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Influence of agricultural landscape structure on breeding bird densities in lowland Polish farmland

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Abstract. The influence of agricultural landscape structure (field fragmentation, share of particular crop types and hedges) on relative density of breeding bird species was surveyed in 2005-2007 on 46 transects (width 200 m, length 540-1570 m each) in four lowland, flat regions of Poland. Correlation analysis showed that the densities of 14 bird species were related to particular landscape variables. Several strictly field bird species preferred fragmented fields, cereal cropland and grasslands. Several bird species preferred hedges and abandoned fields with high (>0.5 m) herbaceous vegetation consisting of perennial plants.

Key words: Agriculture, landscape management, bird habitats.

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I. INTRODUCTION

An increase and maintenance of bird abundance is one of the actions of integrated farming (e.g. HÄNI et al. 1998). Since the number of birds depends in a large measure on the structure of the landscape, the achievement of this goal necessitates the precise recognition of habitats of particular bird species. Such knowledge will enable landscape management favorable to bird protection. In Europe, research concerning the influence of agricultural landscape structure on abundance of breeding bird species has been conducted mainly in western and northern parts of the continent (e.g. GREEN et al. 1994; SPARKS et al. 1996; MASON & MACDONALD 2000a; AUNINŠ et al. 2001; HERZON et al. 2006). An especially suitable area for this type of investigation is Poland. A larger diversity of agricultural landscape occurs in Poland in comparison to other European countries. In Poland large fields occur close to small fields, landscapes with high shares of hedges – next to landscapes without hedges. This allows the study of a very broad spectrum of particular landscape variables. However, investigations into the influence of agricultural landscape structure on abundance of particular breeding species in this country have concerned only a few bird species or landscape components (PANEK & KAMIENIARZ 1998, 2000; KUJAWA 1999; TRYJANOWSKI et al. 1999; KOSIŃSKI & TRYJANOWSKI 2000; GOŁAWSKI & DOMBROWSKI 2002; DOMBROWSKI & GOŁAWSKI 2004; SUR-

MACKI 2004, 2005). Only SANDERSON et al. (2009) have published a more comprehensive study, which however dealt with a mixed landscape (with a share of woodlands). The aim of my study was to examine the effect of agricultural crop structure and share of hedges in an agricultural landscape on densities of many breeding bird species in typical lowland Polish farmland.

II. STUDY AREAS AND METHODS

The field surveys were carried out in 2005-2007 on 46 transects (width 200 m, length 540-1570 m each; mean area 19.5 ha, SD ± 4.4 ha) in four lowland, flat regions of Poland with a different agricultural landscape structure: 2005 – Oleśnica Plain (Lower Silesia, 51º04-12´N, 17º04-14´E, 19 transects); 2006 – Garwolin Plain (eastern Masovia, 52º00-02´N, 21º27-33´E, 6 transects) and Łowicz-Błonie Plain (western Masovia, 52º12-13´N, 20º31-35´E, 9 transects); 2007 – Września Plain (western Wielkopolska, 52º20-22´N, 17º39-45´E, 12 transects). Localisation of regions in which the examined transects were situated is presented in Figure 1.

Nine variables describing agricultural landscape structure (landscape variables) were used in the analysis (Table I). Mean values of landscape variables on transects in particular regions are shown in Table II. Lower Silesia and western Wielkopolska are dominated by medium and large fields.

Fig. 1. Localisation of regions in Poland in which examined transects were situated: 1 – Oleśnica Plain, 2 – Garwolin Plain, 3 – Łowicz-Błonie Plain, 4 – Września Plain.

Table I

Variables describing agricultural landscape structure (landscape variables) used in the analysis and their range and frequency on transects

Variable	Explanation	Range	Frequency
SCER	spring cereals (except maize) [% of area]	0-78	72 %
WCER	winter cereals [% of area]	0-98	72 %
RAPE	winter rape [% of area]	0-63	28 %
BARE	bare ground or almost bare ground (potato, beet, maize, vegetables and lack of vegetation) [% of area]	0-100	83 %
GRAS	meadows and pastures [% of area]	0-100	33 %
LAF	low abandoned fields (height of herbaceous vegetation <50 cm) [% of area]	0-16	30 %
HAF	high abandoned fields (height of vegetation, consisting mainly of perennial herbaceous plants, >50 cm [% of area]	0-100	33 %
HED	hedges (both with tall trees and without tall trees) [m/10 ha]	0-500	61 %
FFI	field fragmentation index [number of fields (parcels occupied by one crop)/10 ha]	0.6-38.7	

Table II

Mean landscape variable values on transects in particular regions

	FFI	SCER	WCER	RAPE	BARE	GRAS	LAF	HAF	HED
Oleśnica Plain	6.1	12.0	21.4	5.3	19.2	9.1	2.2	29.6	103
Garwolin Plain	32.3	40.0	31.6	0	7.5	17.5	1.9	1.0	55
Łowicz-Błonie Plain	9.6	10.6	26.4	0	56.3	0.8	1.9	4.1	107
Września Plain	4.7	21.5	13.5	22.5	38.0	0.1	0.2	0	112

Września Plain is characterized by a high proportion of beet, vegetables and winter rape, Oleśnica Plain – by a high share of abandoned fields. Potato and vegetables are predominant on the agricultural landscape of the Łowicz-Błonie Plain. The eastern Masovia region is characterized by very strong field fragmentation, a low share of hedges and high share of spring cereals and grasslands. The transects were located away from woodlands, buildings and heavily used roads and were selected non-randomly – the goal was to survey a broad spectrum of landscape variables, therefore transects that differed in landscape structure were selected. For each transect the areas occupied by all crops, numbers of plots and lengths of hedges (landscape variables, see Table I) were determined on the basis of direct field measurements, maps and orthophotomaps. Crops occurring sporadically on transects were not taken into account, i.e. those that were present on not more than three transects (7 % of all transects), e.g. strawberry/wild strawberry, allotments, orchards, fruit shrubs and other crops.

Each transect was surveyed three times between 14 April and 3 June (at intervals of a minimum of 13 days), in morning and noon hours (5.30-13.00, exceptionally – only once – to 15.30). Mean control speed was 25 minutes/10 ha. All bird observations and their details (e.g. singing birds, simultaneous statements, battles between birds) were mapped. Birds flying above transects or foraging, without attachment to their breeding habitat, were omitted. In the case of skylark special attention was given to sites of take-off and landing. For each transect relative densities [pairs/10 ha] of particular bird species were determined on the basis of map examinations. Territories were considered as occupied on the basis of at least one record in the breeding season. For statistical analysis the relative densities of 16 most frequently recorded bird species (those occurring on at least 10 transects) were selected. The transect method is especially useful for studies on the habitat of birds at a larger scale (SURMACKI & TRYJANOWSKI 1999).

The correlation matrix of independent variables revealed only one high correlation (Spearman r_s coefficient >0.50; between field fragmentation index – FFI and low abandoned fields – LAF; Table III). Thus the intercorrelation of landscape variables was not a serious problem. Due to the lack of a normal distribution of part of the data ($p<0.01$ in Kolomogorov-Smirnov test, both before and after appropriate transformations), I carried out Spearman rank correlation analysis between independent variables (landscape variables, Table I) and dependent variables (relative density of particular bird species). P-values were adjusted using the Bonferroni correction.

Table III

Spearman correlation matrix of the landscape variables

	SCER	WCER	RAPE	BARE	GRAS	LAF	HAF	HED
FFI	0.48	0.27	-0.06	0.04	0.47	0.54	0.13	0.07
SCER		0.27	0.08	-0.28	0.23	0.17	-0.23	-0.07
WCER			-0.08	-0.19	0.13	-0.06	-0.23	-0.07
RAPE				0.11	-0.18	-0.32	-0.42	0.32
BARE					-0.17	-0.14	-0.28	0.11
GRAS						0.25	-0.09	-0.02
LAF							0.47	-0.01
HAF								0.10

III. RESULTS

A total of 44 breeding bird species was found on all transects (Table IV). 16 species occurred on at least 10 transects; Spearman rank correlation analysis showed that the densities of 14 of them were strongly positively correlated with some landscape variables (Table V). Relative densities of

Table IV

List of all breeding bird species found on 46 transects

Latin name	Common name	Latin name	Common name
Anas platyrhynchos	mallard	*Acrocephalus palustris*	marsh warbler
Perdix perdix	partridge	*Acrocephalus scirpaceus*	reed warbler
Coturnix coturnix	quail	*Hippolais icterina*	icterine warbler
Phasianus colchicus	pheasant	*Sylvia curruca*	lesser whitethroat
Charadrius dubius	little ringed plover	*Sylvia communis*	whitethroat
Vanellus vanellus	lapwing	*Sylvia borin*	garden warbler
Columba palumbus	woodpigeon	*Sylvia atricapilla*	blackcap
Cuculus canorus	cuckoo	*Parus major*	great tit
Lullula arborea	woodlark	*Cyanistes caeruleus*	blue tit
Alauda arvensis	skylark	*Lanius collurio*	red-backed shrike
Anthus campestris	tawny pipit	*Pica pica*	magpie
Anthus pratensis	meadow pipit	*Sturnus vulgaris*	starling
Motacilla flava	yellow wagtail	*Passer montanus*	tree sparrow
Motacilla alba	white wagtail	*Fringilla coelebs*	chaffinch
Luscinia megarhynchos	nightingale	*Serinus serinus*	serin
Saxicola rubetra	whinchat	*Carduelis chloris*	greenfinch
Saxicola rubicola	stonechat	*Carduelis carduelis*	goldfinch
Turdus merula	blackbird	*Carduelis cannabina*	linnet
Turdus pilaris	fieldfare	*Emberiza citrinella*	yellowhammer
Turdus philomelos	song thrush	*Emberiza hortulana*	ortolan bunting
Locustella naevia	grasshopper warbler	*Emberiza schoeniclus*	reed bunting
Acrocephalus schoenobaenus	sedge warbler	*Emberiza calandra*	corn bunting

three strictly field (foraging and nesting on open fields, presence of shrubs and trees irrelevant) species (partridge, yellow wagtail, and particularly skylark) were strongly positively correlated with the field fragmentation index – FFI (Table V). Skylark clearly preferred grasslands and spring cereals, and quail – winter cereals (Table V). Relative densities of seven species were strongly positively correlated with high abandoned fields – HAF (Table V). A strong positive correlation was found between relative densities of four species and hedges – HED (Table V).

Table V

Spearman rank correlation coefficients (r_s) between relative density of particular species and landscape variables (n = 46). Statistically significant (Bonferroni correction, p<0.0056) relationships are bold and underlined

Species	FFI	SCER	WCER	RAPE	BARE	GRAS	LAF	HAF	HED
Perdix perdix	**0.45**	0.33	0.23	0.17	-0.13	0.27	0.20	-0.03	0.19
Coturnix coturnix	0.36	0.13	**0.45**	-0.34	-0.07	0.34	0.32	0.14	-0.20
Phasianus colchicus	0.18	-0.19	-0.18	-0.28	-0.01	-0.26	**0.50**	**0.66**	0.13
Vanellus vanellus	0.24	0.10	0.05	-0.17	0.02	0.10	0.28	0.20	-0.01
Cuculus canorus	-0.10	-0.06	-0.13	0.34	0.13	-0.17	-0.00	-0.02	**0.54**
Alauda arvensis	**0.60**	**0.51**	0.37	-0.26	-0.26	**0.63**	0.39	0.01	-0.07
Motacilla flava	**0.51**	0.34	0.40	0.10	0.23	0.25	0.03	-0.33	0.13
Saxicola rubetra	0.08	-0.37	-0.22	-0.22	-0.30	-0.03	0.33	**0.83**	0.09
Turdus merula	-0.28	-0.30	-0.11	-0.01	-0.07	-0.14	-0.08	0.36	0.36
Locustella naevia	-0.12	-0.38	-0.17	-0.21	-0.21	-0.21	0.30	**0.73**	0.01
Acrocephalus palustris	-0.18	-0.29	-0.26	0.02	-0.00	-0.33	0.01	**0.46**	0.29
Sylvia communis	0.06	-0.18	-0.20	0.22	-0.08	-0.18	0.29	**0.41**	**0.70**
Lanius collurio	0.07	-0.16	-0.27	-0.00	-0.05	0.01	-0.00	0.37	**0.44**
Emberiza citrinella	-0.10	-0.04	-0.25	0.33	-0.10	-0.14	-0.11	0.16	**0.64**
Emberiza schoeniclus	-0.16	**-0.43**	-0.20	-0.25	-0.21	-0.26	0.27	**0.76**	0.06
Emberiza calandra	0.00	-0.18	-0.00	-0.13	-0.37	0.00	0.26	**0.48**	0.27

IV. DISCUSSION

The results showed the influence of particular agricultural landscape variables on densities of 14 breeding bird species. Because this study was conducted in considerably diversified Polish farmland, the detection of hitherto unreported relationships was possible. This especially concerns the influence of field fragmentation (a broad spectrum of values of this landscape variable was investigated) on abundance of some species. The present study was carried out in spring (mid April – beginning of June) and these results should be related only to this period, because later growth of vegetation can have an effect on the number and distribution of birds.

The finding of a strong positive effect of field fragmentation on the density of skylark is consistent with results of other European studies (SCHLÄPFER 1988; JENNY 1990; ERAUD & BOUTIN 2002). Some studies showed differing optimal heights of vegetation for this species: 15-25 cm (JENNY 1990), <20-25 cm (SCHLÄPFER 1988), 20-50 cm (WILSON et al. 1997), 15-60 cm (TOEPFER & STUBBE 2001). Skylark breed on average 2.4-2.8 times per year (DELIUS 1965; JENNY 1990). Single crop types rarely ensure profitable vegetation structure for nesting for the whole breeding season, therefore a structurally diverse crop mosaic, which depends on field fragmentation, is favorable for this species (WILSON et al. 1997). Crop diversity within breeding territory can be favorable for nesting and also foraging – it can increase and diversify food resources on account of the variability of food accessibility in time and space. Field fragmentation is particularly important for species which forage and nest only or mainly on open fields (besides skylark also such species as yellow wagtail and partridge). PANEK and KAMIENIARZ (1998, 2000) showed a positive effect of field fragmentation on density of partridge (consistent with the results of this study), and KOSIŃSKI and TRYJANOWSKI (2000) – on the abundance of yellowhammer and corn bunting (not supported in this study).

Particular crop types (spring cereals, winter cereals, grasslands) are preferred by some species (skylark, quail). It seems that the height of vegetation in these crops in spring is optimal for these species. Results of other European research also showed a preference of skylark to spring cereals (AUNIŅŠ et al. 2001; TOEPFER & STUBBE 2001) and grasslands (POULSEN et al. 1998; PIHA et al. 2003). However, this study did not find a preference of lapwing for spring cereals, which was shown by GALBRAITH (1988) and AUNIŅŠ et al. (2001), and also the finding of GOŁAWSKI and DOMBROWSKI (2002) of a preference of corn bunting for grasslands. A preference for abandoned fields for such species as whinchat, grasshopper warbler, marsh warbler, whitethroat and corn bunting is consistent with results of other research (FISCHER & SCHNEIDER 1996; AUNIŅŠ et al. 2001; GOŁAWSKI & DOMBROWSKI 2002; DOMBROWSKI & GOŁAWSKI 2004; HERZON et al. 2006). Moreover, this study showed a preference of pheasant and reed bunting for abandoned fields. In Great Britain and France, skylark preferred abandoned fields (CHAMBERLAIN et al. 1999; BROWNE et al. 2000; HENDERSON et al. 2000a; MASON & MACDONALD 2000a; ERAUD & BOUTIN 2002), in England also yellowhammer (HENDERSON et al. 2000b), and in Scotland – partridge (WATSON & RAE 1997). However, British and French abandoned fields are annually cut, and the height of vegetation does not exceed circa 50 cm (POULSEN et al. 1998; HENDERSON et al. 2000a, 2000b; ERAUD & BOUTIN 2002), they can be regarded as the equivalent of the category "low abandoned fields" in this study. The influence of low abandoned fields (height of herbaceous vegetation <50 cm) was insufficiently investigated in this study on account of their insignificant share in the area of particular investigated transects.

The positive influence of hedges on abundance of many bird species is well known (KYRKOS et al. 1998; PETERSEN 1998; SCHIFFERLI et al. 1999; MASON & MACDONALD 2000a; AUNIŅŠ et al. 2001). Some studies indicated that hedges are avoided by skylark (PETERSEN 1998; CHAMBERLAIN et al. 1999; KUJAWA 1999; SCHIFFERLI et al. 1999; MASON & MACDONALD 2000a), corn bunting (MASON & MACDONALD 2000b) and yellow wagtail (KUJAWA 1999), which was not found in this study – it is possible that this phenomenon occurs at a higher share of hedges than on the examined transects.

The question of spatial distribution of birds is very complicated. Bird numbers can be influenced by factors not included in the present study, such as: crop configuration, vegetation development pattern, hedges structure etc. These factors are presumably responsible for a part of the unexplained variation in bird density. It is necessary to do further surveys into the influence of agricultural landscape structure on bird abundance, best with experimentally delimited crop configuration.

The results of this study enable the formulation of several general management recommendations. In order to increase the density of many strictly field bird species it is recommended to increase field fragmentation through a reduction of size of fields (parcels occupied by a single crop). This especially concerns western and northern Poland where fields are larger than in the central and eastern part of the country. Abundance of species preferring high abandoned fields can be augmented by establishing small areas of high (>0.5 m) herbaceous vegetation consisting of perennial plants. An increase in density of many typical farmland bird species can be achieved by increasing the share of hedges. Convenient instruments for the realization of the above actions are agri-environment schemes, to which these actions should be included.

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