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Birds on farmsteads – effects of landscape and farming characteristics

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The farmstead, a neglected habitat in studies of birds, is an alternative to other non-cropped habitats in modern farmland. This study aimed at identifying farmstead and landscape parameters that affect the bird fauna in 16 farmsteads in south central Sweden. Bird community composition (RDA) and abundance of several farmland bird species differed significantly between the two studied regions (Uppsala and Heby). We interpret this result as an effect of the degree of openness of the forest-farmland landscape, as no other habitat variables differed between farmsteads in the two adjacent regions. The area of buildings on the farmstead affected bird community composition, total bird density and several abundant species nesting in buildings. Farm production type (livestock or arable production) influenced community composition, species richness and abundance of single species and also total bird abundance. Most of the 42 bird species found in the farmsteads are common in Sweden, but 26 of the species have declined nationally in Sweden since 1975. Farmsteads deserve more attention in conservation of birds in farmland landscapes.

1. Introduction

The intensification of agriculture has dramatically changed the agricultural landscape (Meeus 1993; Fuller *et al.* 1995; Krebs *et al.* 1999; Stoate *et al.* 2001; Benton *et al.* 2003). Loss of semi-natural grassland and non-farmed habitats, simplified crop rotations and more homogeneous and dense crops because of the use of fertilizers and pesticides have all resulted in decreasing bird populations throughout European farmland (Braae *et al.* 1988, Wilson *et al.* 1997, Siriwardena *et al.* 1998). A neglected habitat that might be of importance for farmland biodiversity is the farmstead, including the farmer's house, yard, garden, barns, stables, other buildings and the environment surrounding them (Lack 1992, Freemark & Kirk 2001). In a Finnish study, farmsteads had higher densities of birds in general, including red-listed birds, than other habitats (Virkkala *et al.* 2004). The farmstead is an alternative habitat to edge zones and other non-cropped habitat patches for farmland birds.

Farmsteads offer sheltered nest sites (in houses, nest boxes, trees and shrubs) and food resources, in particular a high abundance of insects, cereals and other seeds, fruit and berries (Mason 2000). Farmland bird species, such as the House Sparrow (*Passer domesticus*), Common Swift (*Apus apus*), House Martin (*Delichon urbicum*) and White Wagtail (*Motacilla alba*), are connected with farmsteads and other human settlements (Lack 1992, Söderlund 2005, Ringsby *et al.* 2006) and all show decreasing populations in Sweden (Lindström & Svensson 2006). In general, animal husbandry (with pastures and manure facilities) is assumed to positively affect farmland birds (Pärt & Söderström 1999, Söderström & Pärt 2000, Ambrosini *et al.* 2002, WallisDeVries *et al.* 2002, Tryjanowski *et al.* 2005). This impact is illustrated by the decrease of the Barn Swallow (*Hirundo rustica*) population in Denmark as a consequence of the decline in livestock farming (Møller 2001).

Farmsteads with trees and shrubs may also attract both farmland and forest birds (Lack 1992). For instance, rural built-up areas covered only 5% of the land cover but hosted 35–60% of the observations of different thrush species in Eastern England (Mason 2000). These species are also associated with forest habitats (Berg 2002b). Even a small proportion of forest (10–20%) in the open farmland may change the dominance in bird assemblages from farmland species to forest species (Berg 2002a).

However, the importance of the farm production type (livestock or arable production) and habitat structure on the farmstead for the farmstead bird fauna is not known in detail. Moreover, small habitat patches, such as farmsteads, might be strongly influenced by surrounding habitat composition, as has been shown for semi-natural pastures (Pärt & Söderström 1999) and short-rotation coppices (Berg 2002b).

The aim of the present study was to investigate how farmstead habitat structure, farm production type (livestock or arable production) and surrounding landscape composition affect the bird fauna on 16 farmsteads in south-central Sweden.

2. Material and methods

2.1. Study area

The 16 farms were situated in south-central Sweden in the county of Uppland. Eight of the farms were situated in the intensively managed agricultural area in a radius of 14 km around the city of Uppsala (59º50’ N, 17º38’ E). The other eight farms were situated in the mixed forest/farmland landscape in a radius of nine km around the small town of Heby (59º56’ N, 16º51’ E), situated 60 km west of Uppsala. The two areas mainly differed in the proportion of forest and agricultural land surrounding the farms.

The farm sizes varied from 34 to 600 ha. The main business on the farms ranged from conventional piglet production to organic dairy production, and from intensive cereal production to part-time farming with some cereal production. The farms were chosen based on the farmer’s willingness to participate in an interview study (Ahnström & Hallgren 2006). We consider this selection of study sites randomized with respect to the location of the farm in the landscape and the production type of the farm.

The landscape surrounding each farmstead was analyzed with ArcGIS 9.1 (ESRI) using (a) the terrain map (vector map) from the Swedish Land Surveying Authority, and (b) the map of subsidized agricultural fields (given in field units) and the corresponding crop data from the Swedish Board of Agriculture. In these crop data, one field unit may have more than one crop but each crop does not have GIS data. In cases where the field unit had more than one crop, the crop with the largest area was chosen to represent the whole field unit. The GIS analysis was done within circles with different radii (100–2,400 m), but only data from 300 m was used in the statistical analysis due to the strong correlation between the different scales.

The habitat composition of the farmstead was initially described by the following habitat variables: number of buildings, trees and nest boxes per hectare of farmstead, the area covered by buildings, lawn, graveled yard, shrubs, manure heap or slurry pit, storage and pasture.

The moderate number of farmsteads in this study (n = 16) forced us to reduce the number of explanatory variables. Therefore, we selected variables with low intercorrelations (all r <0.3) that represented farm production type, farmstead habitat structure and composition of the surrounding landscape. The final five variables selected were Region (Uppsala or Heby; a measure of surrounding landscape composition, with more farmland and less forest in Uppsala than in Heby), house area, number of trees/ha in a farmstead, occur-

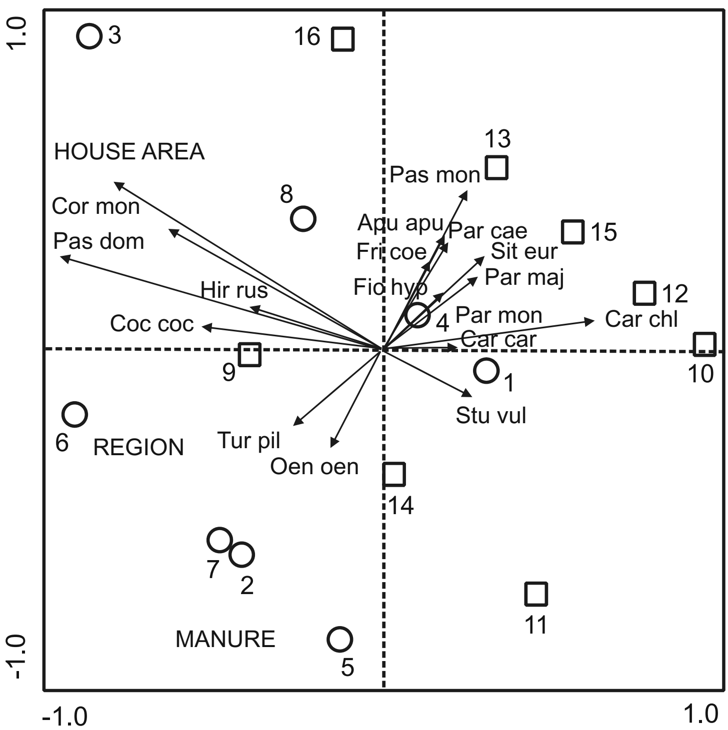

Fig 1. RDA for bird data of max abundance and the following environmental variables: Region, House area, Manure, number of trees and proportion of annual crops. Three variables corresponded significantly with the axis (999 Monte Carlo randomizations); House area (p = 0.001), Region (p = 0.006) and Manure (p = 0.016). These variables cumulatively explain 34%, 58% and 76% of the variance. Manure and Region are not shown with arrows due to their non-continuous character. Only species connected with the axis by at least 20% are shown, but all species were included in the analysis. Uppsala farms are indicated by circles and Heby farms by squares. For species abbreviations, see Appendix 1.

rence of manure facilities (categorical variable) and proportion of annual crops within 300 m from the farmstead (an indicator of intensity of farming in the surrounding landscape).

2.2. Bird censuses

The abundance of birds was surveyed four times at each farmstead from late April to mid-June 2005, between 08.00 and 14.00. The rather late starting hour of the inventory was to respect the privacy of the farmers' family, and because most of the birds in the farmsteads could be efficiently observed throughout the day. The census method used involved a slow, one-hour, walk covering the whole farmstead area. The farms were visited in different order and time of the day to avoid biases due to differences in bird observability.

All adult bird individuals, heard or seen, were noted and the total number of individuals for each species was added up for each visit. However, due to the low number of visits, the visit with the highest number of individuals per species was used as an estimate of the abundance of different species in the analyses (Berg 2002b). The third author, responsible for the inventory, conducted the walk in a way to minimize the risk of counting the same bird twice. Bird taxonomy follows Clements (2007).

2.3. Statistical methods

The proportional farmstead house area and annual crops within 300 m were Arcsine-transformed. No other habitat variables were transformed.

Multivariate techniques (CANOCO 4.5; ter Braak & Smilauer 2002) were used to analyze bird community composition in relation to the selected habitat variables. An initial, detrended correspondence analysis (DCA) was done in order to estimate the compositional gradient length of the bird species data.

The short gradient length (1.3) suggested that redundancy analysis (RDA) should be used for further analyses. In the RDA analysis a manual forward selection of environmental variables and a Monte Carlo test (unrestricted, full model; 999 permutations) was used for identifying significant

Table 1. Effects of local and landscape variables on farmstead bird species richness and total abundance in stepwise analyses. For the whole model dependent variables, R^2, F value and p value (p-model) are presented. For each variable entering the model, the parameter estimate (P.E. values), standard error (S.E.) and p values (p parameter) are presented in the order they were entered into the model. Manure – occurrence of manure treatment facilities, HA – house area, Ann_300 – proportion of annual crops within a 300-m radius from the farmstead.

Dependent variable parameter	Model R^2	F Model	p model	Parameter	PE	SE	p
Species richness	0.28	5.56	0.0334	Manure	3.19	1.35	0.0334
Max abundance	0.29	5.66	0.0321	Manure	35.69 (-)	14.99	0.0321
	0.51	6.89	0.0091	HA	4.02	1.63	0.0285
	0.67	8.01	0.0034	Ann_300	0.73 (-)	0.31	0.0371

variables. The results were illustrated by using CanoDraw for Windows 4.1.

Multiple regressions with stepwise selection of independent variables (Proc Reg; SAS Institute Inc. 2002–2003) were used for analyzing species-richness and total abundance of birds/ha in a farmstead. The abundances of the most common farmland bird species (occurring on ≥ 7 farmsteads) were analyzed using log-linear regressions with stepwise selection of variables (software JMP 6.03) by using generalized linear models with a Poisson distribution and a log-link function.

3. Results

In total, 42 bird species were observed in the farmsteads. Twenty-two of these were considered principally forest species and 20 were considered farmland species (Appendix 1). Mean number of species was 17.1, and the species number ranged between 11 and 20 per farmstead. The most abundant species were House Sparrow, Tree Sparrow (*P. montanus*), Common Swift, Jackdaw (*Corvus monedula*) and Greenfinch (*Carduelis chloris*) (Appendix 2). The most widespread species (occurring at many farms) included Great Tit (*Parus major*), Chaffinch (*Fringilla coelebs*), Common Swift, Blue Tit (*Parus caeruleus*), White Wagtail and Tree Sparrow (Appendix 2).

The RDA revealed that the composition of the bird fauna in the farmsteads was influenced by farmstead production type (occurrence of manure facilities), farmstead structure (house area) and Region (Uppsala or Heby) (Fig. 1). These three variables explained 76% of the variance of the species composition. The composition of the farmsteads in the two regions did not differ significantly in any parameter (all p values >0.05), including also the variables in the initial exploratory analysis.

Manure treatment facilities on a farm were positively associated with total species richness, but were negatively associated with total abundance (Table 1). The negative association between manure and bird abundance is explained by the fact that some abundant birds, such as Jackdaw and Tree Sparrow, were negatively associated with manure. No other variables were associated with total species richness. Total bird abundance was also positively associated with house area and negatively associated with the proportion of annual crops in the surrounding areas (Table 1). Thus, region did not affect total species richness or total abundance. However, Uppsala hosted more farmland bird species than did Heby, while the number of forest birds did not differ between these regions.

In general, the single-species models for farmland birds corroborated the other analyses, i.e., region, house area and the occurrence of manure facilities mostly explained the abundance of birds. Some species, such as Fieldfare (*Turdus pilaris*), Jackdaw and Starling (*Sturnus vulgaris*), were associated with the open landscapes of Uppsala, and some species, such as Yellowhammer (*Emberiza citrinella*), Wheatear (*Oenanthe oenanthe*) and Common Swift, were more common in the mosaic landscapes of Heby. In addition, fifteen scarce species occurred in only one of the regions (Appendix 2). The occurrence of manure facilities also positively influenced the abundance of House Sparrow, Barn Swallow and Starling, and the nega-

Table 2. Effects of local and landscape variables on individual farmstead bird-species abundance in Poisson regression models. Explanatory variables are Region (Uppsala or Heby), House Area in a farmstead (HA), the number of Trees (nTree), the occurrence of Manure-treatment facilities (Manure) and the cover of Annual Crops within 300 m from the farmstead (AC). The model also includes the interactions between Region and Manure (R*M), and Region and Annual Crops (R*AC). The significance levels are +/- <0.05, ++/-- <0.01 and +++/--- <0.001. Symbols within brackets are marginally significant (*p* <0.1).

Species	Scientific	Region	HA	nTrees	Manure	AC	R*M	R*AC
Common Swift	*Apus apus*	---		+++		---		--
Greenfinch	*Carduelis chloris*		---	++	-			
Jackdaw	*Corvus monedula*	+++	+++	---	---			
Yellowhammer	*Embriza citrinella*	-	-		+		+++	
Barn Swallow	*Hirundo rustica*		+++		+			---
White Wagtail	*Motacilla alba*							
Wheatear	*Oenanthe oenanthe*	-					(-)	
House Sparrow	*Passer domesticus*	(-)	+++		+++	--	--	
Tree Sparrow	*Passer montanus*	(-)		-	---			++
Magpie	*Pica pica*		-					
Starling	*Sturnus vulgaris*	+++	+++				+++	
Fieldfare	*Turdus pilaris*	++					(+)	

tively influenced the abundance of Greenfinch, Tree Sparrow and Jackdaw. Furthermore, the effect of manure facilities varied between the two regions (significant interaction Region x Manure) for three species (Table 2). Manure was more important in forested areas than in farmland areas for the abundance of some species.

The farmstead house area was positively associated with the abundance of several species nesting in colonies that are often found in buildings: House Sparrow, Barn Swallow, Jackdaw and Starling. The same factor negatively affected the abundance of Yellowhammer and Magpie (*Pica pica*) (Table 2). Fewer species were associated with the abundance of trees in the farmstead (a positive response for Greenfinch and Common Swift) and with the proportion of annual crops within 300 m, although the latter variable also significantly interacted with region for some species (Table 2).

4. Discussion

We showed that farmsteads may host bird species of both farmlands and forests. Three factors, namely region, house area and the occurrence of manure facilities, had the strongest effect on the farmstead bird fauna studied. The effects of the proportion of annual crops in the surrounding areas and the abundance of trees in the farmsteads were weaker and restricted to a few species.

Region (Uppsala vs. Heby) had a strong influence on the bird assemblage composition (Fig. 1) and on the abundance of several farmland species (Table 2). We interpret this as an affect of the degree of openness of the forest-farmland landscape surrounding the farmsteads, because no other habitat variables differed between farmsteads of the two regions. The landscapes in Heby had relatively large proportions of forest (56% within 2400 m). This was associated with several forest species (Fig. 1), but also with some farmland species such as Yellowhammer and Wheatear (Table 2) that prefer edge habitats and semi-natural pastures (Pärt & Söderström 1999, Söderström & Pärt 2000, WallisDeVries *et al.* 2002).

The more open landscapes surrounding the farmsteads of the Uppsala region (30% forest within 2400 m) were associated with farmland bird species (Fig.1, Table 2). Jackdaw, Starling and Fieldfare that often forage in open landscapes (Møller 1983) were particularly abundant. The strong effect of the surrounding landscape composition is in line with other studies of habitat patches with restricted size such as semi-natural pastures (Pärt & Söderström 1999, Söderström & Pärt 2000, WallisDeVries *et al.* 2002), short-rotation coppices (Berg 2002b) and forest patches (Berg

Table 3. Total species richness and percentage of species in different categories describing main habitat, nest type, home-range size and migration distance in the present and two other studies of farmland birds in the same region. Classification follows Berg (2002b).

	Farmland Berg 2002b	Farmland Söderlund 2005	Farmstead This study
Total species richness	59	39	42
Main habitat			
Forest species (%)	41	38	52
Farmland species (%)	59	62	48
Nest type			
Open (%)	76	64	52
Cavity (%)	24	33	48
Home range			
Small (%)	39	28	19
Intermediate (%)	31	41	36
Large (%)	30	28	43
Migration			
Resident (%)	26	36	43
Short (%)	31	38	26
Long (%)	43	26	31

1997). The effects of the surrounding landscapes can be due to several factors; the use of adjacent habitats by birds nesting in the farmstead, immigration from adjacent habitats (e.g., forests for forest birds in farmsteads), and interactions with other species in the areas surrounding the farmstead (e.g., predators).

The second factor that affected the bird fauna in the farmsteads was the area of buildings on the farmstead. This factor affected bird assemblage composition and the abundance of several farmland bird species (Fig. 1, Table 2). Several abundant species nesting in buildings (e.g., House Sparrow and Jackdaw) were positively associated with this factor, which also resulted in a positive correlation between the total bird abundance and house area (Table 2). In contrast, shrub- and tree-nesting species (e.g., Greenfinch and Yellowhammer), were negatively associated with this factor.

The third factor that strongly influenced the bird fauna was the occurrence of manure facilities on the farmstead. This factor was positive for the abundances of e.g., House Sparrow, Barn Swallow, Yellowhammer and Starling, but some species (Tree Sparrow, Jackdaw and Greenfinch) were negatively linked to this factor (Table 2). This factor also influenced the assemblage composition, species richness and total abundance of birds (Fig. 1, Table 1). Farms with manure facilities had 50% more bird food (mostly insects) than farms without these facilities (Møller 2001). This factor can significantly contribute to the composition of bird fauna.

Most bird species found in the farmsteads are common in Sweden, although most of these (26) have decreased in abundance since 1975, only eight have stable populations, and eight species have increased (Appendix 1). Several of the decreasing farmland species are associated with animal husbandry (this study; see also Møller 2001, Virkkala *et al.* 2004) or semi-natural pastures (Pärt & Söderström 1999). The decline in the number of farms with animal production, especially dairy farms (Statistics Sweden 2006) will negatively affect the bird fauna, leading to a decreased area of grazed grassland and fewer farms with livestock (Møller 2001). For the conservation of farmland bird populations, it is important to encourage farmers to continue animal production on their farms. However, the promotion of such protocols with agri-environmental schemes appears difficult because of the complex decision of whether or not to have animals. Apart from an interest by the farmer, there are other factors to consider, such as the recruitment of staff, the cost of buildings, meat prices and proximity of a slaughter house.

We compared the ecological characteristics of the bird fauna of farmsteads with that of adjacent agricultural fields with autumn sown crops (Söderlund 2005) and farmland sites in field-forest mosaics (Berg 2002a) (Table 3). The farmsteads harbored fewer open-nesting species but more hole-nesters and species with larger home ranges than farmland landscapes in the same region. A probable reason for the generally low proportion of open-nesting species is the high risk of predation in farmsteads due to the occurrence of avian predators and domestic cats (Birkhead 1991, Gillies & Clout 2003, Woods *et al.* 2003).

Many species in farmsteads have relatively large home ranges (e.g., Swift, Swallow, Starling), suggesting that surrounding areas are used for foraging. Consequently, composition of the surrounding landscape may be important for the occurrence of these species. However, we found no significant effect of landscape composition on bird species richness or abundance when connectivity between farmsteads, measured as number of farms and houses in the vicinity, was included. More sophisticated connectivity measures may produce significant results, as demonstrated in other studies (Moilanen & Nieminen 2002). One explanation could be that farmsteads in the Swedish landscape are relatively evenly distributed due to the Swedish land reform in the 1850's. Thus, the farmsteads studied often had another farmstead within 500–1,300 m; however in the present study only one farmstead had another farmstead closer than 100 m. It is probable that species with large home ranges, e.g. Common swift, Jackdaw, Barn Swallow, can exploit several farms within the breeding season, while the farmsteads could be seen as separate units by more local species with smaller home ranges. However, connectivity measures should probably include different habitats for different species (e.g., forest and farmland birds), and different species probably have different threshold levels at which their habitats become connected (Clergeau & Burel 1997, Tischendorf & Fahrig 2000).

Annual crops (e.g., cereals) may generally be less attractive than permanent crops (e.g., ley and pasture) as foraging areas for several bird species (Aebischer & Ward 1997, Potts 1997, Olsson *et al.* 2002). However, some species prefer annual crops, which might explain the weak associations between bird abundance and proportion of annual crops in the surrounding landscape.

The farmsteads also harbored more forest species and more resident birds than forest-farmland mosaics (Table 3). The reasonably high numbers of forest species even in the farmsteads of the Uppsala region suggest that the amount of forest (30% within a radius of 2,400 m of the farmstead) was sufficient for a wide range of forest species. This result is supported by previous studies that have shown that population effects of forest fragmentation occur when habitat proportions decrease below 30% (Andrén 1994, Lindenmayer *et al.* 2008).

To conclude, farmsteads harbor several bird species, including species exhibiting population declines. We found that landscape composition, the area of houses and the occurrence of manure treatment facilities are key determinants of farmstead bird fauna. The simplification of agricultural landscapes through agricultural intensification and other forms of human land use, such as farmsteads and gardens, warrants special attention. These processes often negatively affect threatened farmland birds, but the persistence of these birds can be ensured in simple ways if farmers' attitudes are favorable towards birds. Many farmers willingly and voluntarily support birds in their farmsteads not only by putting up nest boxes and bird feeders, but also by allowing the birds to nest on and in their houses. In fact, many farmers also appear to be interested in and have substantial knowledge about birds and their ecology. Projects aimed at open discussion and meetings among conservationists, ornithologists and farmers are more likely to lead to successful conservation than are general agri-environmental schemes. A good example of this success is the Volunteer and Farmer Alliance in the U. K. (Smallshire *et al.* 2004) and the cooperation of Swedish amateur ornithologists and farmers (Caselunghe 2007).

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Fåglar i gårdsmiljöer – effekten av landskapskomposition och jordbrukssystem

Gårdsmiljöer är ett viktigt habitat för fåglar i jordbrukslandskapet, men få studier har fokuserat på detta habitat. Målsättningen med denna undersökning var att identifiera habitatvariabler (som beskriver gårdsmiljö och omgivande landskap) som påverkade fågelfaunans sammansättning på 16 gårdar i mellersta Sverige. Fågelfaunans sammansättning (analyserat med multivariat RDA) och abundansen av flera fågelarter skiljde signifikant mellan två studerade områden (Uppsala och Heby). Detta tolkas som en effekt av det omgivande landskapets öppenhet (mängd skog), eftersom inga andra variabler skilde sig signifikant mellan gårdarna i de två områdena. Mängden (areal) byggnader påverkade också fågelfaunans sammansättning. Flera av de vanligaste jordbruksfåglar påverkades positivt av denna faktor, vilket resulterade i en positiv korrelation mellan arealen byggnader och total abundans av fåglar.

Gårdens driftsinriktning (djur- eller växtproduktion) påverkade också fågelfaunans sammansättning, artrikedom, abundans av enskilda arter och total abundans av fåglar. De flesta av de 42 observerade fågelarterna är vanliga häckfåglar i Sverige, men 26 av arterna uppvisar minskande populationer sedan 1975. Gårdsmiljöer behöver därför uppmärksammas mer i diskussioner om åtgärder för att bevara jordbrukslandskapets fågelfauna.

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Appendix 1. Farmstead birds of the present study (Berg 2002b). Status: Increase (+) or decrease (–) of population from 1975 to 2005, n.s.= no significant trend (Lindström & Svensson 2006). Type: FOrest or FArmland bird species. Home range: Small (<100 m from the nest), Intermediate (100–200 m) and Large (>200 m). Nest: Cavity (C) or Open (O). Migration: Resident, Short-distance migration and Long-distance migration. Classifications according to Clements (2007).

Species	Scientific	Abbr.	Status	Type	Home range	Nest	Migration
Mallard	*Anas platyrhynchos*	Ana pla	+	FA	L	O	S
Rock Dove	*Columba livia*	Col liv	+	FA	L	C	R
Woodpigeon	*Columba palumbus*	Col pal	–	FA	L	O	S
Common Swift	*Apus apus*	Apu apu	–	FA	L	C	L
Great Spotted Woodpecker	*Dendrocopos major*	Den maj	–	FO	L	C	R
Barn Swallow	*Hirundo rustica*	Hir rus	n.s.	FA	L	C	L
House Martin	*Delichon urbicum*	Del urb	–	FA	L	O	L
White Wagtail	*Motacilla alba*	Mot alb	–	FA	I	O	L
Tree Pipit	*Anthus trivialis*	Ant tri	–	FO	S	O	L
Blackbird	*Turdus merula*	Tur mer	+	FO	I	O	S
Fieldfare	*Turdus pilaris*	Tur pil	–	FA	L	O	S
Redwing	*Turdus iliacus*	Tur ili	n.s.	FO	I	O	S
Willow Warbler	*Phylloscopus trochilus*	Phy tro	–	FO	S	O	L
Garden Warbler	*Sylvia borin*	Syl bor	n.s.	FO	S	O	L
Lesser Whitethroat	*Sylvia curruca*	Syl cur	n.s.	FO	S	O	L
Spotted Flycatcher	*Muscicapa striata*	Mus str	–	FO	I	O	L
Pied Flycatcher	*Ficedula hypoleuca*	Fic hyp	–	FO	S	C	L
Robin	*Erithacus rubecula*	Eri rub	–	FO	S	C	S
Redstart	*Phoenicurus phoenicurus*	Pho pho	–	FO	I	C	L
Whinchat	*Saxicola rubetra*	Sax rub	–	FA	S	O	L
Wheatear	*Oenanthe oenanthe*	Oen oen	–	FA	I	C	L
Marsh Tit	*Parus palustris*	Par pal	–	FO	I	C	R
Willow Tit	*Parus montanus*	Par mon	–	FO	I	C	R
Great Tit	*Parus major*	Par maj	–	FO	I	C	R
Blue Tit	*Parus caeruleus*	Par cae	+	FO	I	C	R
Nuthatch	*Sitta europaea*	Sit eur	+	FO	I	C	R
Treecreeper	*Certhia familiaris*	Cer fam	–	FO	I	C	R
Jay	*Garrulus glandarius*	Gar gla	–	FO	L	C	R
Magpie	*Pica pica*	Pic pic	n.s.	FA	L	O	R
Jackdaw	*Corvus monedula*	Cor mon	n.s.	FA	L	C	R
Carrion Crow	*Corvus corone*	Cor corn	–	FA	L	O	R
Starling	*Sturnus vulgaris*	Stu vul	–	FA	L	C	S
Yellowhammer	*Embriza citrinella*	Emb cit	–	FA	I	O	R
Chaffinch	*Frigilla coelebs*	Fri coe	–	FO	S	O	S
Greenfinch	*Carduelis chloris*	Car chl	+	FA	I	O	R
Siskin	*Carduelis spinus*	Car spi	n.s.	FO	L	O	S
Goldfinch	*Carduelis carduelis*	Car car	–	FA	L	O	S
Linnet	*Carduelis cannabina*	Car can	–	FA	L	O	S
Bullfinch	*Pyrrhula pyrrhula*	Pyr pyr	–	FO	I	O	R
Hawfinch	*Coccoth. coccothraustes*	Coc coc	+	FO	L	O	R
House Sparrow	*Passer domesticus*	Pas dom	–	FA	I	C	R
Tree Sparrow	*Passer montanus*	Pas mon	n.s.	FA	I	C	R

Appendix 2. Information on the studied farms, including manure use (n = no, y = yes) and farmstead size. Species richness, total density, and density of each species are shown. Area: Uppsala (U), Heby (H). Total individuals are the sum of individuals over all four visits. For each species, the maximum abundance/ha from four visits is presented.

Area	U	U	U	U	U	U	U	U	H	H	H	H	H	H	H	H
Farm number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Manure in farmstead	n	n	y	y	y	y	y	n	y	n	y	n	y	n	n	n
Farmstead area (ha)	0.78	0.79	0.41	0.50	1.46	1.23	1.13	0.69	0.61	0.47	1.03	0.44	0.54	0.79	0.56	0.44
Species richness	16	20	13	19	21	17	16	19	20	16	20	11	13	18	20	14
Total bird ind.	100	89	132	112	159	177	152	122	186	135	138	79	102	88	96	105
Passer domesticus	2.6	1.3	24.4	4.0	14.4	24.4	12.4	2.9	57.4	–	–	–	29.6	7.6	–	18.2
Passer montanus	11.5	7.6	14.6	20.0	–	8.1	3.5	17.4	8.2	21.3	9.7	31.8	11.1	5.1	8.9	13.6
Apus apus	2.6	1.3	14.6	8.0	1.4	2.4	5.3	2.9	4.9	12.8	9.7	4.5	11.1	21.5	10.7	18.2
Corvus monedula	9.0	5.1	48.8	2.0	–	2.4	8.8	10.1	4.9	4.3	–	–	–	–	–	2.3
Carduelis chloris	2.6	1.3	–	18.0	4.8	1.6	1.8	5.8	–	14.9	1.9	13.6	3.7	3.8	14.3	4.5
Fringilla coelebs	6.4	2.5	4.9	10.0	3.4	2.4	2.7	5.8	4.9	10.6	1.9	4.5	5.6	2.5	3.6	9.1
Parus major	3.8	2.5	4.9	6.0	3.4	0.8	2.7	2.9	3.3	10.6	2.9	6.8	5.6	5.1	5.4	9.1
Motacilla alba	2.6	6.3	4.9	6.0	1.4	2.4	5.3	4.3	4.9	–	4.9	4.5	3.7	2.5	3.6	6.8
Sturnus vulgaris	2.6	2.5	17.1	2.0	1.4	2.4	5.3	18.8	4.9	–	2.9	–	–	–	3.6	–
Parus caeruleus	1.3	2.5	4.9	2.0	2.1	0.8	2.7	4.3	3.3	12.8	1.0	4.5	3.7	–	7.1	4.5
Hirundo rustica	–	2.5	14.6	4.0	5.5	1.6	2.7	–	6.6	–	4.9	–	3.7	–	3.6	4.5
Emberiza citrinella	5.1	1.3	7.3	6.0	0.7	0.8	–	1.4	1.6	8.5	4.9	6.8	–	7.6	1.8	–
Turdus pilaris	1.3	3.8	4.9	8.0	2.7	4.1	2.7	2.9	1.6	2.1	3.9	–	–	1.3	1.8	–
Sitta europaea	5.1	–	–	2.0	0.7	–	–	2.9	1.6	4.3	1.0	–	–	1.3	5.4	13.6
Ficedula hypoleuca	–	1.3	–	2.0	–	–	1.8	1.4	3.3	12.8	1.9	–	3.7	2.5	1.8	4.5
Pica pica	5.1	–	–	2.0	1.4	1.6	3.5	–	3.3	4.3	1.0	2.3	3.7	1.3	1.8	–
Turdus merula	2.6	1.3	–	–	2.1	0.8	0.9	–	–	–	–	–	–	2.5	1.8	4.5
Carduelis carduelis	–	–	–	–	2.7	–	3.5	–	6.6	–	1.0	–	–	–	–	–
Oenanthe oenanthe	–	1.3	–	–	–	–	–	–	–	–	–	2.3	1.9	1.3	3.6	2.3
Carduelis cannabina	–	–	4.9	–	1.4	–	–	2.9	–	–	1.9	–	–	–	–	–
Columba livia	–	–	–	–	–	1.6	–	–	1.6	–	–	–	7.4	–	–	–
Phylloscopus trochilus	–	1.3	–	2.0	–	0.8	–	–	–	2.1	1.0	–	–	1.3	1.8	–
Delichon urbicum	–	–	–	–	–	–	–	–	–	–	7.8	–	–	–	–	–
Erithacus rubecula	–	–	–	2.0	–	–	–	1.4	1.6	–	1.0	–	–	1.3	–	–
Parus montanus	–	–	–	–	–	–	–	–	–	6.4	–	–	–	–	–	–
Muscicapa striata	–	1.3	–	4.0	–	–	–	–	–	–	–	–	–	–	–	–
Dendrocopos major	–	–	–	–	–	–	–	–	–	4.3	–	–	–	–	–	–
Carduelis spinus	–	–	–	–	–	–	–	1.4	–	2.1	–	–	–	–	–	–
Columba palumbus	–	1.3	–	–	–	–	–	–	–	–	–	2.3	–	–	–	–
Garrulus glandarius	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3	1.8	–
Corvus corone cornix	1.3	–	–	–	–	–	–	–	1.6	–	–	–	–	–	–	–
Certhia familiaris	–	–	–	–	0.7	–	–	–	1.6	–	–	–	–	–	–	–
Anthus trivialis	–	–	–	–	–	–	–	–	–	–	1.0	–	–	1.3	–	–
Pyrrhula pyrrhula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	–
Sylvia curruca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	–
Anas platyrhynchos	–	–	–	–	–	–	–	1.4	–	–	–	–	–	–	–	–
Saxicola rubetra	–	–	–	–	–	–	–	1.4	–	–	–	–	–	–	–	–
Phoenicurus phoenicurus	–	–	–	–	1.4	–	–	–	–	–	–	–	–	–	–	–
Sylvia borin	–	1.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coccoth. coccothraustes	–	–	–	–	0.7	–	–	–	–	–	–	–	–	–	–	–
Parus palustris	–	–	–	–	0.7	–	–	–	–	–	–	–	–	–	–	–
Turdus iliacus	–	–	–	–	0.7	–	–	–	–	–	–	–	–	–	–	–