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The Relative Abundance of Birds on Farmland in Relation to Game-Cover and Winter Bird Crops

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1. EXECUTIVE SUMMARY

1. This report describes an analysis of the densities of gamebirds and indigenous bird species recorded on "winter bird crops" (i.e. game-cover crops and wildbird mixes within the set-aside scheme and Arable Stewardship Pilot Scheme) over three winters between October 1998 and March 2001.

2. The survey comprised a total of 192 selected from English arable and mixed farming regions. On each farm, volunteers were allocated a survey plot comprising one winter bird crop (usually a strip or margin) and between two and four neighbouring conventional "crops" (including grassland). Volunteers counted the birds on their plot six times between October and March in each winter, by walking around and through (where possible) the winter bird crop and nearby fields.

3. Bird densities on winter bird crops were generally higher than on conventional crops, except for Grey Partridge, Skylark, Rook and Reed Bunting. Among winter bird crops, kale, quinoa, turnips and seeding cereals were most consistent in supporting high densities of birds, including Biodiversity Action Plan (BAP) species such as Grey Partridge, Skylark, Song Thrush, Tree Sparrow, Bullfinch, Linnet and Corn Bunting. Brassicas such as turnips, rape or mustard were also predominant crop supporting higher densities of species than sunflowers, buckwheat or phacelia for example.

4. In late winter (February/March) there was greater contrast between crops in their support of birds, but kale, cereal stubbles and maize were the main crops still supporting birds. Sunflowers were largely depleted by December.

5. Densities of birds on Arable Stewardship plots were generally lower than on conventional wildbird crops. Arable Stewardship plots tended to comprise a higher proportion of buckwheat, sunflowers and grasses and a lower proportion of kale, maize, linseed, quinoa, cereals and turnips than conventional wildbird crops.

6. Preliminary recommendations indicate that, for most species, winter bird crops are preferred to conventional crops. In particular, relatively simple crop mixes that include seeding cereals, brassicas (kale, rape, turnips and mustard), quinoa or linseed would be most effective for attracting the widest range of bird species to arable farmland. Higher densities of Grey Partridges, Tree Sparrows and Reed Buntings tended to be associated with weedy winter bird crops. Notably, as well as seed-eating species, both kale and quinoa attracted high densities of insectivorous species such as thrushes and Dunnock.

2. INTRODUCTION

There is increasing evidence that for many farmland birds, post-breeding mortality is significant in driving population declines (for Song Thrushes: Thomson *et al*. 1997; for Reed Buntings: Siriwardena *et al.* 1998 and for Cirl Buntings *Emberiza cirlus*: Evans & Smith 1994). For seed-eating passerines, measures to increase food availability in winter is now recommended in many agri-environment initiatives, such as field-stubble prescriptions within the Arable Stewardship schemes as weedy cereal stubbles is strongly advised for the future recovery of some of these species in arable areas (Evans & Smith 1994; Aebischer 1997; Evans 1997; Buckingham *et al*. 1999; Robinson & Sutherland 1999). In Britain, regional success has been achieved for the Cirl Bunting, for which farmers have retained winter cereal stubbles with a high weed-seed content, on which this species depends ((Peach *et al.* 2001). At a national level, there has been less success where a large increase in the year-round availability of fallow land, as set-aside for example, has not been reflected in trend reversals among populations of declining farmland birds (Vickery & Buckingham 2001).

It is a key goal of conservation on farmland to succeed in integrating habitats into the countryside that are of sufficient quality and quantity to influence a significant proportion of the population of widespread bird species (Donald & Vickery 2001; Vickery & Buckingham 2001). One option for increasing the uptake, by farmers, of habitats providing food at high density is to manage strips or field margins appropriately. In favourable conditions, many bird species, including several of high conservation status, such as Grey Partridge *Perdix perdix*, Song Thrush *Turdus philomelos*, Tree Sparrow *Passer montanus*, and Linnet *Carduelis cannabina*, will forage along field edges at densities exceeding those in open field areas (e.g. Henderson *et al*. 2000). Many farmers and landowners in the UK already grow "wild bird crops" designed to provide winter food and cover for gamebirds (Ring-necked Pheasants *Phasianus colchicus*), Grey Partridge and Red-legged Partridge *Alectoris rufa*). These crops are versatile, though often grown along field edges and their variable content of maize, millet, cereals, kale, mustard, and other exotic seed producing plants, may be adapted to attract indigenous seed-eating passerines as well as gamebirds, for which they are traditionally grown. Some winter bird crops are eligible within the set-aside scheme (as "wildbird" mixtures), a condition for which participating farmers receive arable area payments (Henderson & Evans 2000).

Recent evidence that links changing bird populations or bird survival rates on farmland with the availability of food in winter, has promoted a developing interest in the provision of food to birds, not least in the form of specialist winter bird crops.

To do this, we compared the densities of a bird species found on a variety of winter bird crops across England, with densities on conventional crops. The analysis also compares the use of Arable Stewardship margins to conventional winter bird crops.

3. METHODS

3.1 Study Sites, Bird and Habitat Recording

The field survey gathered data over three winters 1998/1999, 1999/2000 and 2000/2001, from farms selected arbitrarily from arable and mixed farming regions across England. On each farm an observer was allocated a plot comprising one pre-selected winter bird crop and up to four nearby conventional fields. To sample birds, in each month, from October to March, the observer walked around the perimeter of the winter bird crop and once through the crop where this was possible. The observer then walked the perimeter of each conventional field before crossing the middle of that field once. The location of all birds seen or heard on fields or boundaries was recorded along with: (i) field content, (ii) an estimate of crop height (cm), (iii) whether the crop was weedy (i.e., non-crop plants occupied at least 50% of the intra-crop spaces) or weed free, (iv) the proportion of each field boundary that comprised a hedge/wood edge and an estimate of its average height, and (v) a count of mature trees (> 5m height) in each boundary. Individual birds were recorded in the first field or boundary that they were sighted. Visits were made throughout the day but not in heavy rain or in wind greater than force four.

3.2 Analysis

To compare the habitat preferences of gamebirds ("Pheasant" i.e., (Ring-necked Pheasant), Red-legged Partridge *Alectoris rufa* and native Grey Partridge *Perdix perdix*), native seed-eating passerines (i.e., Alaudidae, Passeridae, Fringillidae, Emberizidae) and native insectivores passerines (e.g., Dunnocks *Prunella modularis*, and thrushes (Turdidae)), crops were categorised in the following way:

(a) Conventional crops were: (i) *Bare soil*; (ii) *Cereal stubbles*; (iii) *Grassland*: improved, permanent, grazed or ungrazed; (iv) *Non-cereals:* potatoes, carrots and legumes; (v) *Sugar Beet*; and (vi) *Winter cereals*: wheat, barley or oats.

(b) Winter bird crops: (1) *Buckwheat*: seed-producing annual, usually mixed with other cover crops; (2) *Canary grass (Phalarius* species*)*: tall perennial grasses grown as cover for Pheasants; (3) *Cereals*: wheat, barley, oats or triticale that drop seed over winter, providing food and cover for birds; (4) *Kale*: a hardy biennial crop often used as a cover for gamebirds throughout the winter but producing a seed head and food during the second winter; (5) *Linseed*: grown separately as a commercial crop for seed or mixed with cover crops for winter birds; (6) *Maize*: used mainly as a cover crop but produces a seed "cob" generally mixed with millet; (7) *Millet*: provides gamebird cover (hardy red "Tanka" variety) or seed (white millet); (8) *Mustard*; and related "Texsel Greens" are grown mainly for early winter gamebird cover in southern latitudes; (9) *Phacelia*: an annual or biennial seed-producing cover; (10) *Quinoa:* an exotic, hardy, tall annual providing a prolonged seed-drop for birds; (11) *Rape*: forage rape provides hardy, brassica cover in winter and is often mixed with linseed for seed for gamebirds; (12) *Sorghum*: tall maize-like plant without a seed cob, used as gamebird cover; (13) *Sunflowers*: grown as an annual seed crop but providing relatively little cover; (14) *Teasels:* added to cover mixes as a source of food for seed-eating passerines; (15) *Turnips*: stubble turnips provide brassica cover for winter birds.

In mixed winter bird crops (e.g., kale, maize and sunflowers) the true association of birds with individual component crops was not known, therefore the total number of birds of a species recorded on the whole crop was divided by the number of component crops. This allowed these data to be used without pseudo-replication of the total bird count for that crop. However, this method also assumed that the area covered by each component crop was equal, and that birds were evenly distributed throughout the mix. It therefore placed equal weight upon each of the component crops within a mix and was thus conservative in detecting differential preferences for crops by birds.

The relationship between bird abundance and crop type was analysed by Generalised Linear Modelling with a log-link function and Poisson error term. The models were fitted to the bird count data from each individual field on each farm site for each of the six visits. Sometimes, where models failed to converge, the mean count across visits was used to reduce the proportion of zeros in the dataset (means raised to the nearest integer for GLM analysis). Independent variables included sample year, plot, visit, crop height, field area, weed content, hedgerow length and height. Since not all variables contributed to every model, the permutation that produced the best model fit was selected in each case. Type 3 likelihood-ratio (LR) probabilities tested for the effect of each independent variable in turn, while controlling for others in the equation. An over dispersion factor (√scaled deviance/degrees of freedom) was used to adjust model parameters and probabilities. The differences in bird densities among crop types were calculated relative to the commonest crop on farmland, winter cereals, for which true densities were also calculated. This procedure was used to assess the use of crops by birds of: (1) the presence/absence of weeds, (2) the crops designation as set-aside or not, and (3) the crops designation as an Arable Stewardship prescription or not. The component content of Arable Stewardship crops was compared to conventional winter bird crops using a test for Goodness-of-fit (Siegel & Castellan 1986).

4. RESULTS

Across all three years, data were collected from 192 farm plots from 161 individual farms across England with 122, 130 and 82 farm plots surveyed in winters 1, 2 and 3 respectively. Their distribution is shown in Figure 4.1.

4.1 Species Densities

Significant responses to crop type were recorded for 18 bird species (at α=0.05), of which six are subject to national Biodiversity Action Plans, and 11 contribute to the national farmland bird index (Table 4.1). No significant differences between crops were recorded for indicator species; Stock Dove *Columba oenas*, Jackdaw *Corvus monedula* or Starling *Sturnus vulgaris* or for seed-eating species, House Sparrow *Passer domesticus* and Brambling *Fringilla montifringilla*. Some species of high conservation interest, such as Twite *Carduelis flavirostris*, Lesser Redpoll *Carduelis flammea* and Cirl Bunting *Emberiza cirlus* were recorded too infrequently for meaningful inclusion in the analysis.

For the remaining 18 species, the strongest model fits used combined field and boundary counts for each species (valid in winter when most species are distributed according to the availability of food rather than nest sites). For majority of these species densities on winter bird crops exceeded those on conventional crops (Table 4.1). Exceptions included Skylark, for which highest densities were recorded on cereal stubbles, Rooks *Corvus frugilegus* for which winter cereals and cereal stubbles were important, Grey Partridge, for which grassland and non cereals were important and Reed Buntings *Emberiza schoeniclus* for which non cereals (legumes or root crops) were important (Table 4.1). Across all 18 species, kale, particularly in its second year, had the most consistent rank within the top three crops preferred by birds (Table 4.1), and had the highest average rank among crops for seed-eating species (sparrows, finches and buntings) and BAP species (Table 4.1; Figure 4.2). Turnips were the preferred crops of insectivorous species: Dunnock *Prunella modularis* and Blackbird *Turus merula*, and seed-eating Chaffinch *Fringilla coelebs*, Reed Bunting and Yellowhammer *Emberiza citrinella* (Table 4.1, Figure 4.2). Quinoa was especially important for Greenfinch *Carduelis chloris*, Bullfinch *Pyrrhula pyrrhula*, Corn Bunting *calandra* and Tree Sparrow *Passer montanus* (for two of three winters), with a high average rank among seed-eating passerines, insectivorous passerines and BAP species (Figure 4.2). Some preferences were shown for cereals (either as stubbles or as seeding crops) and oilseed rape among buntings, while linseed was important for both finches and buntings (Table 4.1; Figure 4.2). Canary grass was of specialist interest to Song Thrushes, Pheasants and Yellowhammers but was otherwise of low average rank, especially among other insectivorous and BAP species (Figure 4.2). Three crops, buckwheat, phacelia and sunflowers were consistently low ranking crops, although sunflowers were important for Greenfinches. Among gamebirds, maize was especially important for Pheasants and Red-legged Partridges but also attracted Woodpigeons *Columba palumbus* (Table 4.1).

The ranked crop preferences of Pheasants and Red-Legged Partridges were only weakly correlated with those of other species, although 2nd-year kale, seeding cereals, rape and linseed were the preferred crops of all groups (Figure 4.3).

In late winter (February/March), bird densities peaked in December, but then declined on all crops (χ^2_5=64.3, P<0.01; Figure 4.4a) and throughout the winter larger plots held lower densities of birds (χ^2_{22}=102.2, P<0.01; Figure 4.4a). There were significant differences in

bird densities across months for all crops shown in Figure 4.4 (b & c; $P<0.001$). Second-year kale and turnips and quinoa maintained relatively high densities in late winter (Figure 4.4 b & c). For 2nd-year kale this decline was only 31% between October and February, while densities on sunflowers declined sharply after December and by 66% between October and February (Figure 4b & c). Kale, cereal stubbles, maize, quinoa and linseed were again of high average rank for both passerines and gamebirds (Figure 4.5), and the correlation between the mean ranks of crops for the gamebirds and passerines was higher than for the winter as a whole (in late winter: $r^2=0.43$ for seed-eaters; $r^2=0.19$ for insectivores, cf. Figure 4.3).

4.2 Additional Factors; Weeds, Boundaries and Set-Aside

Weed content was positively related to the occurrence of Grey Partridge, Tree Sparrow and Reed Bunting (in kale, maize and quinoa ($P<0.05$); in kale, millet and mustard ($P<0.01$); and in kale, maize and cereals ($P<0.01$) respectively).

The positioning of winter bird crops near boundaries was a significant factor in the occurrence of Pheasant, Dunnock, Song Thrush, Greenfinch and Yellowhammer on winter bird crops (Table 4.1). Higher densities of Tree Sparrows, Greenfinches and Linnets occurred in crops grown by averagely higher hedgerows, while higher densities of Corn Buntings were found in crops grown by open boundaries and averagely lower hedges (Table 4.1).

The designation of crops as set-aside or not made no significant difference to the distribution of birds of any species.

4.3 Arable Stewardship

The densities of birds on 28 Arable Stewardship plots were lower than on conventional winter bird crops for 17 of the 18 species (Wilcoxon Signed-ranks: $P<0.001$), that is with the exception of Bullfinch. The difference was statistically significant for Pheasant, Red-legged Partridge, Skylark, Blackbird, Song Thrush, Goldfinch *Carduelis carduelis*, Greenfinch, Linnet and Chaffinch. There were statistically significant differences in the frequency of occurrence of component crops in conventional winter bird crops compared to Arable Stewardship crops (Goodness of fit: $\chi^2_{18}=68.8$, df=18, $P<0.001$). Compared to conventional winter bird crops, a higher proportion of Arable Stewardship crops contained buckwheat, sunflowers and phacelia, and a lower proportion of Arable Stewardship crops contained kale, linseed, quinoa and turnips (Figure 4.6).

5. DISCUSSION

The high average rank across species of kale, particularly in its second year, was a key result from this study, given the use made of this crop, not only by granivorous species but also by three declining insectivorous passerines, Dunnock, Song Thrush and Blackbird. With the conformity between gamebirds and passerines being poor for most crops, kale was also exceptional in being highly ranked in both groups with important connotations for the uptake of this crop on a national scale, given the widespread popularity of gamebird hunting in the UK. Kale was among the top three preferred crops for Grey Partridge, Skylark, Song Thrush, Tree Sparrow (in weedy crops), Bullfinch and Corn Bunting, each species of high conservation concern and subject to national recovery programmes (Gibbons *et al.* 1996; Crick *et al*. 1998). Along with kale, other brassicas, such as turnips, rape, mustard and cereals (as a seed crop or stubble) also predominated within the higher ranks of winter bird crops, with special importance for Yellowhammer, Reed and Corn Bunting for which kale was less important. With cereals also exploited by Pheasant, Goldfinch and Linnet, brassica/cereal combinations must be considered among optimal choices for crops aimed at increasing biodiversity on winter farmland, in the broader perspective, that is based on the number of species that would benefit from these crops' presence.

Other important crops included linseed and quinoa. Linseed had a high average rank amongst both seed-eating passerines and gamebirds, and was ranked within the top three crops for Skylark, Yellowhammer and Red-legged Partridge, but its tendency to deteriorate in late winter may mean this crop is less suitable at this critical late phase. In contrast, quinoa has an abundant seed drop often extending into February (e.g., King 1998). Along with kale and cereals, quinoa maintained relatively high densities of bird into the late winter phase. Across the whole winter period, its high average rank among both seed-eating and BAP species included three species of high conservation priority, Tree Sparrow, Bullfinch and Corn Bunting. As a common complimentary plant to kale in terms of its taller structure and faster development the uptake of quinoa among winter bird crops may be tempered only by its status as a non-native species to the UK.

Some crops had specific appeal to some species, such as sunflowers to Greenfinches, and canary grass to Pheasants, Song Thrushes and Yellowhammers, especially in late winter. For Yellowhammers, this association is consistent with this species' preference for grass-seed, grass margins and cereals fields. Maize was a common winter bird crop, but used mainly by Pheasants and Red-legged Partridges with both the cover and the cob attracting large numbers of Wood Pigeons. Companion crops that invariably accompany maize were not always identified by observers and thus millet in particular was probably under represented in the current survey and its status for attracting birds either under estimated or masked by maize itself.

In the current study measures of the weed content of winter bird crops were relatively crude and qualitative, and no distinction made between the types of weeds present. The influence of the weeds was equivocal since, in single factor statistical models, there were strong positive relationships with bird numbers that diminished with the addition of crop type. Crop type was thus the predominant influence and weeds of secondary importance. However, for three BAP species Grey Partridge, Tree Sparrow and Reed Bunting, weeds remained a significant influence on their distribution. There were week effects for Grey Partridge in 1st-year kale, maize, cereals and grassland but much stronger effects for Tree Sparrow and Reed Bunting in all crops, and it seems likely that for these two species in particular weedy-rich

crops or grassland are principal habitats. It may also explain the preference by Reed Buntings for non-cereals in which weeds are more difficult to control than in winter cereals. Certainly their preference for weedy crops is consistent with previous studies of seed-eating birds on winter farmland where weed-rich stubbles or fallow fields were strongly preferred foraging habitats of Skylarks and buntings (e.g, Donald & Evans 1994; Evans & Smith 1994; Buckingham *et al*. 1999). To allow weeds to flourish among winter bird crops requires careful management so that the crop itself is not compromised. In established crops, however, the contribution of late seeding docks *Rumex* species, thistles *Cirsium* species and other species of Cruciferae and Compositae, would provide birds with an exceptionally valuable source of additional, late winter food (Robinson *et al.* 1999).

In the last 10 years there have been extensive programmes of research into habitat selection and declining populations of birds on farmland in the UK (e.g., Rands 1985; Donald & Evans 1994; Evans & Smith 1994; Buckingham *et al*. 1999; Robinson *et al.* 1999; Chamberlain *et al*. 2000), during which several initiatives have emerged aimed at improving conditions for wildlife on farmland. Among these is the Arable Stewardship (AS) scheme with prescriptions designed to present farmers with practical agri-environmental protocols. There are also national and regional biodiversity action plans for the recovery of species identified for priority attention, and a government national biodiversity index developed to monitor the progress of farmland bird populations (among other taxa) over time.

A critical finding of the current extensive survey was that winter bird crops grown under the AS scheme supported lower densities of birds than conventional winter bird crops, for which crop content was the most likely explanatory factor. A higher proportion of conventional crops contained crops that we now associate with higher bird densities, especially kale, quinoa and cereals. A relatively high proportion of AS scheme crops contained plants associated with lower average densities of birds such as buckwheat, phacelia and especially sunflowers. These results suggest that for birds, AS crops could be simplified to include key crops, that are resistant to climatic conditions and of higher optimal value to birds, including BAP species of high conservation concern and species contributing directly to the national farmland bird index.

The proper establishment of winter bird crops requires careful planning and active management since soil conditions, air temperatures, plant pathogens and pests contribute to successful crop development. For successful wide geographical uptake of key winter bird crops two further influences are important. First, the conformity between gamebirds and indigenous species for crop preferences will help uptake since many landowners already include gamebird crops in their current management regimes. In this respect, conformity between the two main quarry species on farmland, Pheasant and Red-legged Partridge and indigenous species was generally poor in the current study, although 2nd-year kale, linseed, seeding cereals and rape supported relatively high densities of all species. Second, climate will influence crop content since crops such as maize, millet and sunflowers are intolerant of cooler conditions and northern latitudes in England. Frost resistant varieties of kale, as well as cereals, such as oats, and quinoa can, however, thrive under these conditions. For kale, in particular, vulnerability to disease (club-foot) or pests (flea beetle) is a problem that can lead to complete crop failure. Active management through the use of pesticides, the careful choice of varieties and the constant rotation of crops is therefore required. Other brassicas such as turnips or rape might also provide successful alternatives.

5.1 Recommendations

The ability of kale to attract both gamebirds and passerines, (including species of high conservation status) throughout the winter suggests that mixes including this crop can increase the general level of bird biodiversity on farmland across England. Our results suggest that combinations of brassicas (especially kale, turnips or rape) and cereals, such as triticale, wheat or oats and the hardy exotic crop, quinoa, are key choices for optimal crop mixes for attracting birds in both abundance and variety. Linseed may add seed for *Cardueline* finches such as Linnet and Goldfinch. Complex mixes of component crops, that in this study, were more typical of Arable Stewardship areas than conventional winter bird crops, supported lower average densities of birds, suggesting that attention to crop composition was of greater influence to birds than crop complexity *per se*.

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Species	Winter bird crops															Conventional field types						Top three crops	Model effects			
	BK	CG	CL	K1	K2	LI	ML	MU	MZ	PH	QU	RA	SU	TE	TU	BA	CS	GR	NC	SB	WC True density		Crop	Hedge		N
																							P	% bnd	Hgt (m)	
PH	1.1	2.7	2.5	0.9	1.6	1.9	1.0	0.9	1.9	0.9	1.4	1.4	0.8	0.8	1.4	1.8	1.5	1.7	0.6	0.8	*0.07*	**CG, CL, MZ**	***	***	ns	1162
P.[(BAP)/(FI)]	0.0	0.0	0.8	0.3	2.7	0.5	0.7	0.6	0.7	0.0	0.7	1.6	0.3	0.8	1.0	1.5	1.1	2.1	0.0	0.1	*0.09*	**K2, GR, RA**	***	ns	ns	238
RL	1.2	1.0	1.0	0.6	2.0	2.0	0.7	0.9	1.8	0.7	0.9	1.4	1.1	1.8	0.7	1.3	1.4	0.8	1.4	1.4	*0.12*	**LI/K2, MZ**	***	ns	ns	1132
WP[(FI)]	0.7	0.1	0.9	0.5	2.0	0.4	1.5	1.3	5.1	0.6	1.2	3.1	1.6	1.7	1.8	1.8	1.1	1.5	1.6	2.5	*0.76*	**MZ, RA, SB**	***	ns	ns	7713
S.[(BAP)/(FI)]	0.0	0.0	0.5	2.1	1.1	1.6	1.3	0.5	0.9	0.0	0.5	0.8	0.5	0.0	1.3	1.1	2.5	1.3	0.7	1.5	*0.24*	**CS, K1, LI**	***	ns	ns	1264
D.	1.5	1.2	1.5	2.1	2.2	1.4	1.3	1.3	1.7	0.9	1.7	1.4	1.3	1.4	2.3	1.3	1.3	1.3	1.6	1.6	*0.06*	**TU, K2, K1**	***	+*	ns	294
B.	0.9	1.0	1.3	1.5	2.0	0.9	1.0	1.2	1.2	0.7	1.4	1.3	1.0	1.2	2.1	1.1	1.1	1.4	1.1	3.8	*0.15*	**SB, TU, K2**	***	ns	ns	467
ST[(BAP)]	1.6	4.1	1.3	2.5	2.5	0.9	1.3	0.6	1.3	0.9	2.2	1.9	0.8	2.0	2.3	1.0	0.9	0.9	1.3	1.5	*0.02*	**CG, K1/K2**	***	+*	ns	147
RO[(FI)]	0.0	0.0	0.1	4.5	0.7	0.8	0.7	0.7	0.7	0.0	0.5	0.6	0.4	0.0	0.1	0.8	1.6	0.6	0.3	0.6	*0.55*	**K1, WC, CS**	*	ns	ns	1913
TS[(BAP)/(FI)]	0.0	0.0	1.4	2.8	4.5	2.0	2.4	2.1	2.1	0.0	2.5	3.4	1.2	0.8	0.0	0.1	1.0	1.9	0.0	0.7	*0.00*	**K2, K1, RA**	*	ns	+**	93
BF[(BAP)]	0.0	1.5	0.8	1.3	2.4	0.8	1.3	1.6	2.4	0.0	2.9	0.0	0.0	0.0	0.8	0.9	0.7	2.1	1.0	0.0	*0.02*	**QU, K2, MZ**	***	ns	ns	67
GO[(FI)]	1.2	6.7	3.0	0.8	1.3	2.1	1.0	0.4	0.8	0.5	0.9	0.6	0.6	0.8	0.5	1.1	1.3	2.1	3.3	0.3	*0.18*	**CG, NC, CL**	***	ns	ns	836
GR[(FI)]	3.2	6.2	2.9	2.7	4.5	4.2	2.7	2.9	3.1	3.9	8.0	3.0	5.3	2.5	4.5	0.9	4.1	1.3	4.4	3.3	*0.06*	**QU, CG, SU**	***	+*	+**	1496
LI[(BAP)/(FI)]	0.2	1.1	0.5	0.9	1.8	1.8	0.4	1.9	0.8	0.2	0.9	1.2	0.6	0.2	1.3	0.2	1.9	1.0	2.8	0.3	*0.11*	**NC, MU/CS**	***	ns	-*	1526
CH	1.6	1.9	2.9	3.2	6.0	2.7	1.7	1.1	2.1	0.3	2.6	1.7	1.5	1.6	3.8	1.0	1.7	1.4	2.7	0.9	*0.22*	**K2, TU, K1**	***	ns	ns	2328
RB[(BAP)/(FI)]	1.0	0.0	1.8	2.3	2.7	1.1	1.8	1.8	2.1	3.1	2.7	3.2	2.1	2.2	10.1	0.9	2.5	2.1	4.1	0.0	*0.19*	**TU, NC, RA**	***	ns	ns	847
Y.[(FI)]	0.6	11.8	2.9	1.0	1.9	1.9	1.0	0.8	1.0	0.2	1.2	1.9	0.6	1.7	1.8	0.8	1.6	0.9	0.6	0.5	*0.22*	**CG, CL, RA/LI**	***	+**	ns	217
CB[(BAP)/(FI)]	0.0	0.0	3.0	3.4	0.1	2.9	0.2	3.4	0.6	0.0	3.4	0.0	0.0	0.0	2.1	0.3	3.4	0.0	0.0	3.3	*0.06*	**CS/ KI/MU/QU**	*	-*	-*	49
TMD	*1.1*	*5.7*	*1.4*	*1.6*	*4.2*	*0.8*	*1.3*	*1.9*	*3.1*	*0.6*	*2.2*	*1.7*	*1.5*	*1.5*	*1.8*	*0.3*	*0.6*	*0.4*	*0.4*	*0.3*	*0.2*					

Table 4.1. Densities of birds on winter crops relative to winter cereals (turnips for Tree Sparrow), for which true densities are given in for each species (ha^{-1}). *P* shows significant affects of crop type (followed by boundary length (% bnd) and hedge height (hgt)) for each bird species. **P*<0.05, ***P*<0.01, ****P*<0.001. *N* is a rounded mean number of birds recorded on each visit in each year. TMD is true mean density (ha^{-1}) across species for each crop. Abbreviations are: 1. Winter bird crops: buckwheat (BK), canary grass (CG), cereals (CL), 1st-year kale (K1), 2nd-year kale (K2), linseed (LI), millet (ML), mustard (MU), maize (MZ), rape (RA), phacelia (PH), sunflowers (SU), teasles (TE), Turnips (TU) and quinoa (QU); 2. Conventional crops: bare earth (BA), cereal stubbles (CS), grassland (GR), non-cereal stubbles (NS) and sugar beet (SB); and 3. Bird species are: Ring-necked Pheasant (PH), Grey Partridge (P.), Red-legged Partridge (RL), Woodpigeon (WP), Skylark (S), Dunnock (D), Blackbird (B), Song Thrush (ST), Tree Sparrow (TS), Bullfinch (BF), Goldfinch (GO), Greenfinch (GR), Linnet (LI), Chaffinch (CH), Reed Bunting (RB), Yellowhammer (Y) and Corn Bunting (CB). Species subject to national Biodiversity Action Plans are denoted [(BAP)]. Those contributing to the farmland bird index are denoted **[(FI)].**

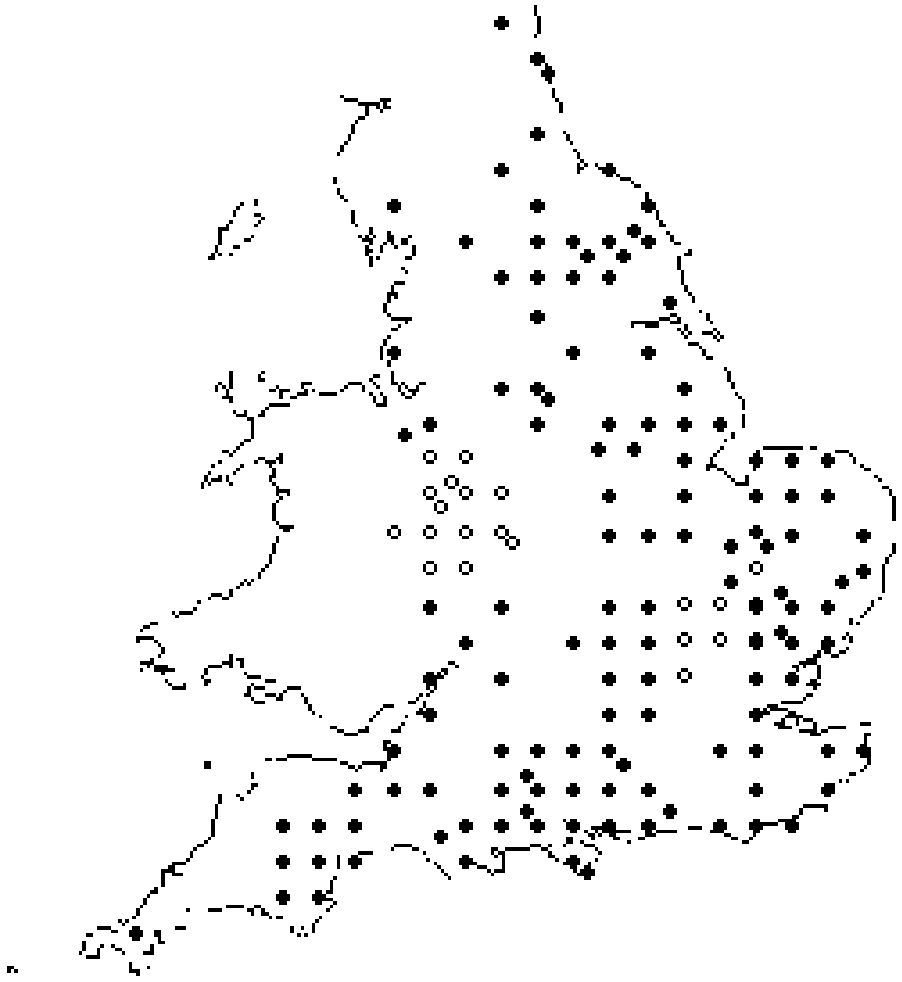

Figure 4.1 The distribution of winter bird cover plots visited during the extensive survey. Open dots represent Arable Stewardship sites, closed dots represent conventional winter bird cover plots. Some locations are superimposed due to the close proximity of plots in certain areas.

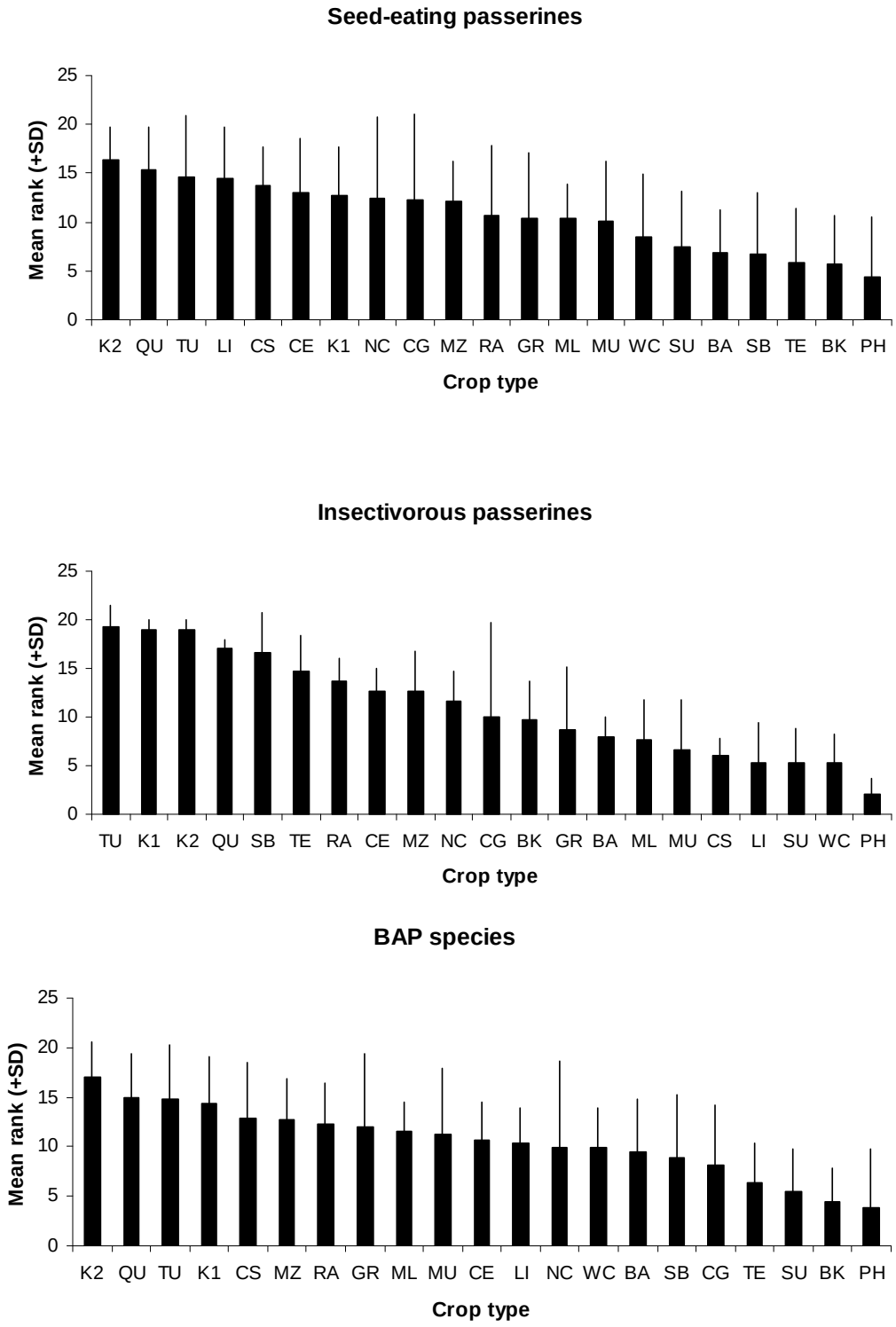

Figure 4.2 The distribution of three categories of birds, Seed-eating Passerines (Bullfinch, Goldfinch, Greenfinch, Chaffinch, Linnet, Tree Sparrow, Reed Bunting Yellowhammer, Corn Bunting); Insectivorous Passerines (Dunnock, Blackbird and Song Thrush); and Biodiversity Action Plan (BAP) Species (Grey Partridge, Song Thrush, Tree Sparrow, Bullfinch, Linnet, Corn Bunting and Reed Bunting), in relation to winter bird crop type (mean rank ± 1 SD). Crop types are: bare ground (BA), buckwheat (BK), cereals in seed (CE), canary grass (CG), cereal stubble (CS), grassland (GR), 1st-year kale (K1), 2nd-year kale (K2), linseed (LI), millet (ML), mustard (MU), maize (MZ), non cereals (NC), phacelia (PH), quinoa (QU), rape (RA), sugar beet (SB), sunflowers (SU), teasels (TE), turnips (TU) and winter cereals (WC).

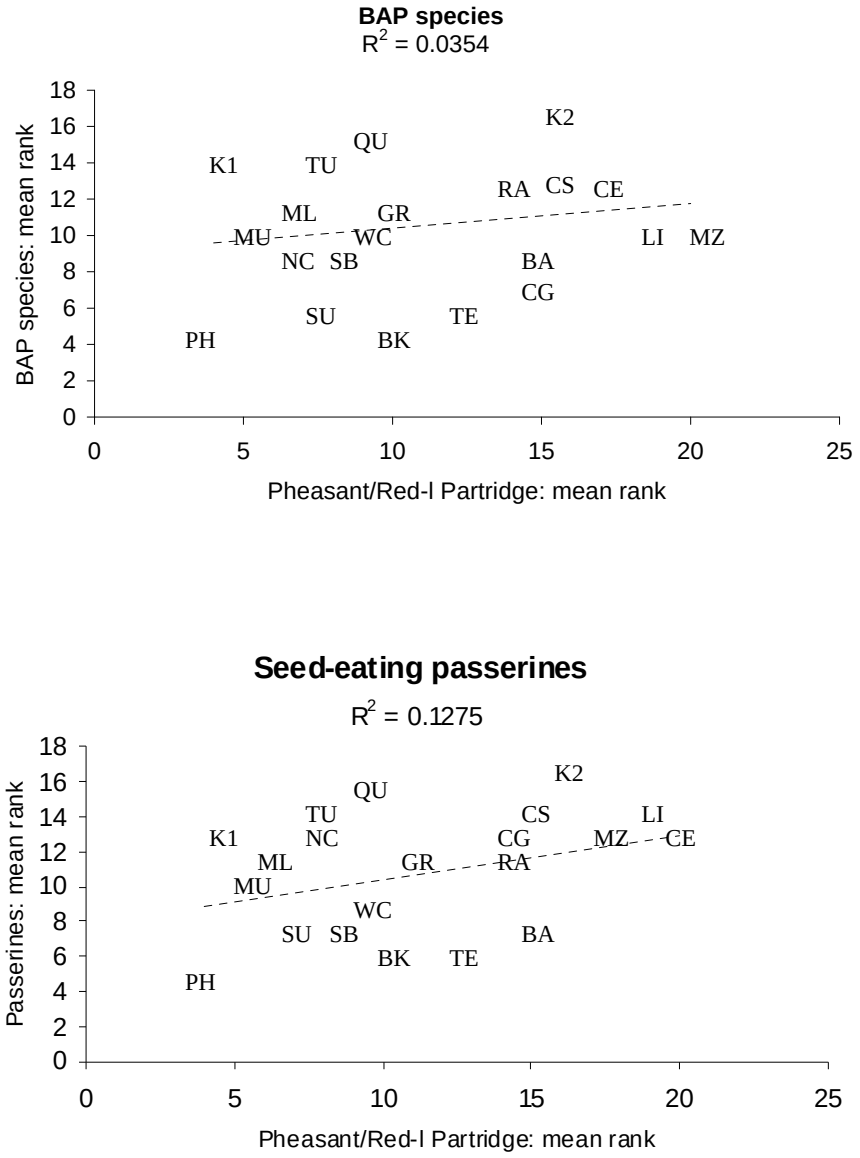

Figure 4.3 Comparing the crop preferences (mean rank) of Ring-necked Pheasants and Red-legged Partridges with (a) Seed-eating passerines (Bullfinch, Goldfinch, Greenfinch, Chaffinch, Linnet, Tree Sparrow, Reed Bunting, Yellowhammer, Corn Bunting) and (b) Biodiversity Action Plans (BAP) species (Grey Partridge, Song Thrush, Tree Sparrow, Bullfinch, Linnet, Corn Bunting and Reed Bunting). Crop types are: bare ground (BA), buckwheat (BK), cereals in seed (CE), canary grass (CG), cereal stubble (CS), grassland (GR), 1st-year kale (K1), 2nd-year kale (K2), linseed (LI), millet (ML), mustard (MU), maize (MZ), non cereals (NC), phacelia (PH), quinoa (QU), rape (RA), sugar beet (SB), sunflowers (SU), teasel (TE), turnips (TU) and winter cereals (WC).

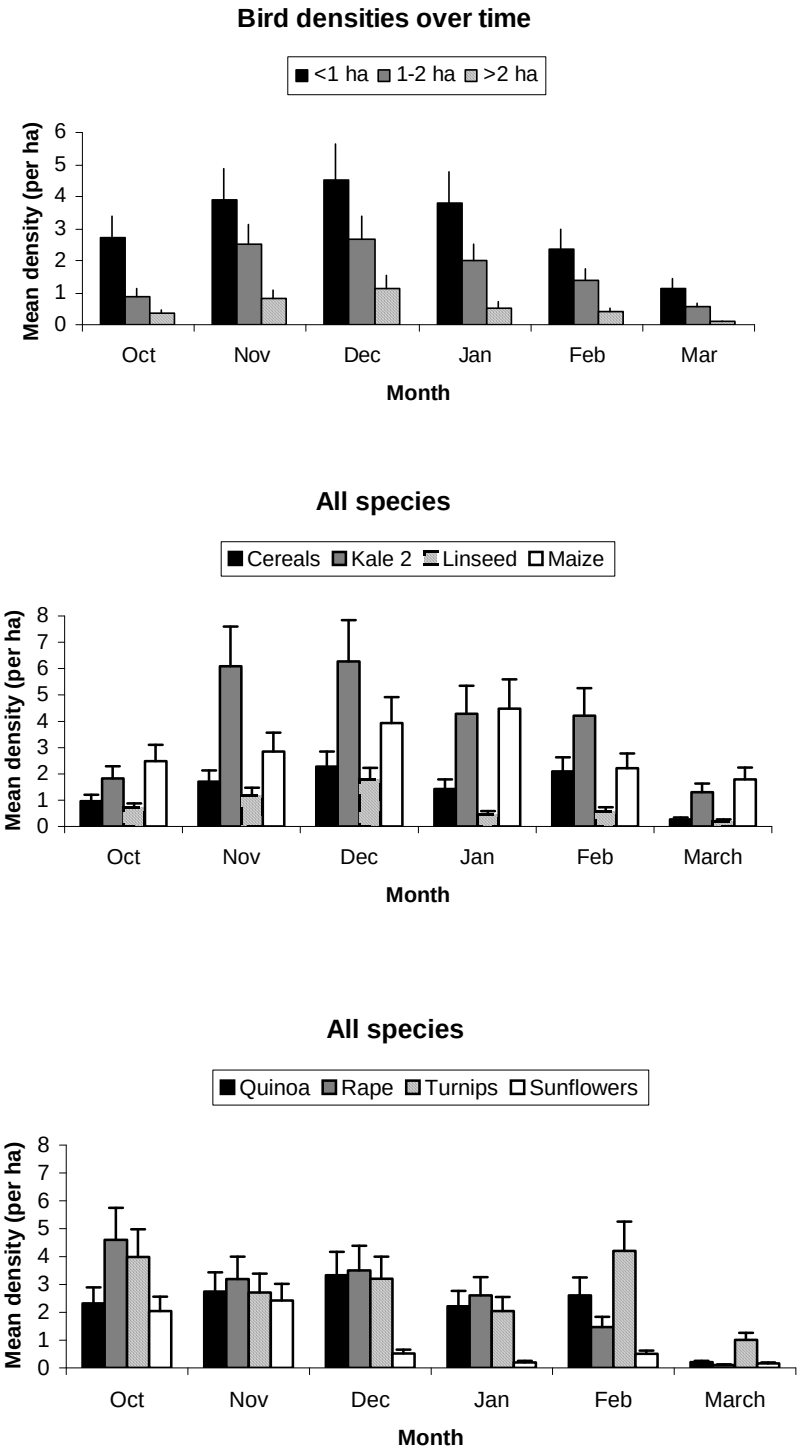

Figure 4.4 **(a)** Mean densities (ha^{-1}) of birds (per area category) (all species combined +1SD) on winter bird crops of <1 ha in area (<1 ha; mean n per month=101), between 1 and 2 ha in area (1-2 ha; mean n per month=30) and over 2 ha in area (>2 ha; mean n per month=28) over the winter period October to March. In **(b)** and **(c)** the change in bird densities on eight winter bird crops for the period October to March is shown. Kale 2 refers to 2nd-year kale.

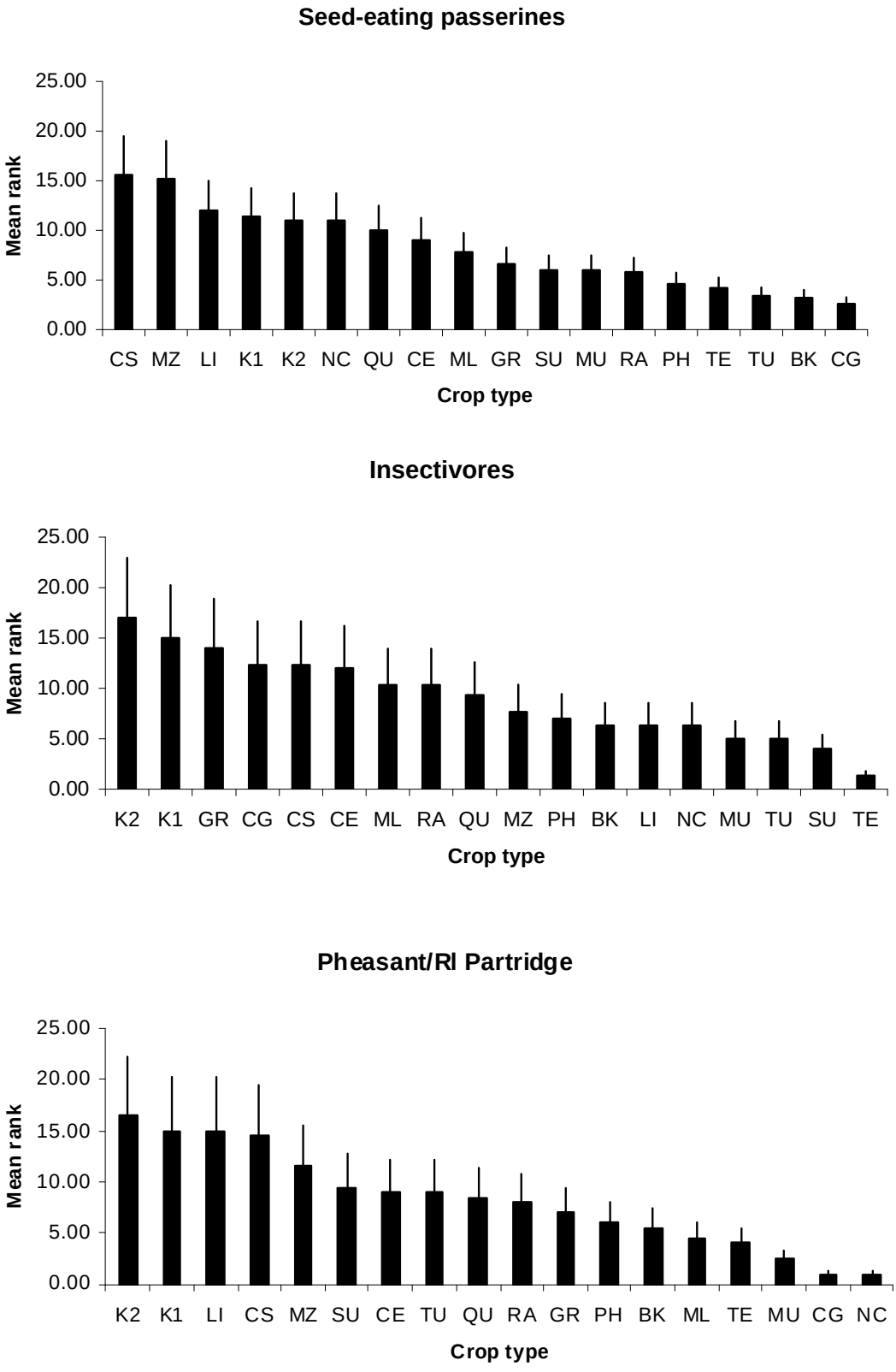

Figure 4.5 Mean ranks (+1SD) of crop types for three species groups using winter bird crops during late winter (February/March).

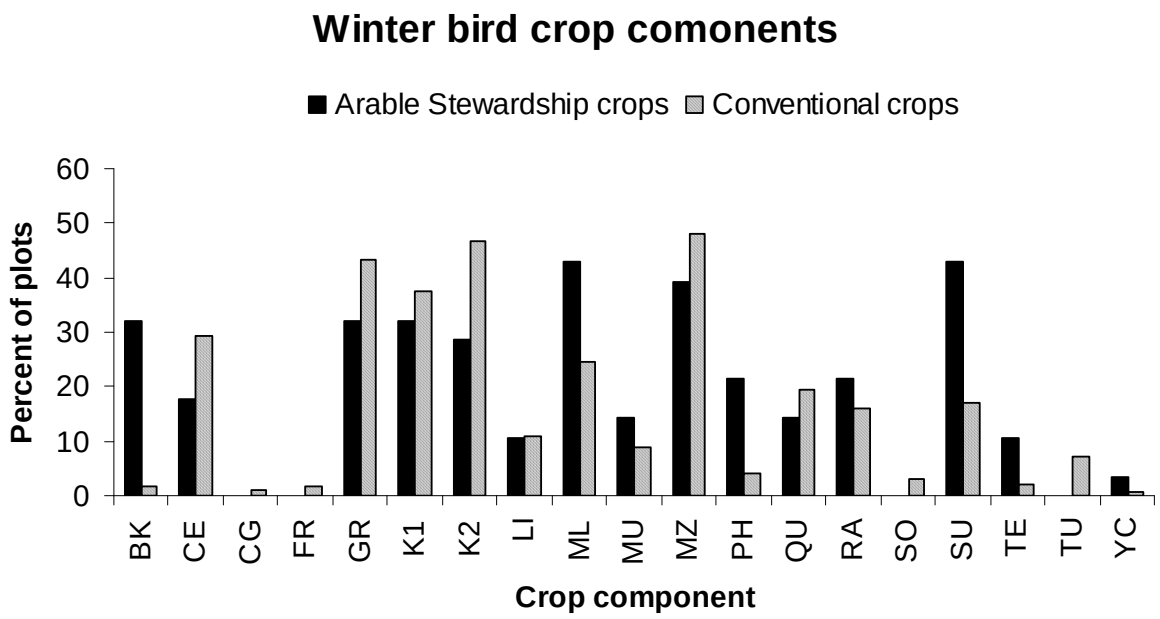

Figure 4.6 The frequency of component crops in conventional (*N*=192) and Arable Stewardship (n=28) winter bird cover. Crop types are: buckwheat (BK), cereals in seed (CE), canary grass (CG), fathen (FH) grassland (GR), 1st-year kale (K1), 2nd-year kale (K2), linseed (LI), millet (ML), mustard (MU), maize (MZ), phacelia (PH), quinoa (QU), rape (RA), sugar beet (SB), sorgum (SO), sunflowers (SU), teasels (TE), turnips (TU) and yellow cover (YC). .