crop (usually the largest available) was paired to an adjacent crop of winter wheat or oilseed rape, respectively the dominant crop and dominant break crops of lowland England. Since crops moved location between years, with the rotation, occasionally the study pea crop and adjacent crop switched location in consecutive years, providing a direct control over field and boundary characteristics.

Birds counted were collated from five visits to each field between March and August in each year of the study. On each visit, the perimeter of each field was walked and the precise position of all birds seen or heard on the field or boundary were recorded onto maps using standard codes and guidelines for consistency (e.g. Marchant &Gregory 1994). Singing or displaying birds were recorded separately as an indication of breeding territoriality. Birds were recorded in the first field or boundary in which they were seen. No visits were made in persistent heavy rain or in wind greater than Beaufort force four.

Bird densities were compared between field types using a repeated measures regression analyses (for the five visits) and with factors included in models for farm (site) and the year of the study. Field area was included as an offset variable. Bird counts were generally low and thus zero-inflated, so either Poisson or Binomial error terms were adopted for the analyses (with adjustments for deviations in the data from these distributions using √deviance/degrees-of- freedom. Regression models produce Likelihood ratio Chi-squared values and type 3 probabilities (i.e. with statistical controls for independent variables). Where parametric analyses were inappropriate or regression models inaccurate, non-parametic tests were used. Bird densities were calculated either on an individual species basis or by amalgamating functional groups of species; that is, aerial insectivores (Swift *Apus apus*, and Swallow and martins Hirundines), insectivorous passerines (wagtails Motacillidae, Wren *Trogolodytes trogolodytes*, Dunnock *Prunella modularis*, thrushes Turdidae and warblers Syliviidae) and seed-eating passerines (sparrows Passeridae, finches Fringillidae and buntings Emberiziidae). Grey Partridge, Lapwing and Skylark were treated separately but the latter two species were not expected to yield analysable data sets since both species tend to avoid marginal areas of crops.

2.2 Pesticide Trials

In 2001 and 2002, pesticide trials were conducted on the outer 6 m (in 2001) or 12 m (in 2002) sections of pea crops. These outer crop sections were sub-divided into alternating sprayed and non sprayed (zero application) replicates, each approximately 100 m long. In total there were 36 replicate sections from five farms (six margins) in 2001 and 28 replicates from eight margins and seven fields in 2002. All experimental replicates, however, were treated with pre-emergent herbicides (glyphosate) prior to drilling. The 'stale' seed-bed is normal practice for peas and meant all trials had a similar starting point in terms of vegetation cover.

2.3 Breeding Skylarks

On 10 field-pairs of peas and winter wheat, selected at random from the large data set above, the activity budgets of Skylarks were recorded during a series of five, one-hour observations per year, between April and August 1999, 2000 and 2001. The main aim was to quantify changes in behavioural activity during crop development and between crop types, by measuring song flight and 'other' flight activity frequency as indices of the breeding and foraging activity *per se*. We assumed that singing individuals represent territoriality and that non-singing flight frequency was a general index of activity that would includ foraging. Song flight density was recorded as the maximum number of simultaneously singing birds per one-hour, per ha. General flight frequency was analysed by calculating the total number of flights per hour per ha, with no distinction possible between the age or sex of individual birds. All flight data were analysed by repeated measures, General Linear Models regressions, with Poisson or Binomial error terms as described above. Direct observations of forging Skylarks are very difficult to acquire, but the advantage of measuring flight behaviour is that it reduces the effect of crop height on the detectability of birds.

2.4 Breeding Lapwings

In 2003, breeding Lapwings were studied as a consequence of findings from the general study above, but on a different and larger sample of farms. For Lapwings, 41 pea-growing farmers (from a potential pool of approximately 500) agreed access to look for breeding birds. Each farm received at least two visits between April and May, to locate breeding Lapwings, either on peas or the adjacent two to four fields, this group of field therefore represented the sample unit. Together the sample units mainly comprised fields containing or prepared for: peas, winter cereals, oilseed rape, sugar beet and set-aside (fallow). On sites where Lapwing territories were found, based on the presence of incubating or displaying birds, a series of repeated two-hour observation periods, every seven to 11 days, was initiated to cover the period to hatching. During each two-hour observation a continuous record was kept of the birds' activities, with special interest in: 1) the onset of incubation, 2) territorial activities, and, 3) the choice of foraging location between neighbouring fields. For the majority of nests, either the incubation start date or chick hatching date was known at least to within less than a week. If not, one was estimated from the other, depending on which one was the most accurately recorded, assuming a four-week period in between (BWP). The 2-hour observation period was shared between the number of observation points used on a field (usually one or two). These data provided information on nesting and foraging occupancy rates for habitat types, and recorded nesting progress in relation to crop conditions.

3. RESULTS

3.1 Crop Use by Birds

When all species were combined across all growing months (April to August), median densities of birds were higher on peas than winter cereals for 19 of 20 farms in 1999 (Wilcoxon Signed ranks: T=21, P<0.001) and for 17 of 18 farms in 2000 (Wilcoxon Signed ranks: T=19, P<0.001) (Fig. 1a). Twenty out of 21 fields that switched from peas to cereals, or visa versa, in consecutive years, held higher bird densities on peas than on cereals (Wilcoxon Signed ranks: T=21, P<0.001), and overall there were significantly higher densities on peas (t-test: 2-tailed t=4.89, n=21, P<0.001; Pea-mean=3.1, SD=1.1; cereals-mean=0.81, SD=0.3; Fig. 1b).

Compared to rape, peas supported lower combined densities of birds but the two crops supported different bird faunas (Fig. 2a). Peas held significantly higher densities of Lapwing, Grey Partridge, Woodpigeons and Yellow Wagtail and higher densities of Skylarks, though the difference was not significant for this species. Lapwings were associated with 20 of all 41pea fields and 12 of the 21 farms surveyed between 1999 and 2002, compared to only two records in winter cereals (recorded in March/April only) and none in rape (Fig. 2a). Breeding pairs of Lapwings were recorded on seven farms but the prevalence of records in July implies that most were non-breeding or post-breeding birds. Skylarks were recorded in all fields (cereals, peas and rape) but were more abundant in peas than in rape, and both crops supported significantly higher densities of Skylarks than winter cereals. Seed-eating specialists, such as finches, buntings and sparrows were significantly more abundant in rape than in peas, as were Swifts and hirundines, Blackbird and Whitethroat, but each of these species or groups was more abundant in peas than winter cereals (Fig. 2a).

Twenty-eight out of 35 species were recoded at higher mean density on peas than cereals (Wilcoxon signed ranks: T=28, P<0.01, N=28 and mean species richness (per summer) was significantly higher on peas than on winter cereals (t-test: 2-tailed t=9.45, n=21, P<0.001). There was no significant difference between peas and oilseed rape (t-test: 2-tailed: t=1.01, n=21, ns).

3.2 Intra-Seasonal Field Use

With all species combined, peas supported significantly higher mean densities of birds than winter cereals from May to August (Likelihood ratio, χ^2_3 =8.11, P<0.05). Between March and early April, combined bird densities were higher on winter cereals than peas, although the difference was not statistically significant (Likelihood ratio, χ^2_1 =1.97, P<0.11; Fig. 3a).

3.3 The Effects of Pesticide Treatments on Birds Using Peas

Fifteen out of 18 species occurred at higher median density on unsprayed margins than sprayed margins and so for seven species the opposite was true (Wilcoxon signed ranks: T=25.5, P<0.01, N=18; Fig. 4). The average difference in density across species was around 1.3 times higher on unsprayed crop margins, but for none of these individual species was the difference statistically significant (however, for Grey Partridge the probability was P=0.06). When all species were combined, there was a tendency for bird densities to be higher on unsprayed rather than sprayed crops although the relationship was not statistically significant (Repeated measures, Poisson regression: Likelihood ratio χ^2_1 =2.97, P<0.08; including controls for farm site (P<0.001) and sample year (P<0.05)).

3.4 Breeding Skylarks

From 120 hours of intensive observations from 10 pea fields over three summer seasons (using a different field in each summer), there were significant differences in the mean densities of song-flights (“territory density”) between peas and adjacent winter wheat fields (Likelihood ratio: χ^2_4 =10.11, P<0.05). For peas, territory density and thus breeding activity peaked in week 26 (late June) whereas for cereals the peak was in week18 (late April) (Fig. 4). On winter cereals, there was no significant difference between the distribution of song-flights and non song-flights (Likelihood ratio: χ^2_4 =3.97, ns). For peas, however, with song flight density peaked earlier (in June) than non song-flight activity (in July) (χ^2_4 =9.5, P=0.05).

3.5 Breeding Lapwings

3.5.1 Distribution between farms and breeding densities

Overall, 17 out of 41 farms held breeding Lapwings but in one region 16 of 26 farms held breeding pairs (61.5%) with significant differences in regional occupancy (Likelihood ratio: χ^2_1 =15.7, P<0.001). On farms with breeding Lapwings, 88% of peas crops (n=17) had at least one breeding Lapwing. This compared to 36.4% of sugar beet crops (n=11), 5.6% of winter cereal crops (n=18), one pair on one of the two spring cereal crops, no pairs on rape (n=5) and 100% of set-aside fields (n=7). There were significant differences between field types in the densities of breeding Lapwings recorded (Likelihood ratio: χ^2_4 =21.9, P<0.01). Lapwing breeding densities were highest on set-aside, but fields prepared for peas supported the highest breeding densities of Lapwings among crops (Table 1). The difference between pea and sugar beet fields, however, was not statistically significant (χ^2_1 =1.99, ns). For chicks, hatching densities were correlated with nest densities in that there were significant differences between crops in the densities of chicks hatched (Likelihood ratio: χ^2_4 =15.7, P<0.05) but there were no significant differences in the number of chicks hatched per nest between the different field types (Likelihood ratio: χ^2_4 =5.31, ns). In peas, eight clutches (21%) were known to have been lost and new clutches were re-laid. At least seven of the original clutches were lost due to the fields being cultivated or drilled. Of the re-laid clutches, six pairs (75%) succeeded in hatching 11 chicks (1.83 chicks per clutch). The outcome of one late clutch is unknown (this was laid in mid June).

3.5.2 Timing of breeding between field types

Incubation ranged from week 14 (early April) to week 22 (late May), with median week 17.3 (21 April) for peas, but week 16 (mid April) for other field types (Fig. 5a). Chicks therefore hatched between weeks 18 and 24 (early June), median week 22 (late May) on peas and 21 (mid May) on other field types (Fig. 5b). Mean vegetation heights at the commencement of incubation were 0 for peas (range 0 to 10 cm), 5 cm for sugar beet (range 0-10), 15 cm for set-aside (range 10-20 cm), 20 cm for winter cereals (range 15-33 cm) and 15 cm for spring cereals. There was a overall significant negative correlation between vegetation height at incubation and the likelihood that pairs would hatch chicks (Spearman rank, *rho*= -0.51, n=53 , P<0.05), even though the highest hatch rate occurred in set-aside (Table 1).

3.5.3 Intra-field spatial distribution of foraging birds

All of the 21 chicks that hatched in set-aside (from eight broods) were recorded within the set-aside field at least 5 m from the boundary, throughout the period of observation for this study. This is in contrast to chicks hatched in peas or sugar beet, where 82.4% of chicks that were at least 72 hours old (n=63 or 33 broods) were recorded along the outer 5 m field edge or in adjacent set-aside, whereas only 13 chicks (six broods) were recorded within the crop itself. The difference in chick distribution between set-aside and crops was significant (Chi-squared: χ^2_1 =467.1, P<0.001; in fact to generate expected values for this test, 'field edge' had to include the outer 10 m of the total field area in this test, which represented 9.82% of the whole field area (SD=3.12)). Chicks that were less than 72 hours old (n=56) were mainly recorded within the crop itself, but at least 79% of these chicks were still seen to be brooded by the parents. Based on 103 hours of observations of 35 pea or sugar beet crops and 71 foraging birds (from 46 pairs), adult Lapwings foraged exclusively on inner field areas when not escorting chicks.

3.5.4 Diet

From a total of 22 hours of diurnal observation of chicks, 98% of apparently swallowed food items were too small to identify. Earthworms were identified in only 0.95% of cases and large ground beetles also recorded in 0.95% of cases.

4. DISCUSSION

The extensive survey revealed that a greater number of species and a greater abundance of most types of species were recorded on pea fields compared to cereal fields, including insectivores and seed-eating species. The densities of these species (particularly Skylarks) were typically less than one third lower than those recorded in prime farmland habitats in previous studies, such as rotational set-aside fallows. However, compared to other neighbouring crops, peas supported a distinctive bird fauna and in this way contributed to local biodiversity. Since the majority of the individual birds recorded during surveys were flushed from crops it is unlikely that differences between crops are solely explained by differences in detectability, perhaps with the exception of gamebirds. In particular, higher bird densities in peas compared to winter cereals included aerial feeding Swifts, Swallows and martins as well as singing Skylarks and so all were recorded in flight above crop height. Quail were detected by their call.

Compared to winter cereals, both peas and oilseed rape (the major break crop in the UK) supported high densities of all bird species groups (insectivorous and seed-eating species). Oilseed rape supported the highest densities of seed-eating birds such as finches (especially Linnet) and buntings (especially Reed Bunting and Yellowhammer). Peas, however, supported higher densities of Lapwings, Skylarks and Yellow Wagtails than rape, and each of these species is currently of high conservation status in the UK. No Lapwings were found on rape due to its tall structure. On peas, Lapwings were recorded (on at least one visit) on over a half of all fields visited, and especially in the Humberside region. Peas provided a habitat for both breeding pairs and foraging individuals and groups.

On peas, across the growing season, bare soil (in March) was avoided by most species, and at this stage densities of species such as Skylarks were higher in young winter cereal crops. Greater use was made of peas in sparse or developing pea crops from April to June (the key phase) and later into July (after the harvest, in July and August densities of Skylarks in particular dropped off considerably). As a consequence, farming activities before April were unlikely to have much affected the birds using the pea fields. However, crops rolled several weeks after drilling, would clearly pose some threat to ground nesting clutches of Skylarks and possibly Lapwings during late April and May. Compared to winter cereals singing Skylarks were most abundant in June and July implying that they were continuing to attempt breeding on peas later into the summer than was possible in winter cereals. In doing so, they are more likely to raise second brood and increase reproductive output. The value of peas in increasing heterogeneity within the crop rotation is therefore to increase both the breeding densities and reproductive output of this species. When foraging, Skylarks used pea fields much less frequently and often foraged beyond the pea-field boundary into neighbouring fields of oilseed rape, set-aside, or turnips.

For other species, aerial feeding species and Yellow Wagtail, used peas when first arriving from migration. They then appeared to disperse during May (probably onto breeding areas or territories) but returned to forage in peas during June and July and especially during the pea flowering phase.

Overall, the mosaic created by pea crops, cereals and other crop types on rotational farms will help to maintain foraging and breeding opportunities for this species throughout the summer and for a longer period over the summer than would be available from winter–sown cereals alone.

4.1 Margins and Pesticide Treatments

Since thrushes, finches and buntings occurred at higher densities nearer field boundaries, they would probably benefit from field margin conservation management. This is a fairly well established feature for boundary-based birds on farmland, and one that is also recognised in other studies of farmland birds. In general, however, although these species occurred at higher density in pea crop margins than in the crop interior, absolute numbers of birds in crop margins were low and low sample sizes contributed to low power in detecting differences between sprayed and non-sprayed treatments. Nevertheless, the general trend was for higher densities of birds on unsprayed areas. This was especially true for insectivorous species (Dunnock, thrush species and Yellow Wagtail) as well as Grey Partridge but was less apparent for finches and buntings. Skylarks and Lapwings tend only to use marginal strips of crops where they occur on open boundaries between fields.

4.2 Breeding Lapwings

On farms with breeding Lapwings, 88% of pea fields supported at least one pair, compared to 36.4% of sugar beet fields, 5.6% of winter cereals. Peas, then sugar beet, had highest breeding densities of Lapwings, spring and winter cereals were one to two orders of magnitude lower. The timing of crop cultivation explained the different use of crops by Lapwings. In eastern England, peas appear to be particularly suitable for incubating birds that rarely settled in vegetation over 5 cm tall ($P<0.01$). Also, where four weeks or more was available between management activities (e.g. cultivation, rolling, drilling), in April and May, then clutch losses were low and most broods hatched. The study indicates that while mixed rotations will generally provide breeding and feeding options for farmland birds, attention to particular crop combinations will optimise these benefits. For Lapwings, not all spring crops were equally successful in attracting breeding pairs, thus peas or sugar beet were a significant improvement on spring cereals. Also, since chicks tended to be escorted off their natal crops, onto nearby fallow areas to forage, adjacent non cropped habitats may be an important part of successful rotations for this species.

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Crop	Adults				Chick productivity		
	Total area (ha)	No. pairs incubating	Breeding density (pairs per ha)	Minimum % pair failure rate*	Minimum chicks hatched	Minimum chicks per nesting attempt	Minimum chicks per ha
Set-aside	45	9	0.21	11.1	21	2.33	0.470
Peas	262	37	0.14	18.9	79	2.14	0.302
Sugar beet	90	9	0.10	22.2	19	2.11	0.211
Spring cereals	36	1	0.03	0	2	2	0.056
Winter cereals	291	2	0.007	50.0	1	0.5	0.003
Oilseed rape	92	0	0		0	0	0

*NB this value assumes that pairs were only unsuccessful if both the initial and re-laid clutches failed.

Table 1 Breeding densities and breeding productivity of Lapwings in arable habitats.

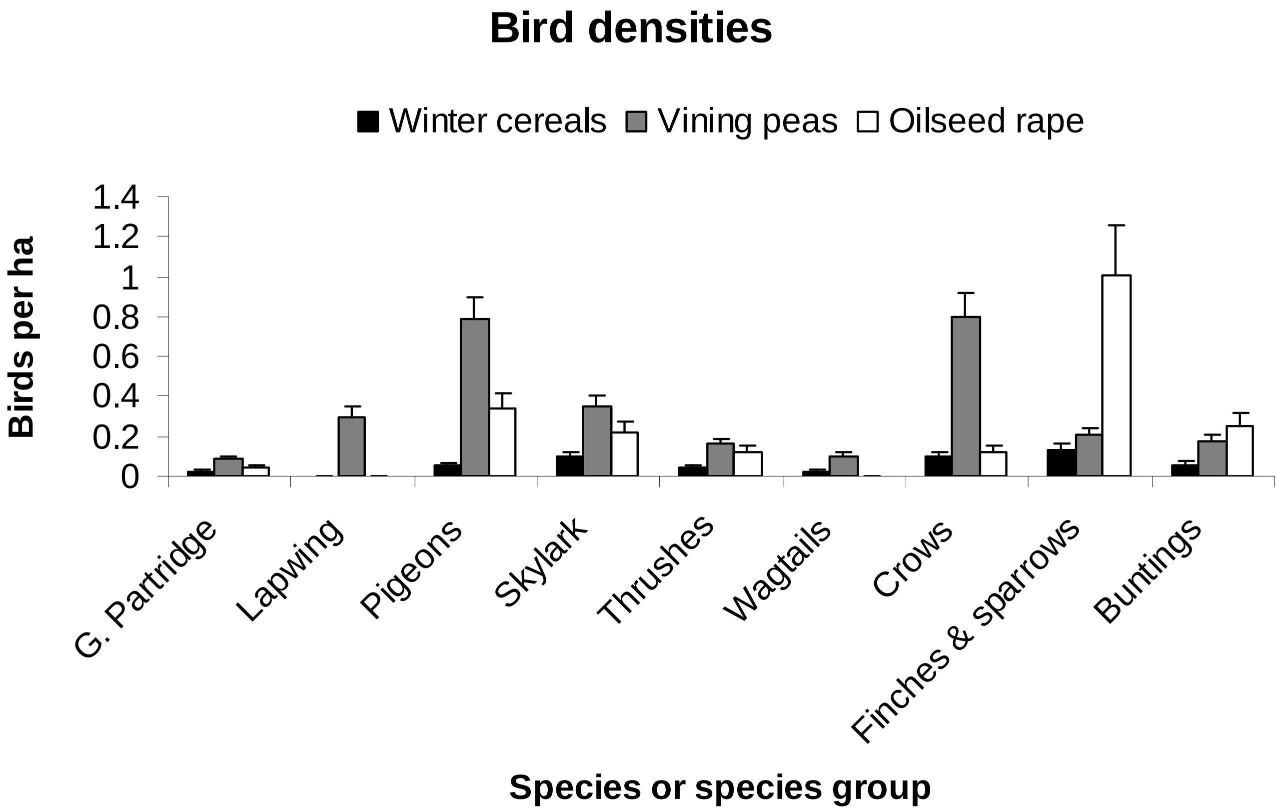


Figure 1. Comparative densities of birds on peas, winter cereals and oilseed rape (all plots combined).

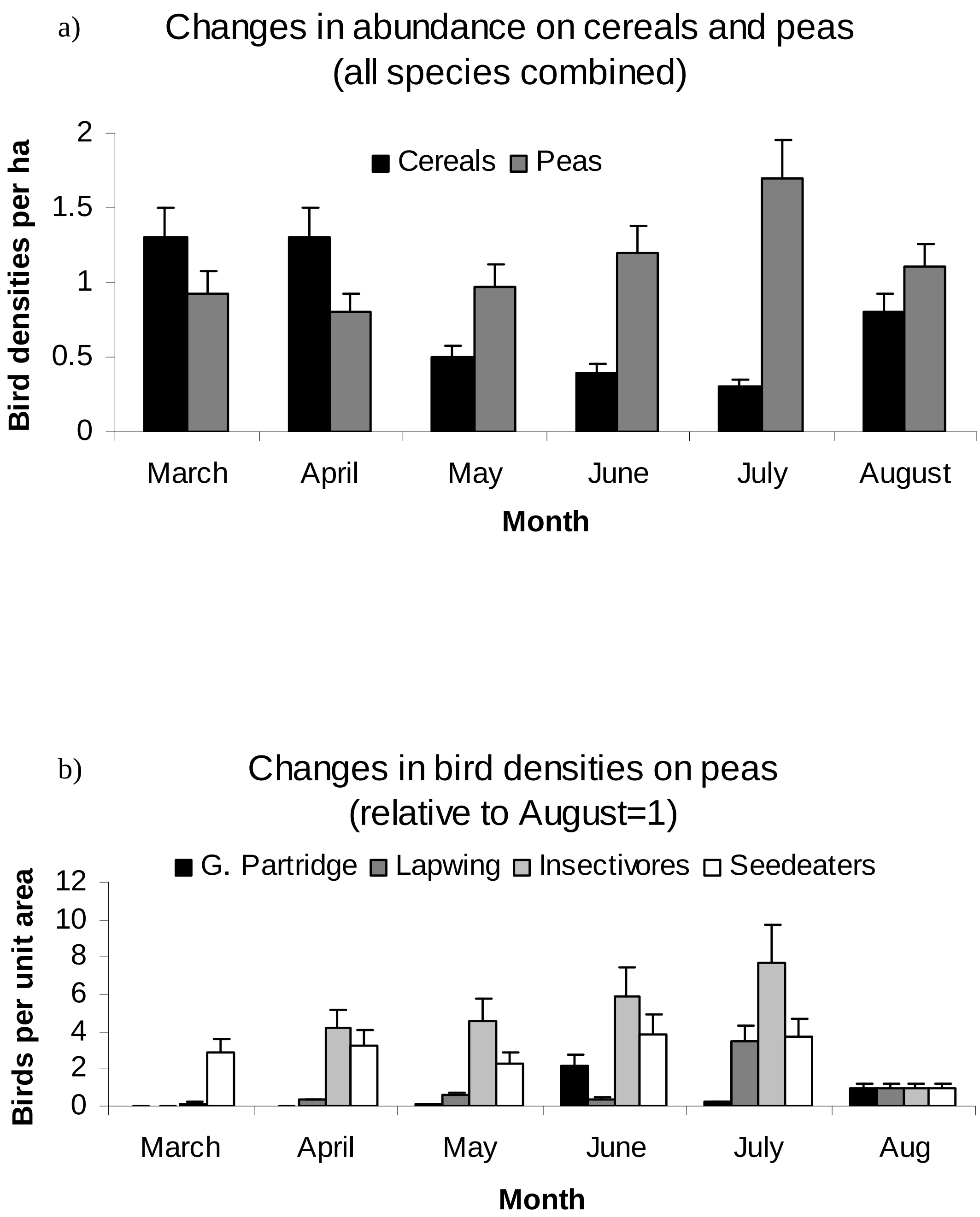


Figure 2. (a) Change in the densities (+/-95 cl) of birds on cereals and peas during the growing period of peas. In (b), relative densities of birds using peas, for two species and two functional groups relative their densities in August (where density =1).

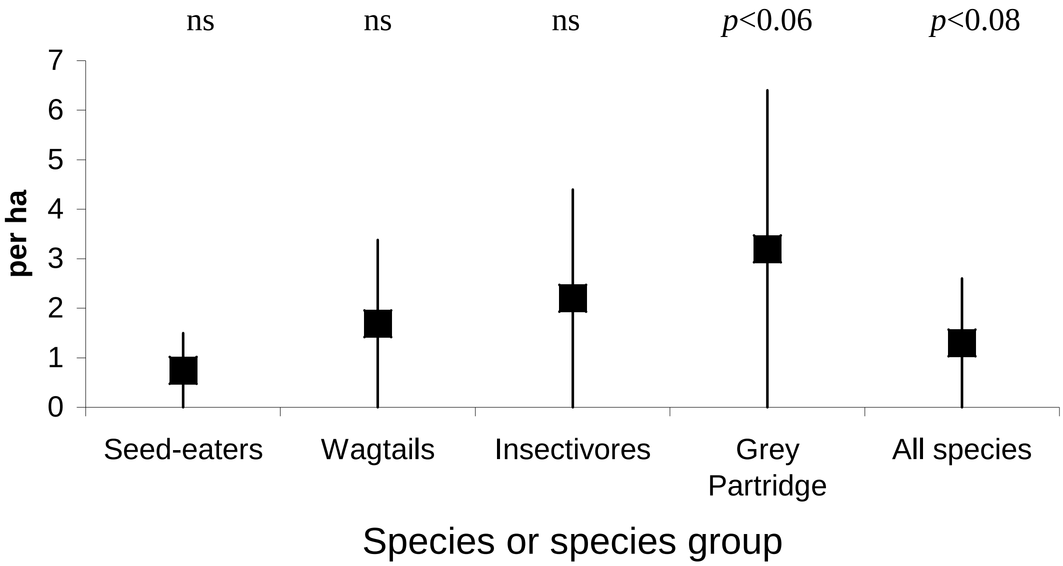
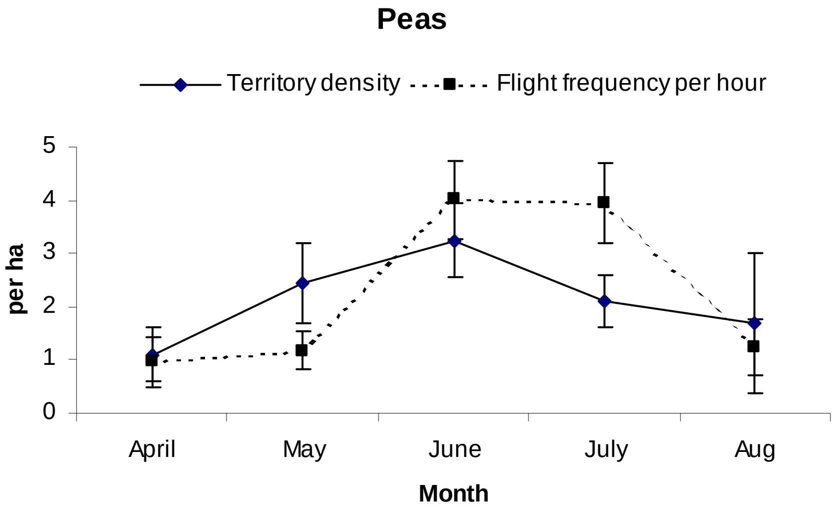


Figure 3. Crop treatments: Relative mean densities (and 95% confidence limits) of Grey Partridge and four species groups on non-sprayed margins relative to sprayed crop margins on peas. Zero is the null expected value.



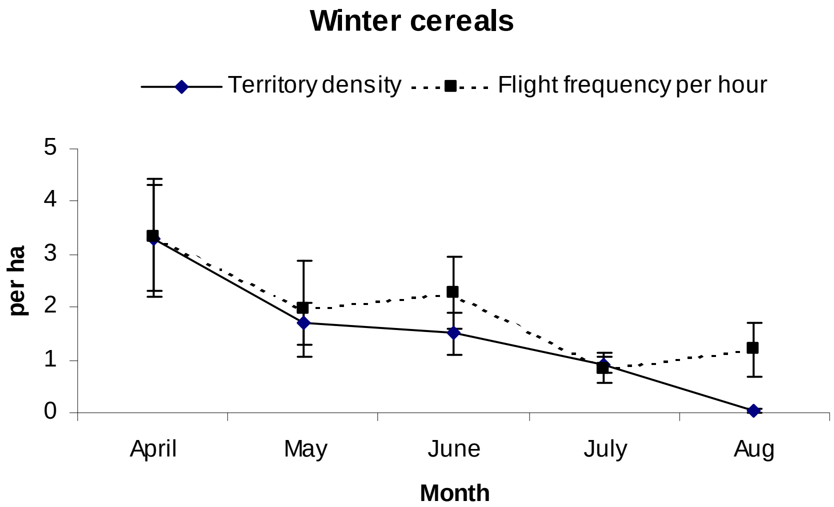
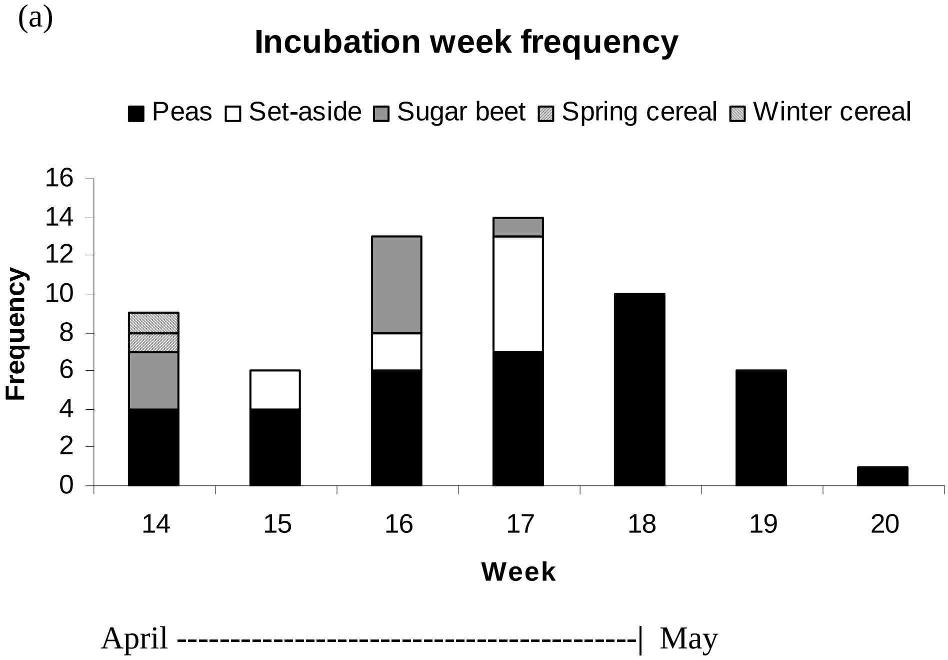


Figure 4. Change in the densities (+/-95% cl.) of Skylarks territories (song flight density) and generally flight activities (based on non song-flight activities) for (a) peas and (b) winter cereals during the main pea growing period – April to August.

(a)



(b)

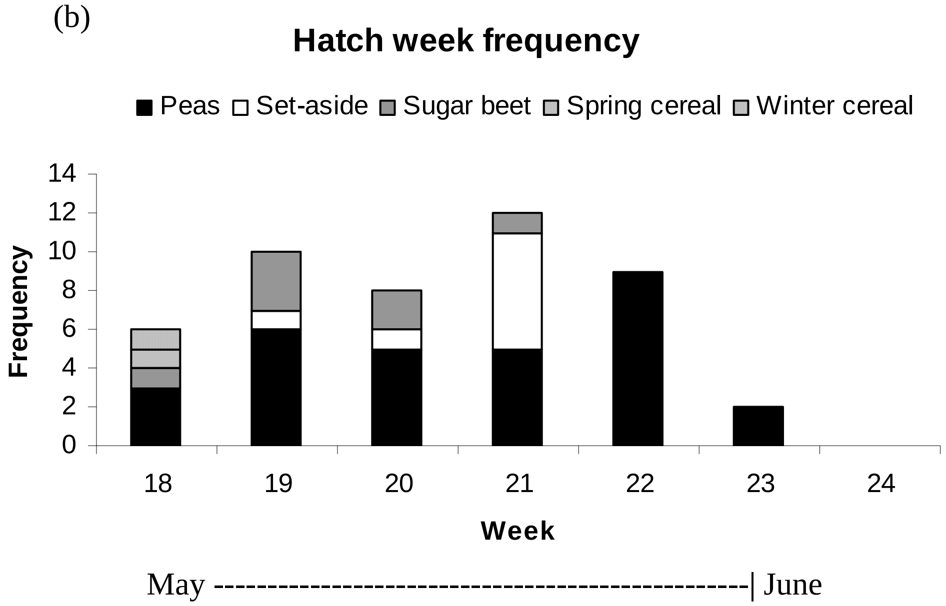


Figure 5. Related frequency distributions of the timing of (a) the onset of incubation and (b) the hatching of Lapwing broods, over the summer period April to June.