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Counting birds on farmland habitats in winter

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Capsule Perimeter counts underestimate the number of birds using agricultural fields.
Aims To determine the degree to which farmland birds may be undercounted on field surveys and the factors influencing this.
Methods In a study of 96 fields, birds in the field were counted during a walk of the perimeter. Afterwards transects were walked across the field to determine the number of birds missed. Additionally in a national survey we looked at the birds seen in field transects expressed as a proportion of the total seen in the transect and on perimeter counts.
Results To obtain an accurate count of birds on a field requires the use of the whole-area search methodology especially for species such as Grey Partridge *Perdix perdix*, Snipe *Gallinago gallinago*, Skylark *Alauda arvensis* and Meadow Pipit *Anthus pratensis*. However, for a large number of species, including thrushes, flocking finches and buntings, over 90% of individuals can be recorded using the much less time-consuming perimeter count method.
Conclusions Perimeter counts are likely to be reliable for most species but special efforts may be required for a few cryptic species.

Detectability and bias are often problems in sampling animal populations (Greenwood 1996). Animals tend to be mobile, sometimes cryptic and travel in groups violating assumptions of independence between individuals. The habitats in which they live are also variable in nature (e.g. vegetation height or density) which may cause variation in detectability. For studies where counts or densities are required, the sampling techniques need to be tailored to the questions being asked and the biology of each species (Greenwood 1996). This can range, for example, from complete censuses for populations of conspicuous species (Gibbons & Wotton 1996) to estimates of population size or density based on randomized sampling (e.g. Skylarks *Alauda arvensis*; Gillings & Fuller 2001).

In recent years much effort has been directed towards assessing the impacts of modern agriculture on bird populations. Many species of farmland bird have undergone rapid population declines and range contractions in the last 25 years (Fuller *et al.* 1995, Siriwardena *et al.* 1998, Gregory *et al.* 2004) and these have been linked to changes in farming practice (Fuller *et al.* 1995, Campbell *et al.* 1997, O'Connor & Shrubb 1986).

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One problem with surveying birds on arable land in winter is that birds vary in their detectability. There is approximately a 20-fold difference in size between a Linnet *Carduelis cannabina*, one of the smallest species to regularly use fields in winter, and a Woodpigeon *Columba palumbus*, one of the largest. Some species travel in flocks, e.g. Linnet, whereas others such as Skylark are cryptic and tend to occur singly.

Studies which estimate population size or density of birds in agricultural habitats in winter have tended to use one of two methods. The first method uses counts from the perimeter only ('perimeter counts'; Gillings *et al.* 2005, Tucker 1992); the second involves walking parallel transects across the field sufficiently close together to ensure that everything is flushed and counted ('whole-area search'; Moorcroft *et al.* 2002, Wilson *et al.* 1996). For small-scale studies the more accurate whole-area search method is preferable but at larger scales, e.g. for national surveys, it is prohibitively time-consuming and expensive. Instead, for the Winter Farmland Bird Survey (Wilson & Gillings 2002), which was a national survey, a compromise method was employed involving field edge counts and across-field transect counts which subsequently could be used to

identify problem species or habitats for which edge counts alone might be biased.

Although perimeter counts are frequently used in surveys of wintering birds, and are known to underestimate numbers of some species, there have been few attempts to quantify the magnitude of such underestimates. Here we use field data from a national survey of birds in winter (the BTO/JNCC Winter Farmland Bird Survey, WFBS) and a small-scale field survey of birds on stubble fields in East Anglia, UK, to directly compare numbers of birds detected through perimeter counts and whole-area search. We address three questions: first, to what extent do perimeter counts underestimate birds using agricultural fields; second, how does this differ between species (i.e. for which species are perimeter counts least effective); and third, how does this differ between habitats? These results can then be used to inform future studies.

METHODS

Small-scale surveys: whole-area search

Over a period of 20 days between February and March 1998, winter bird surveys were carried out on 96 arable fields in Norfolk, England, comprising 47 fields of young cereal crop, 35 of cereal stubble and 14 of sugar beet stubble. The area of these fields was about 1090 ha (528, 384, 178 ha of cereal crop, cereal and beet stubble, respectively) ranging in size from 3.13 to 37.56 ha (Fig. 1). Two survey methodologies were adopted: 'perimeter counts' and 'whole-area searches'. In the former, an observer walked slowly around the field edge at a distance of no more than 6–10 m into the field and recorded all birds seen using the hedge, field margin (defined as a 10 m strip from the hedge into the field itself) and field centre. Following the perimeter count, a whole-area search was conducted in which the observer then walked in a series of parallel transects across the field ensuring all parts of the field were covered to within approximately 20 m. Any birds seen during field transects, but not during the perimeter counts, were recorded separately allowing an estimate of the percentage of birds missed by the first, less intensive method. Double counting may have been an issue but as the flocks of birds were well spread out and as numbers were low, it was straightforward to locate birds previously seen from the edge, whilst performing the field transect.

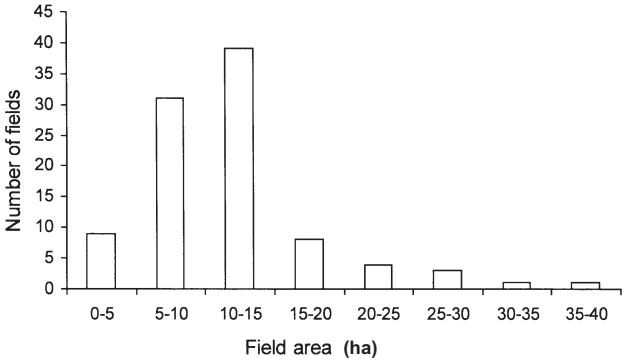

Figure 1. Histogram of the numbers of fields surveyed in the small-scale survey in East Anglia, based on the area of the field.

The number of birds seen during the field transects but not the perimeter count and the total number of birds recorded were tabulated and species recorded on 15 or more fields subjected to statistical analysis, unless all birds were recorded from the perimeter count over all the fields surveyed. As the physical characteristics of the field were likely to influence the detectability of birds, the percentage cover of bare earth, weeds and crop volunteers (newly emerging crop plants from seeds left in the stubble) were estimated by eye from twenty 0.5 × 0.5 m quadrats placed at random along the transect walks. Stubble and vegetation heights were measured within these quadrats using a ruler. The effects of field area, vegetation or stubble height, the total green cover (weeds and crop volunteers) and bare ground on the proportion of each bird species seen only during the field transects was examined using a series of single species univariate logistic regressions with the dependent variable being of the form: (numbers of birds seen from the perimeter/total number of birds recorded in the field).

Winter Farmland Bird Survey

In the winter of 1999/2000 a total of 870 randomly selected 1-km squares were surveyed by volunteer observers under the BTO/JNCC Winter Farmland Bird Survey. The numbers of 30 farmland bird species on each field were recorded on three four-hour visits between November and February. This suite of 30 'target' species included declining species of conservation concern and winter visitors, but in 1999/2000 did not include highly abundant species (e.g. Woodpigeon, corvids). Observers walked around the edge of each field and recorded birds in three zones: boundary (all birds in hedges and other boundary structures including any 'verge' vegetation adjacent to the crop or uncropped margin); margin (all birds in the outer 20 m of the crop); interior (all birds in the field beyond the margin zone). Birds were assigned to the zone in which they were first

detected. After completing a circuit of the field, observers walked a single straight transect across the middle of the field. Any birds in the first or last 20 m of the transect would have already been counted in the margin component of the perimeter walk so were not double counted. Transects were only 20 m wide (10 m either side) to ensure that all birds in the strip would be detected irrespective of vegetation height. The habitat (i.e. crop type) of each patch was recorded.

Three of the target species (Woodlark *Lullula arborea*, Twite *Carduelis flavirostris* and Snow Bunting *Plectrophenax nivalis*) were recorded on too few squares to include in analyses. For the remaining 27 species we summarize the percentage of total individuals that were recorded solely from the transect as opposed to from the field edge (i.e. in any field zone, but seen from the perimeter). Since the transect did not cover the whole area it could not give a complete estimate of the number of birds 'missed' from the field perimeter. Instead we use these data to derive an index that can be compared across species and identify those for which potentially large numbers of individuals are missed by perimeter counts alone. For these species the effects, on detectability, of field area (ha) and broad habitat type (three levels: grass, crop, stubble) and the interaction between three variables were examined using logistic regression in the Genmod procedure in SAS. We used an events/trials syntax with the number of birds seen from the transect as events and total number recorded in the patch (transect plus perimeter walk) as trials. Since a large proportion of patches were not occupied by a given species on a particular visit, on 75% of visits only two patches contributed data per square for most species (three patches for Skylark, Song Thrush *Turdus philomelos*, Starling *Sturnus vulgaris* and Yellowhammer *Emberiza citrinella*, four patches for Chaffinch *Fringilla coelebs*). We therefore considered patches as suitable independent units, though there may have been issues relating to over-dispersion for flocking species. We used the square root of the deviance/degrees of freedom to scale models and reduce over- or under-dispersion. Significant effects of area and habitat were determined from sequential type III likelihood ratio (LR) statistics (i.e test for habitat effects after first controlling for area effects).

RESULTS

Small-scale survey

A total of 7699 birds of 32 species were recorded: 754 birds of 23 species on cereal crop fields, 4060 birds of 26 species on cereal stubble fields and 2885 birds of 24 species on sugar beet stubble fields (Table 1). The percentage of individual birds seen using the perimeter count (assuming that detectability using the whole-area search method is 100%) is given for 32 species of farmland bird in Table 2. Fourteen species were recorded on more than ten fields. Of these 14 species, no additional birds were detected by the whole-area search for four species (Fieldfare *Turdus pilaris*, Woodpigeon, Goldfinch *Carduelis carduelis* and Pied Wagtail *Motacilla alba*), and over 90% of individuals were detected from the perimeter for six species (Chaffinch, Greenfinch *Carduelis chloris*, Mistle Thrush *Turdus viscivorus*, Linnet, Red-legged Partridge *Alectoris rufa* and Pheasant *Phasianus colchicus*). For the remaining species, the boundary method under-recorded birds relative to the whole-area search and was least accurate for Skylark (47% of individuals detected, n = 745) and Meadow Pipit *Anthus pratensis* (48%, n = 42), Yellowhammer (89%, n = 485), and Grey Partridge *Perdix perdix* (74%, n = 87).

With the exception of Chaffinch, the amount of bare ground, height of vegetation or stubble and the area of the field had a significant effect on the proportion of birds missed on the perimeter counts (Table 3). Field area had a significant effect for only two species whereas the height of the vegetation or stubble and the amount of bare ground had a significant effect for the majority of species (six out of seven species considered). The numbers of birds missed increased as vegetation height increased and/or the extent of bare ground decreased.

Winter Farmland Bird Survey (WFBS)

A total of 14 222 patches were surveyed in 1999/2000, covering over 400 km^2 of farmland and generating approximately 30 000 records of over 300 000 individual birds of the 30 target bird species.

Figure 2 shows that the percentage of individuals seen from the field transect varied markedly between species. For 17 species, less than 5% of all individuals reported from all 801 squares were seen on field transects. However, a further ten exceeded the arbitrary 5% cut-off. Snipe *Gallinago gallinago*, Skylark and Meadow Pipit were extreme with over one-fifth of individuals seen from transects. This is despite the fact that transects comprised only a small fraction of the surveyed area of each field, being only 20 m wide. If this transect area were extrapolated over the rest of each field, the number of individuals of these species missed

Table 1. Total number of birds recorded on cereal crop, cereal stubble and sugar beet stubble fields in Norfolk during the small-scale survey in winter (February/March 1999). The number of fields on which birds were recorded appears in parentheses.

Species	Cereal crop (*n* = 47 fields)	Cereal stubble (*n* = 35 fields)	Sugar Beet stubble (*n* = 14 fields)	Total (*n* = 97 fields)
Black-headed Gull *Larus ridibundus*	1 (1)	70 (2)	59 (1)	130 (4)
Brambling *Fringilla montifringilla*	0 (0)	366 (6)	0 (0)	366 (6)
Carrion Crow *Corvus corone*	3 (2)	9 (3)	6 (2)	18 (7)
Chaffinch *Fringilla coelebs*	6 (2)	672 (15)	172 (4)	850 (21)
Common Gull *Larus canus*	0 (0)	14 (1)	1 (1)	15 (2)
Egyptian Goose *Alopochen aegyptiacus*	3 (2)	0 (0)	0 (0)	3 (2)
Fieldfare *Turdus pilaris*	148 (5)	460 (1)	408 (5)	1016 (11)
Goldfinch *Carduelis carduelis*	0 (0)	103 (11)	39 (2)	42 (13)
Green Sandpiper *Tringa ochropus*	1 (1)	0 (6)	0 (3)	1 (10)
Greenfinch *Carduelis chloris*	1 (1)	208 (0)	39 (0)	248 (1)
Grey Partridge *Perdix perdix*	32 (12)	50 (10)	5 (2)	87 (24)
Jackdaw *Corvus monedula*	6 (1)	180 (1)	16 (3)	202 (5)
Lapwing *Vanellus vanellus*	1 (1)	0 (0)	492 (2)	493 (3)
Linnet *Carduelis cannabina*	0 (0)	132 (9)	52 (3)	184 (12)
Magpie *Pica pica*	0 (0)	1 (1)	2 (1)	3 (2)
Meadow Pipit *Anthus pratensis*	10 (4)	97 (15)	43 (5)	150 (24)
Mistle Thrush *Turdus viscivorous*	8 (2)	7 (4)	8 (4)	23 (10)
Moorhen *Gallinula chloropus*	2 (1)	0 (0)	0 (0)	2 (1)
Pheasant *Phasianus colchicus*	15 (10)	35 (12)	13 (7)	63 (29)
Pied Wagtail *Motacilla alba*	2 (1)	45 (2)	78 (7)	125 (10)
Pink-footed Goose *Anser brachyrhynchus*	0 (0)	0 (0)	600 (1)	600 (1)
Red-legged Partridge *Alectoris rufa*	51 (11)	87 (17)	25 (8)	163 (36)
Redwing *Turdus iliacus*	11 (1)	0 (0)	23 (3)	34 (4)
Reed Bunting *Emberiza schoeniclus*	1 (1)	61 (7)	0 (0)	62 (8)
Rook *Corvus frugilegus*	27 (1)	221 (2)	0 (0)	248 (3)
Skylark *Alauda arvensis*	199 (21)	514 (26)	32 (4)	745 (51)
Snipe *Gallinago gallinago*	0 (0)	23 (1)	0 (0)	23 (1)
Starling *Sturnus vulgaris*	0 (0)	140 (1)	169 (4)	309 (5)
Stock Dove *Columba oenas*	10 (1)	27 (1)	21 (5)	58 (7)
Tree Sparrow *Passer montanus*	0 (0)	28 (4)	0 (0)	28 (4)
Woodpigeon *Columba palumbus*	213 (8)	28 (3)	582 (7)	823 (18)
Yellowhammer *Emberiza citrinella*	3 (2)	482 (21)	0 (0)	485 (23)
Total	754	4060	2885	7699
Total number of species	32	32	32	32

by conventional field perimeter counts becomes a serious issue.

The degree to which field edge counts underestimate numbers of birds differed between habitat types. Table 4 summarizes the percentage of individuals in transects separately for crops, grass and stubble. Note that no Redpolls *Carduelis flammea* were recorded on transects. The effect of habitat type may be confounded by field area if field size differs in a consistent way with habitat type. However, after controlling for differences in field area, 13–15 species showed strongly significant differences (either area * habitat or habitat at $P < 0.0001$) in the percentage of birds seen on transects (compared to transects plus edge counts) between habitat types. For example, around one-quarter of Skylarks were recorded on transects in crops and grass but in stubble this figure rose to 40%. A similar pattern was apparent for Goldfinch, with only 5–6% recorded on transects in crops and grass but 15% on transects in stubble.

DISCUSSION

Bird detectability using perimeter counts and whole-area searches

The results suggest that significant numbers of birds may be missed in the field centre using a perimeter method of surveying, particularly where the field vegetation is tall or dense. The magnitude of differences between the two survey methods was large for some key farmland bird species. For example, over 50% of Skylarks and Meadow Pipits were missed from perimeter counts in a small-scale intensive survey and, together with Snipe, were found to be the species most

Table 2. The proportion of the total number of birds seen on a field in the small-scale surveys, which were detected by the initial perimeter count. Species are listed in descending order of abundance.

Species	Birds seen from edge of field (%)	Number of fields with species present	Total number of individuals seen
Fieldfare	100	11	1016
Chaffinch	99.9	21	850
Woodpigeon	100	18	823
Skylark	46.9	51	745
Pink-footed Goose	100	1	600
Lapwing	100	3	493
Yellowhammer	89.0	23	485
Brambling	100	6	366
Starling	100	5	309
Greenfinch	99.2	10	248
Rook	100	3	248
Jackdaw	100	5	202
Linnet	94.0	12	184
Red-legged Partridge	90.2	36	163
Meadow Pipit	48	24	150
Goldfinch	100	13	142
Black-headed Gull	100	4	130
Pied Wagtail	100	10	125
Grey Partridge	74.7	24	87
Pheasant	95.2	29	63
Reed Bunting	95.2	8	62
Stock Dove	100	7	58
Redwing	88.2	4	34
Tree Sparrow	100	4	28
Mistle Thrush	91.3	10	23
Snipe	100	1	23
Carrion Crow	100	7	18
Common Gull	100	2	15
Egyptian Goose	100	2	3
Magpie	100	2	3
Moorhen	100	1	2
Green Sandpiper	100	1	1

Table 3. Field characteristics that significantly affected the proportion of birds missed on the perimeter counts in the small-scale survey. Only significant relationships as indicated by likelihood ratio tests are shown.

Species/ parameter	Size of field (ha)	Height of vegetation or stubble (cm)	Bare ground (%)
Chaffinch			
Grey Partridge			+ ***
Meadow Pipit	+ ***	+ ***	***
Pheasant		+ *	
Red-legged Partridge		+ ***	– ***
Skylark		+ ***	– ***
Yellowhammer	+ *	+ *	– ***

+, Positive relationship; –, negative relationship. ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

likely to be under-recorded from the field edge in a national survey of wintering farmland birds. Failure to detect species from the perimeter is undoubtedly due to a combination of species behaviour, foraging ecology and field characteristics. Skylarks and Meadow Pipits, in general, do not form such large flocks on fields and individuals tend to flush at much shorter distances than species such as Linnet and Chaffinch. In general, detectability was reduced more by increases in the density or height of vegetation than by increasing field area.

Tucker (1992) stated that perimeter surveys in winter might not detect species smaller than thrushes and thus restricted his study to larger species. In the current study, this was also generally the case, with the exception of Snipe and, perhaps surprisingly, Grey Partridge.

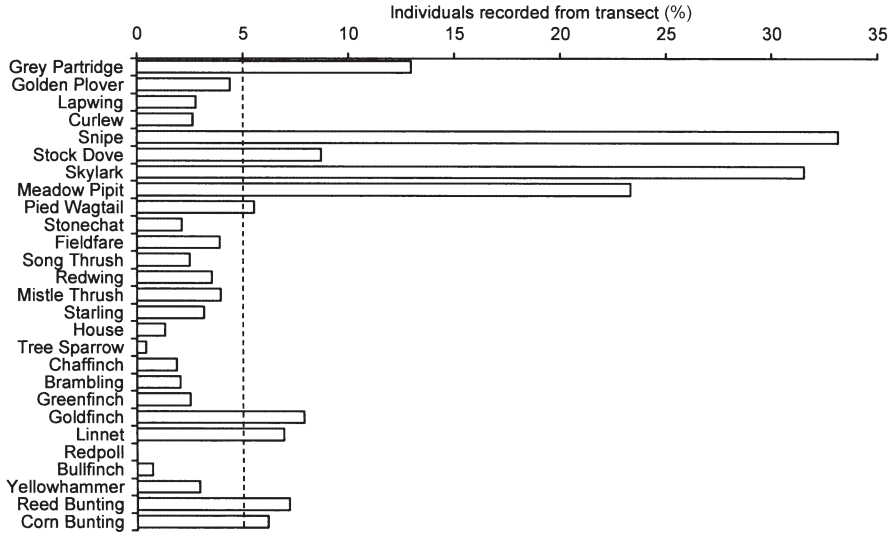

Figure 2. Percentage of all individuals of each species recorded from the transect as opposed to from the field perimeter in the Winter Farmland Bird Survey counts. An arbitrary cut-off of 5% is shown by the dotted line.

Table 4. Percentage of all individuals recorded from the field transect in the Winter Farmland Bird Survey classified by three broad habitat types.

	Habitat (%)			Area	Area * Habitat	Habitat
Species	Crop	Grass	Stubble	LR χ^2_1	LR χ^2_2	LR χ^2_2
Grey Partridge	11	13	17	3.0	4.5	5.4
Golden Plover	2	0	4	9.1**	7.0*	0.9
Lapwing	3	3	4	1.8	1.7	5.1
Curlew	3	2	8	5.9*	11.6**	5.5
Snipe	20	33	39	2.3	1.6	6.9*
Stock Dove	4	2	19	0.5	40.2***	34.8***
Skylark	25	27	40	7.5**	34.3***	59.9***
Meadow Pipit	31	20	32	8.2**	6.1*	27.6***
Pied Wagtail	8	4	9	19.8***	4.0	30.7***
Stonechat	3	2	0	3.7	3.7	0.5
Fieldfare	2	4	4	31.9***	96.0***	14.9***
Song Thrush	7	1	1	262.9***	61.9***	41.8***
Redwing	5	3	5	27.0***	7.8*	41.7***
Mistle Thrush	1	5	5	10.7**	71.7***	2.6
Starling	2	4	3	1.0	7.6*	2.3
House Sparrow	2	0	2	71.9***	42.2***	59.5***
Tree Sparrow	0	0	0	0.0	0.0	0.0
Chaffinch	4	2	1	19.8***	244.0***	4.5
Brambling	7	0	0	9.1**	12.8**	0.0
Greenfinch	4	2	1	2.7	7.4*	32.1***
Goldfinch	6	5	15	73.1***	12.8***	107.3***
Linnet	11	7	5	0.6	13.9**	8.7*
Redpoll	0	0	0	0.0	0.0	0.0
Bullfinch	1	1	0	42.2***	26.7***	34.5***
Yellowhammer	3	2	5	10.4**	6.8*	50.8***
Reed Bunting	3	1	18	0.2	46.5***	46.4***
Corn Bunting	5	7	6	1.8	1.9	2.5

Significance: *$P < 0.05$, **$P < 0.01$; ***$P < 0.001$.

However, results from this study are encouraging in that they indicate that some smaller species, such as Linnet, may be adequately censused from the perimeter of a field. Where detectability is an issue, comparisons of bird densities or numbers between fields will not be possible purely from using perimeter counts, as the mean height of vegetation or amount of bare ground is likely to vary between and within field habitat types. For this reason, where comparisons between fields are required, whole-area searches or standardized within-field transects will be necessary.

Most of the species that were under-recorded are farmland birds that have undergone serious population declines in the last 25 years and are thus of high conservation concern. Skylark and Grey Partridge are both UK Biodiversity Action Plan species (Anon 1995a, 1995b). The population decline of Yellowhammer is more recent (from around the late 1980s; Baillie *et al*. 2005) and the species has recently been red-listed, having exhibited a population decline in excess of 50%. These three species are also part of the farmland bird index (Vickery *et al.* 2004). Meadow Pipit has also exhibited a population decline and has been afforded Medium BTO Alert.

The population declines of many granivorous farmland birds have been linked with declines in survival outside the breeding season, probably caused by a lack of food in winter (Siriwardena *et al*. 2000, Moorcroft *et al.* 2002). There is, therefore, a real need to gain a better understanding of the winter ecology, habitat preferences and foraging behaviour of many of these species. The results here suggest that, for some key species, field studies designed to provide an accurate count of numbers of birds, or compare the use made by birds of different fields and habitat types, require the use of the whole-area search methodology (although distance between transects will vary with habitat type; Hancock & Wilson 2003). We recommend this method particularly for Grey Partridge, Snipe, Skylark and Meadow Pipit. However, for a large number of species, including thrushes, sparrows, finches and buntings in most field types, over 90% of individuals

can be recorded using the much less time-consuming perimeter count method.

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