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BREEDING BIRD COMMUNITIES IN RELATION TO DIFFERENT HABITAT ISLANDS

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Abstract: The structural parameters were compared of bird communities in habitat islands in a farmland landscape within the Jura Landscape Park System near Kraków. Four types of island habitats were distinguished in line with their structure: woody, scrubby, field-meadow and mixed. The size of individual islands ranged from 0.3 to 40 hectares. In woody and mixed islands the number of breeding species, the species diversity indices (H') and the evenness indices (J') reached significantly higher values than those pertaining to scrubby and field-meadow islands (ANOVA, $p < 0.001$). The density of pairs was, however, the highest on the scrubby islands and differed significantly from the corresponding data obtained for mixed and field-meadow islands ($p < 0.001$). In the bird communities of the woody islands, the most numerous species were: Chaffinch *Fringilla coelebs* and Blackcap *Sylvia atricapilla*, whereas Marsh Warbler *Acrocephalus palustris* and Whitethroat *Sylvia communis* dominated in mixed and scrubby islands, and Skylark *Alauda arvensis* and Marsh Warbler dominated within field-meadow islands. The results obtained indicate that the maintainance of the habitat diversity in the agricultural landscape results in an increasing diversity of species in the bird communities and thus leads to the increased biodiversity of the area. Despite the usual sub-optimum character of the habitat islands they are of enormous importance to birds and, depending on the structure of habitats and plant communities, they also support their characteristic bird fauna. It is thus important that the nature conservation and physical planning in farmlands should not be limited to routine activities such as introducing tree belts or clumps, but should seek solutions at the level of the whole landscape, considering the role of environmentally different habitat islands in maintaining biodiversity.

Key words: breeding bird communities, habitat islands, habitat fragmentation, biodiversity, agricultural landscape, southern Poland.

INTRODUCTION

In the ecology of the landscape, so-called habitat islands are of paramount importance. This term describes patches of habitats surrounded and isolated by other, often contrasting types of ecosystems. These can be woods, tree clumps or green belts among cultivated fields, but also glades within large woodland complexes. They add to the mosaic character of otherwise homogenous anthropogenic landscapes (agricultural, urban or industrial), and the patches of natural vegetation constitute important refuges for many plant and animal species. The limited size and isolation of these habitats dispersed in an environment which is ecologically different, mirror the situation of islands scattered in an ocean, and thus in the interpretation of phenomena occurring in such ecological systems many researchers refer to the theory of island biogeography formulated by McArthur and Wilson (1967). It turned out later, however, that the determination of the biodiversity in the environmental islands, in terrestrial locations, is a much more complex process then implied by assessments and theories pertaining to ocean islands (Gilbert 1980; Middleton and Merriam 1983; Dąbrowska-Prot 1998). With the development of landscape ecology, the studies on the functioning of the environmental islands utilised both classic models of population ecology and the concept of metapopulation, in an attempt to explain in an understandable and effective manner, the causes of stabilisation or population changes in mosaic landscapes through theoretical models (Levins 1970; Łomnicki 1988; Gotelli and Kelley 1993; Hanski and Gilpin 1997; Moilanen and Hanski 1998).

The studies of birds in habitat islands already have a long tradition. Most authors do concentrate on the adverse effects of fragmentation of habitats, particularly of woodlands, with respect to breeding birds (Saunders et al. 1991;

Haila et al. 1993; Cieślak and Dombrowski 1993). The agricultural landscapes undergo particular pressure from human activity both in terms of space and time. Because of this, many organisms owe their chances of survival or residence in the area strictly on the presence therein of enclaves of natural or semi-natural environments. Ornithological studies have attempted to determine the importance of habitat islands to the populations of birds in relation to both the size of island and the degree of isolation (Opdam et al. 1985; Blake and Karr 1987), as well as the elements of the spatial structure of such islands (Bersier and Meyer 1994; McGarigal and McComb 1995). These studies provided then the basis for either the formulation of general conclusions for bird populations, depending on certain habitats characteristics (Rolstad 1991; Kujawa 1997), or for detailed guidelines aimed at particular species (Hinsley et al. 1995; Villard et al. 1995). Many authors (Virkkala 1987; Loman and von Schantz 1991; Bentley and Catterall 1997; Tworek 2001) indicate fairly equivocally that some bird species react favourably to the environmental changes resulting in the increased fragmentation of habitats or landscape. It seems understandable when agrocoenoses predominate in the landscape, but some studies suggest similar conclusions even with respect to the fragmentation of woodlands (Haila et al. 1994; Hagan et al. 1996; Nour et al. 1999). In a rapidly changing agricultural landscape it is important to evaluate the significance to birds of habitat islands of various type and origin, especially in view of the lack of direct comparisons within a single area.

Having in mind that the results of such studies should always be considered with respect to particular species with definite individual ranges, food and ecological requirements (Opdam 1991), I have tried to determine – against the background of the diversity of habitats of the agricultural landscape in the neighbourhood of Kraków – the similarities and differences in the communities of birds inhabiting islands of different habitat features, and then use this information to assess the value which they represent for birds in the agricultural landscape and to indicate the major threats. These results could find practical applications in physical planning and in nature conservation.

STUDY AREA

The study area is situated in an agricultural landscape within the Jura Landscape Park system, north-west of Kraków (50°06'-50°08'N, 19°45'-19°55'E). According to the physical-geographical divisions of Poland made by Kondracki (1994) the study area is chiefly within the Krzeszowicki trough mesoregion. This is a Tertiary fault block depression spanning along an east-west direction between the Olkusz upland and the Garb Tenczyński (Tenczyn hummock). This location at the border of two different geobotanical units results in a great natural variability of habitats and thence of vegetation. Fertile soils predominate and are mostly occupied by cultivated fields, as well as by meadows and fresh pastures, which, owing to intensive draining, fertilising and other agricultural practices have gradually replaced previous fertile moist meadows (Michalik 1980). Depending on the soil fertility two separate plant associations emerge:

- a complex of communities on fertile soils, occurring predominantly on loess soils and in river valleys where rape and maize predominate in cultivation, and
- a complex of communities on poorer soils where older sediments are covered by sands and loams, and cultivation is more diversified (cereals, root crops).

Bodies of water are important elements of the landscape. The most significant are the Rudawa river and its tributaries (of which the Będkówka and Kobylanka are the largest) and the Sudół stream, a tributary of the Prądnik stream. There are also several old river-beds along the Rudawa river, and numerous draining ditches and small streams. Usually, there are remnants of natural woodland communities near water bodies. Among the wet meadows, mainly in the Rudawa river valley, fragments of alder carrs occur, of much disturbed composition resulting from intensive draining. Along the Rudawa and Będkówka rivers, and in depressions in the terrain some fragments of riverine woodland occur. Wetlands in the depressions are occupied by mires overgrown by trees and shrubs to a varying degree. The species composition of bogs changes fairly rapidly because of drainage. Small patches dispersed among wet meadows, which are not managed for hay, and mires, form osier scrub beds, which emerged as a result of the overgrowing of the reed communities as well as replacing cut alder woods in marshy habitats. These also occur along streams and older drainage ditches. On hay meadows there are only individual osier clumps. Among wetter habitats, some patches of reed and rush communities and less fertile wet meadows of various stages of degradation can be found.

The plant associations of the study area are less dependent of the high level of moisture. The portion of the study area situated within the Garb Tenczyński is covered by multi-species oak-hornbeam forests with a predomination of beech. In several places, usually at the borders between cultivated fields and settlements there are orchards or tree groups of a park type, or garden allotments. The farmland where agricultural practices have been discontinued turns rapidly into communities of ruderal vegetation. There are also new tree belts or clumps planted, particularly in the areas closer to Kraków.

METHODS

I conducted field studies in the period 1995–1999. In the study area, I earmarked sample plots, which constituted habitat islands of various types. Depending on the predominating habitat, I adopted a conventional classification for four types of sample plots:

- woody (forests, tree clumps, tree lanes and green belts),
- scrubby (shrubs, osier beds, reed beds),

– field-meadow (meadows, pastures, cultivated fields, abandoned land),
– mixed (of ecotone character, often a combination of various habitats).

Table 1. The parameters of studied habitat islands in four types of plots

Parameter	Island type			
	woody	mixed	scrubby	field-meadow
N	30	31	17	24
Mean area (hectares)	10.43	15.94	9.6	19.48
Range (hectares)	0.8–38.0	0.9–40.0	0.3–31.0	2.3–35.0
SD	11.99	13.22	10.54	10.76

The parameters of the habitat islands are presented in Table 1.

In order to estimate the numbers of birds I used the territory mapping method (Bibby et al. 1992). In each breeding season, I conducted 7-11 counts on the sample plots. I started the counts usually early in the morning (4 am to 6 am) and continued till the evident drop in bird activity (usually between 11 am and 12 noon). Alternatively I started in the afternoon (4 am – 5 am) and continued till dusk. I tried to conduct at least one evening count in May or June on each sample plot. Depending on the weather conditions, the counts in subsequent years started at the end of March or the beginning of April and continued till July.

Then I charted all the observations on plans of plots prepared beforehand with orientation points already marked. On small, similar plots located next to each other I tried to locate as many nests as I could to determine to which plot a given pair or individual ranges should be ascribed. When I found no direct evidence of breeding, I based the determination of territory on at least three records of a singing male, pair of birds or other behaviour signifying the possession of a territory. When recording singing males of the most numerous species, I paid particular attention to simultaneous observations. I estimated the population density in Pheasants on the number of males calling, and in the case of Cuckoos, the only base for a record was the mating behaviour of a pair.

Each year, the following parameters of bird associations were estimated on sample plots: number of breeding pairs (*N*), species domination (N%), population density (N/hectare), number of species (*S*), and species diversity according to Shannon function (*H*'):

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i,$$

Table 2. Percentage domination of most numerous species in four types of habitat islands. In brackets the total number of breeding species per type of plot

WOODY (73 species)		MIXED (68 species)	
Species	% domination	Species	% domination
Fringilla coelebs	7.9	*Acrocephalus palustris*	15.7
Sylvia atricapilla	7.3	*Sylvia communis*	10.1
Parus major	6.1	*Turdus pilaris*	4.9
Turdus merula	5.2	*Carduelis carduelis*	4.7
Erithacus rubecula	4.8	*Emberiza citrinella*	3.2
Phylloscopus collybita	4.3	*Sylvia atricapilla*	3.1
Phylloscopus trochilus	4.1	*Carduelis cannabina*	3.0
Parus caeruleus	3.9	*Fringilla coelebs*	2.9
Total	43.6	Total	47.6
SCRUBBY (45 species)		FIELD-MEADOW (32 species)	
Species	% domination	Species	% domination
Acrocephalus palustris	34.6	*Alauda arvensis*	25.3
Sylvia communis	9.9	*Acrocephalus palustris*	22.1
Emberiza schoeniclus	7.1	*Motacilla flava*	8.6
Saxicola rubetra	6.3	*Saxicola rubetra*	8.5
Locustella naevia	4.6	*Sylvia communis*	6.6
Carduelis cannabina	3.2	*Vanellus vanellus*	5.0
Locustella fluviatilis	3.1	*Anthus pratensis*	3.5
Crex crex	2.6	*Emberiza schoeniclus*	2.8
Total	71.4	Total	82.4

where S = number of species in the association, p_i = fraction of individuals of i-th species in the association, and the evenness index (J') according to Pielou's formula (1975):

$$J' = H' / H'_{max}$$

where $H'_{max} = \log_2 S$

The significance of differences between the sizes of habitat islands of the types distinguished in this study and the significance of differences of the parameters measured depending on the type, I tested using the analysis of variance (ANOVA). I made the comparisons of means *post hoc* between the distinguished types of areas by using Scheffe's test (Hays 1988). In performing statistical calculations and drawing graphs I used the STATISTICA package for Windows.

RESULTS

Although the study employed sample plots of variable parameters (Table 1), no significant differences in plot sizes were found in comparisons among various types of plots, grouped in line with their sizes (ANOVA, $p > 0.05$ for all comparisons). A total of 98 breeding bird species were found on all sample plots (see Appendix). On individual islands, there were from 6 to 202 breeding pairs nesting, representing 3–46 species. Calculated per unit area it amounted to a density ranging from 0.5 do 50.0 pair/hectare. The highest average density of birds was found in the scrubby type islands, and the lowest one on the field-meadow type (Fig. 1). The differences are statistically significant (ANOVA, $p < 0.01$), except for the result of comparisons between the mixed and field-meadow types ($p > 0.05$). On the mixed and woody plots, significantly more bird species nested ($p < 0.001$), than on scrubby and field-meadow plots (Fig. 2).

The species composition and the domination structure in bird communities varied depending on the type of environmental island (see Appendix). On the plots of field-meadow type, Skylark and Marsh Warbler constituted nearly 50% of the pairs, and the group of dominating species included also Yellow Wagtail, Whinchat, Whitethroat and Lapwing. On the scrubby-type islands Marsh Warbler was definitely dominant, and the 5% threshold of domination was also exceeded by Whitethroat, Reed Bunting and Whinchat. On the mixed islands, Marsh Warbler and Whitethroat dominated clearly, with Fieldfare and Goldfinch also occurring in numbers. In the woody type plots Chaffinch, Blackcap, Great Tit, Blackbird and Robin were most numerous (Table 2). The variability of the species domination shows a much wider range for particular plots, especially because of the fact that on the smallest islands supporting tiny populations it was enough to record a species once to include it in the class of dominants.

The Shannon diversity index varied over a wide range: the lowest value (1.27) was recorded in a fallow field whereas the highest value (5.07) was found in small woods of a wood-park type in a military ground. In comparing average values, the highest species diversity (Fig. 3) was recorded on sample plots of mixed type (H' = 4.13), and the lowest – on plots of field-meadow type (H' = 2,46). The evenness index reached the highest average value on the plots of woodland type (J' = 0.95), and the lowest average values – on the plots of scrubby type (J' = 0.79), ranging on individual plots from 0.59 on the fallow field to 0.98 on several woody plots The indices of species diversity and evenness on the plots of woody type and mixed type were significantly higher than those on scrubby and field-meadow plots (ANOVA, $p < 0.001$). The value of the H' index is affected more by the number of species ($r = 0.91$), then by the evenness of domination structure ($r = 0.73$). On the woody and mixed-type plots the correlation coefficients for H' and J' are statistically insignificant ($p > 0.05$), whereas the correlation coefficients (r) of the H' index and the number of species reached 0.95 and 0.93, respectively. On the plots of scrubby type, unlike in other comparisons, the correlation between H' and J' was higher than that between H'H" and the number of species ($r = 0.94$ and 0.91, respectively), whereas on plots of field-meadow type, this relation is reversed ($r = 0.87$ and 0.90). These correlations with the Shannon diversity indices are statistically significant ($p < 0.05$).

DISCUSSION

Many researchers of bird communities in agricultural landscapes provide the results for the entire, sometimes quite heterogenous study areas (Witkowski et al. 1995; Tworek 1998; Tryjanowski 1999). In this study the sample plots which were treated as habitat islands were naturally demarcated from the agricultural landscape and thus they are only fragments of it. Despite similarities of methodology (large area within an agricultural landscape, data collected by a mapping method, exclusion of build-up areas from the study), when drawing conclusions from the comparisons of measured parameters of bird communities, one should remember the difference in the approach to the selected sample area because the average results obtained by summing up all the results for sample plots of the same type correspond to a single large fragment of a given habitat only as a matter of convention. The issue of setting up sample areas is connected with the requirements of birds regarding their individual territories, and all the features of what we call the ecological niche. The selection of the appropriate, ecological scale of studies changes in a broad range, not only depending on the studied organisms but also on the purpose of the study (whether we are interested in individuals or whole populations). If it is assumed, after Opdam et al. (1994), that the occurrence of birds is determined by processes considered on three levels of the spatial scale: local, landscape and biogeographical, the size range of plots (0.3 to 40 hectares) adopted in the agricultural landscape in the neighbourhood of Kraków would pertain to the local scale.

A characteristic feature of woody type islands, including various habitat-related varieties of woods and tree clumps/belts was the predominance of tree vegetation. The average levels of population densities obtained on these plots (Fig. 1) are, however, higher than for coniferous forests (Chmielewski 1992; Solonen 1996), beech woods (Wysocki 1997) and for most of oak-hornbeam forests (Kosiński 1993). This results from the fact that many sample plots were of a tree clumps/belts nature. In these habitats birds can reach the highest densities (Kurlavičius 1995; Wuczyński 1995; Kujawa 1997), comparable only with urban parks or the richest oak-hornbeam forests (Głowaciński 1975; Tomiałojć and Profus 1977), riverine carrs of a primary type (Tomiałojć et al. 1984) and some river valleys (Tomiałojć and Dyrcz 1993; Kieś et al. 1997).

The analysis of the species within the woody island size gradient indicates that the adverse effect of woodland fragmentation pertains mainly to so-called birds of the inner parts of woodlands. At the same time, for a large group of woodland birds (e.g. Chaffinch, Fieldfare, Woodpigeon,

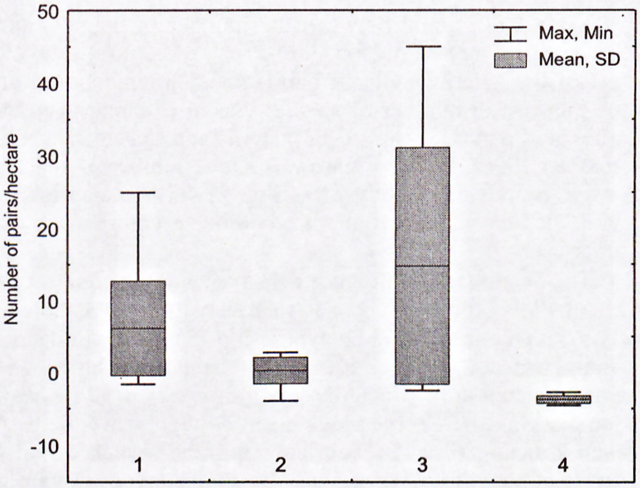

Fig. 1. Bird pair densities (N/hectare) in four types of habitat islands: 1 – woody, 2 – mixed, 3 – scrubby, 4 – field-meadow.

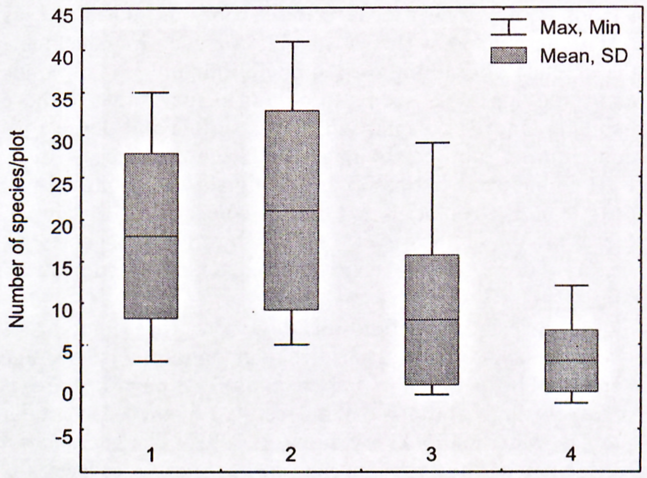

Fig. 2. Number of breeding species in four types of habitat islands: 1 – woody, 2 – mixed, 3 – scrubby, 4 – field-meadow.

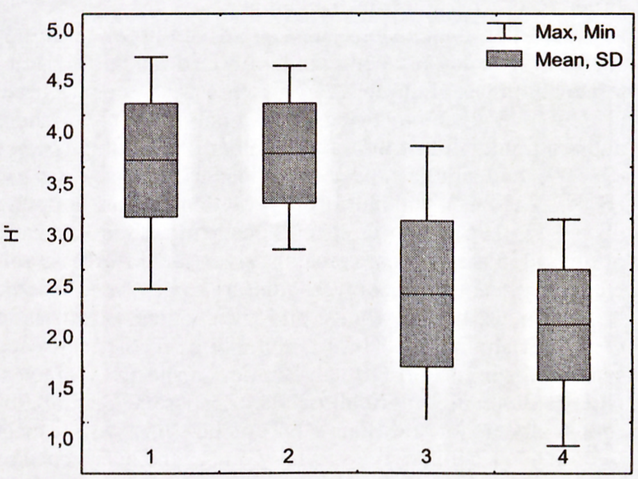

Fig. 3. Shannon diversity index H' values in four types of habitat islands: 1 – woody, 2 – mixed, 3 – scrubby, 4 – field-meadow.

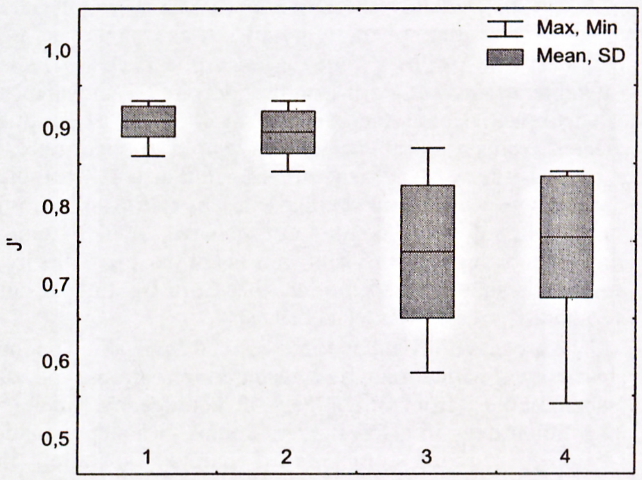

Fig. 4. Evenness index J' values in four types of habitat islands: 1 – woody, 2 – mixed, 3 – scrubby, 4 – field-meadow.

Icterine Warbler, Starling, Yellowhammer, Willow Warbler, Blackbird, Magpie), the process of the fragmentation of woodland is neutral and more often even advantageous. It should be remembered, however, that the effects of predation or parasitism were not recorded in this study, and these phenomena could markedly affect the breeding success in fragmented woodlands (Paton 1994; Matthysen et al. 1995). This problem is to a great extent connected with the fact that the species of the inner parts of woodlands are generally rarer, i.e. more vulnerable, and thus nature conservation concentrates on the adverse outcome of these processes. It is understandable that the phenomenon of fragmentation on a global scale could bring disastrous consequences in contributing to the extinction of a number of taxa. It is nevertheless worth noting that on the local scale this may entail positive effects in contributing to the increased biodiversity.

On the plots of scrubby type the undergrowth layer vegetation predominated, accompanied by reed communities in wetter places. The scrubby type plots had the highest values of bird density (Fig. 1), which testifies to the great value and importance of these type of habitats, often omitted in the studies on the effects of woodland fragmentation. The low values of the Shannon diversity index and the most even structure of species domination in the island of scrubby types prove that these specific habitats have definite and characteristic bird fauna. This includes, above all Marsh Warbler, whose domination can exceed 30% (see Appendix). Other characteristic species are, primarily: Whitethroat, Reed Bunting, Whinchat and Grasshopper Warbler, and Linnet, River Warbler and Corncrake to a lesser extent. The typical woodland species are absent, however, which is implied by the structure of vegetation in islands of this type. Because the scrubby islands were, as a rule, associated with wet habitats or even marshy ones, the practice of draining wetland by eliminating small ponds and removing reeds seems to be a principal threat to these habitats. On a small plot with osier scrubs and dense forb communities along a drainage ditch, the densities of birds were found to be extremely high, actually the highest of all sample plots (from 43.3 do 50.0 pairs/hectare). The value of these habitats is, however, reduced by the low species diversity (H' = 1.52–2.46) and very uneven domination structure (J' = 0.63–0.79).

On the islands of field-meadow type, trees and shrubs occurred isolated and in an irregular pattern. The average density of birds found in these islands (1.21 pairs/hectare) is relatively high compared with results obtained for similar plots by other authors (Tryjanowski 1999). The characteristic feature of the bird communities in agro-ecosystems is the domination of Skylark. The order of other species in the structure of numbers of bird species depends principally on the characteristics of the plot itself. In the study area, because of the great proportion of fertile meadows and the proximity of wetlands, the numbers of Marsh Warbler are very close to that of the Skylark. Also numerous are Whinchat and Yellow Wagtail (see Appendix). There is a notable absence of Corn Bunting, despite the prevalence of vast open spaces. According to Gromadzki (1970), this species avoids a mosaic of habitats devoid of open spaces, but as this type of landscape prevails in the study area, the species could live there. Perhaps its absence results from the specific relief of the bottom of the Krzeszowicki trough and from the high fertility and wetness of the area. This hypothesis is supported by the fact that Corn Buntings occur in adjacent areas (Kieś et al. 1997).

The process of fragmentation, defined as breaking up the continuity of habitats can be considered for various types of discontinuities: from minor gaps in homogenous habitats (e.g. fallen trees in a forest, tree clumps in a steppe landscape) to isolated remnants of habitats scattered in a changed environment (e.g. parks in an urban area). Although the studies in variable-habitat landscape regard chiefly the latter understanding of fragmentation (Wiens 1994), when demarcating sample areas I combined both methods of considering the phenomenon of fragmentation, with a tendency to combine into larger units even markedly different habitats but with a gradual transition zone. This entailed some problems with the allocation of some islands of an ecotone character. For this reason it seemed necessary to set up a category for the most diversified habitats. These were included in the "mixed" category. Relatively low densities of birds on such islands resulted from a significant proportion of meadows and abandoned land, thence the value of this parameter was only slightly higher than in the field-meadow islands (Fig. 1). Nevertheless, the highest species diversity and the highest number of species in bird communities were found in these islands, which results from a strong influence of external factors and associated penetration of species from adjacent areas (Wuczyński 1995). This result was supported by the strong correlations between the number of habitats and number of species ($r = 0.93$, $p < 0.001$), and between the number of habitats and the index of species diversity ($r = 0.78$, $p < 0.001$). The effect of the heterogeneity of habitats and fragmentation on the increase in number of species was also emphasised by other authors (Hansson 1983; Helle and Järvinen 1986; Solonen 1996). For this reason, the low number of species on the islands of scrubby type (Fig. 2) may be also linked with the uniformity of the vegetation structure on such plots.

The Shannon diversity index (H') reaches the highest values on plots of mixed type, and relatively low on the plots of scrubby and field-meadow types (Fig. 3), underlining the significance of the heterogeneity of habitats to birds. The woody islands are characterised by the most even structure of domination, whereas the plots of scrubby type have the least even structure (Fig. 4). The latter may be treated as early stages of forest succession, and the studies by Głowaciński (1981) indicate that the stability of bird communities – in line with the theory of ecosystems – increases with the gradient of forest succession. The result is a confirmation of how strongly the organisation of bird communities depends on the structure of vegetation in habitats.

Interesting conclusions may be arrived at when the results of this study are compared with bird fauna of characteristic biotopes of the Jura Landscape Park System (Kieś et al. 1997). With an equally great diversity of habitats, these authors found almost the same number of breeding species (S = 99), and similar ranges of indices for species diversity (H' = 1.22–4.82) and uniformity of domination structure (J' = 0.47–0.96). Only 12 species occurring in the Jura were not found in the study area which, given the different gradient of habitats (the Błędowska "desert" patch, pine forests, beech woods, mixed woods, and river valleys) testifies to the major similarity of bird communities in the landscape scale. The absence of Ortolan Bunting, a species characteristic of diversified agricultural landscapes in Central Europe (Hagemeijer and Blair 1997), is puzzling with respect to both areas compared, especially due to the occurrence of habitats of similar characteristics to those in some other regions (e.g. the Nadwiślańska lowland or the Tarnobrzeska plain) where this species is relatively numerous (Author's own observations). Kuźniak et al. (1997) suggest that the principal reason for the dwindling numbers of this species is the reduction in diversity of agricultural landscape, particularly consolidation and increase of cultivated plots at the expense of balks, little ponds amidst cultivated fields, fragments of meadows, fallow lands etc. However, the ecotone character of the study area proves that – as in the case of Corn Bunting – the absence of this species is the result of other reasons. They might be linked with intensive farming on fertile soil in combination with the application of herbicides and insecticides. This results in reducing food supplies and the number of places to feed. At the same time the absence of this species confirms the overall decline in the populations across most of Europe (Tucker and Heath 1994).

In agricultural landscapes, the environmental islands with different habitats have their characteristic bird fauna and, as the results show, their importance might be extremely different for particular species. This suggests the need of maintaining diverse habitats in order to keep the highest possible level of biodiversity. The simplest way to increase biodiversity in agricultural landscapes is to introduce tree rows and shrub hedges, tree lanes, green belts and small woods. However, of almost the same importance is the requirement to create and protect meadows, pastures and wetlands (Petersen 1998). This issue is omitted by most of the authors who concentrate on the consequences of the fragmentation of woodlands despite the fact that the bird species living in open spaces on farmlands show a reduction in numbers perhaps even steeper than the woodland species (Tucker and Heath 1994; Hagemeijer and Blair 1997).

The study area has no endangered or vulnerable species, which results from the sub-optimum character of most of sample plots in farmland surroundings. However, the number of breeding pairs and the species diversity among birds living within these islands of different habitats signify the enormous importance to birds, as substitute habitats: tree clumps, small ponds and forb communities. These are the communities, which might be deemed useless from the viewpoint of cultivation but whose advantageous effect on the occurrence of breeding birds has been repeatedly proven (Berg and Pärt 1994; Green et al. 1994; Tworek 1998). It is worth to note that the increase in structural diversity of the agricultural landscape affects favourably not only birds but also other groups of animals (Ryszkowski and Bałazy 1994), and, which of utmost importance, also contribute to the increased yield of cultivated plants (Pain and Pienkowski 1997).

In a diversified landscape, habitats come under great pressure from the surroundings, which translates into biocoenotic relationships. When looking for solutions that could be applied in rapidly changing landscapes one should prevent fixing a schematic way of thinking which permits any use of the surroundings of an habitat island (Brussard et al. 1992). This type of conclusion could be derived from the theory of island biogeography (e.g. "single large or several small" debates) and emerge not only in public life but even in political activities. The attempt to evaluate the importance of various environmental islands can be applied as guidelines in nature conservation management and physical planning. The effective conservation, however, will require comprehensive actions pertaining to the entire landscape, not its single components. Otherwise we might be involved in paradoxes such as protecting a tree with a nest of a woodland species amidst cultivated land. In a quest for solutions in nature conservation and management, considering the sometimes-contradictory recommendations, acting upon methods proven in practice and based on sound scientific foundations seems to be the best approach.

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REFERENCES

Bentley J.M., Catterall C.P. 1997. The use of bushland, corridors and linear remnants by birds in southeastern Queensland, Australia. Conserv. Biol. 11: 1173–1189.

Berg A., Pärt T. 1994. Abundance of breeding farmland birds on arable and set-aside at forest edges. Ecography 17: 147–152.

Bersier L.-F., Meyer D. R. 1994. Bird assemblages in mosaic forests: the relative importance of vegetation structure and floristic composition along the successional gradient. Acta Oecol. 15: 561–576.

Bibby C.J., Burgess N.D., Hill D.A. 1992. Bird census techniques. Academic Press, London.

Blake J.G., Karr J.R. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68: 1724–1734.

Brussard P.F., Murphy D.D., Noss R.F. 1992. Strategy and tactics for conserving biological diversity in the United States. Conserv. Biol. 6: 157–159.

Chmielewski S. 1992. Awifauna lęgowa rezerwatów leśnych "Tomczyce" i "Modrzewina" (Breeding avifauna of forest nature reserves "Tomczyce" and "Modrzewina"). Not. Orn. 33: 81–92 (in Polish with an English summary).

Cieślak M., Dombrowski A. 1993. The effect of forest size on breeding bird communities. Acta Orn. 24: 29–62.

Dąbrowska-Prot E. 2000. Ecological problems of habitat islands in the landscape, with particular reference to forest islands. In: J. Banaszak (ed.) – Ecology of Forest Islands: 169–183. Bydgoszcz University Press, Bydgoszcz.

Gilbert F.S. 1980. The equilibrium theory of island biogeography: fact or fiction? J. Biogeogr. 7: 209–235.

Głowaciński Z. 1975. Ptaki Puszczy Niepołomickiej: studium faunistyczno-ekologiczne (Birds of the Niepołomice Forest: A faunistic-ecological study). Acta zool. crac. 20: 1–88 (in Polish with an English summary).

Głowaciński Z. 1981. Stability in bird communities during the secondary succession of a forest ecosystem. Ekol. pol. 29: 73–95.

Gotelli N.J., Kelley W.G. 1993. A general model of metapopulation dynamics. Oikos 68: 36–44.

Green R.E., Osborne P.E., Sears E.J. 1994. The distribution of passerine birds in hedgerows during the breeding season in relation to characteristics of the hedgerow and adjacent farmland. J. Appl. Ecol. 31: 677–692.

Gromadzki M. 1970. Breeding communities of birds in mid-field afforested areas. Ekol. pol. 18, 14: 307–350.

Hagan J.M., van der Haegen W.M., McKinley P.S. 1996. The early development of forest fragmentation effects on birds. Conserv. Biol. 10: 188–202.

Hagemeijer E.J.M., Blair M.J. (red.) 1997. The EBCC atlas of European breeding birds: their distribution and abundance. T. & A.D. Poyser, London.

Haila Y., Hanski I.K., Niemela J., Puntilla P., Raivio S., Tukia H. 1994. Forestry and the boreal fauna: matching management with natural forest dynamic. Ann. Zool. Fenn. 31: 187–202.

Haila Y., Saunders D.A., Hobbs R.J. 1993. What do we presently understand about ecosystem fragmentation? In: R.J. Hobbs, P.R. Ehrlich, D.A. Saunders (eds.) – Nature Conservation 3: Reconstruction of fragmented ecosystems: 45–55. Surrey Beatty & Sons, Chipping Norton, New South Wales, Australia.

Hanski I., Gilpin M. (eds.) 1997. Metapopulation biology: ecology, genetics and evolution. Academic Press, London.

Hansson L. 1983. Bird numbers across edges between mature conifer forest and clearcuts in central Sweden. Ornis Scan. 14: 97–103.

Hays W.L. 1988. Statistics (3rd ed.). CBS College Publishing, New York.

Helle P., Järvinen O. 1986. Population trends of North Finnish land birds in relation to their habitat selection and changes in forest structure. Oikos 46: 107–115.

Hinsley S.A., Bellamy P.E., Newton I., Sparks T.H. 1995. Habitat and landscape factors influencing the presence of individual breeding bird species in woodland fragments. J. Avian Biol. 26: 94–104.

Kieś B., Schneider G., Tomek T. 1997. Awifauna lęgowa charakterystycznych biotopów Zespołu Jurajskich Parków Krajobrazowych (Breeding avifauna in the typical habitats of the Jurassic Landscape Parks (southern Poland). Not. Orn. 38: 1–26 (in Polish with an English summary).

Kondracki J. 1994. Geografia Polski. Mezoregiony fizyczno-geograficzne (Geography of Poland. Physical-geographical mesoregions). Wydawnictwo Naukowe PWN, Warszawa (in Polish).

Kosiński Z. 1993. Ugrupowania ptaków lęgowych Dąbrowy Krotoszyńskiej na tle grądów zachodniej Polski (Breeding birds of the Dąbrowa Krotoszyńska forest compared with other oak-hornbeam forests studied in Western Poland). Not. Orn. 34: 333–345 (in Polish with an English summary).

Kujawa K. 1997. Relationships between the structure of mid-field woods and their breeding bird communities. Acta Orn. 32: 175–184.

Kurlavičius P. 1995. Birds of forest islands in South-East Baltic region. Baltic ECO, Vilnius.

Kuźniak S., Dombrowski A., Goławski A., Tryjanowski P. 1997. Stan i zagrożenia polskiej populacji ortolana *Emberiza hortulana* na tle sytuacji gatunku w Europie (Present condition and threats to the Polish population of the Ortolan Bunting Emberiza hortulana against the species situation in Europe). Not. Orn. 38: 141–150 (in Polish with an English summary).

Levins R. 1970. Extinctions. In: M. Gerstengaber (ed.) Some Mathematical Problems in Biology. Lectures of Mathematics in Life Sciences 2: 75–108. American Mathematical Society, Providence, Rhode Island.

Loman J., von Schantz T. 1991. Birds in a farmland – more species in small than in large habitat islands. Conserv. Biol. 5: 176–188.

Łomnicki A. 1988. Population Ecology of Individuals. Princeton University Press, Princeton, New Jersey.

MacArthur R.H., Wilson E.O. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey, USA.

Matthysen E., Lens L., Van Dongen S., Verheyen G.R., Wauters L.A., Adriaensen F., Dhondt A.A. 1995. Diverse effects of forest fragmentation on a number of animal species. Belg. J. Zool 125: 175–183.

McGarigal K., McComb W.C. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. Ecol. Monographs 65: 235–260.

Michalik S. 1980. Roślinność rzeczywista centralnej części Wyżyny Krakowskiej (The contemporary vegetation of the central part of the Cracow Upland). Ochr. Przyr. 43: 55–74 (in Polish with an English summary).

Middleton J., Merriam G. 1983. Distribution of woodland species in farmland woods. J. Appl. Ecol. 20: 625–644.

Moilanen A., Hanski I. 1998. Metapopulation dynamics: effects of habitat quality and landscape structure. Ecology 79: 2503–2515.

Nour N., van Damme R., Matthysen E., Dhont A.A. 1999. Forest birds in forest fragments: are fragmentation effects independent of season? Bird Study 46: 279–288.

Opdam P. 1991. Metapopulation theory and habitat fragmentation: a review of holarctic breeding bird studies. Landscape Ecol. 5: 93–106.

Opdam P., Foppen R., Reijnen R., Schotman A. 1994. The landscape ecological approach in bird conservation: integrating the metapopulation concept into spatial planning. Ibis 137: 139–146.

Opdam P., Rijsdijk G., Hustings F. 1985. Bird Communities in small woods in an agricultural landscape: effects of area and isolation. Biol. Conserv. 34: 333–352.

Pain D.J., Pienkowski M.W. (eds.) 1997. Farming and birds in Europe. The Common Agricultural Policy and its implications for bird conservation. Academic Press, London.

Paton P.W.C. 1994. The effect of edge on avian nest success: how strong is the evidence? Conserv. Biol. 8: 17–26.

Petersen B.S. 1998. The distribution of Danish farmland birds in relation to habitat characteristics. Ornis Fenn. 75: 105–118.

Pielou E.C. 1975. Ecological diversity. J. Wiley and Sons, New York.

Rolstad J. 1991. Consequences of forest fragmentation for the dynamics of bird populations: conceptual issues and the evidence. Biol. J. Linn. Soc. 42: 149–163.

Ryszkowski L., Bałazy S. 1994. Functional appraisal of agricultural landscape in Europe. RCAFE PAS, Poznań.

Saunders D.A., Hobbs R.J. Margules C.R. 1991. Biological consequences of ecosystem fragmentation: a review. Conserv. Biol. 5: 18–29.

Solonen T. 1996. Patterns and variations in the structure of forest bird communities in southern Finland. Ornis Fenn. 73: 12–26.

Tomiałojć L., Dyrcz A. 1993. Przyrodnicza wartość dużych rzek i ich dolin w Polsce w świetle badań ornitologicznych (Nature conservation in large river valleys of Poland: an ornithological outlook). In: L. Tomiałojć (ed.). Ochrona przyrody i środowiska w dolinach nizinnych rzek Polski (Nature and environment conservation in the lowland river valleys of Poland): 13–38. Wyd. IOP PAN, Kraków (in Polish with an English summary).

Tomiałojć L., Profus P. 1977. Comparative analysis of breeding bird communities in two parks of Wrocław and in an adjacent *Querco-Carpinetum* forest. Acta Orn. 16: 117–177.

Tomiałojć L., Wesołowski T., Walankiewicz W. 1984. Breeding bird community of primeval temperate forest (Białowieża National Park, Poland). Acta Orn. 20: 241–310.

Tryjanowski P. 1999. Effect of habitat diversity on breeding birds: comparison of farmland bird communities in the region of Wielkopolska (W. Poland) with relevant data from other European studies. Pol. J. Ecol. 47: 153–174.

Tucker G.M., Heath M.F. 1994. Birds in Europe: their conservation status. BirdLife International, Cambridge, UK.

Tworek S. 1998. Znaczenie zróżnicowania siedlisk dla awifauny lęgowej terenów rolniczych w dolinie Rudawy koło Krakowa (The importance of habitat diversity for breeding avifauna of agricultural land in the Rudava River valley near Kraków). Chrońmy Przyr. Ojcz. 54: 39–52 (in Polish with an English summary).

Tworek S. 2001. Charakterystyka ptasich zgrupowań w siedliskach wyspowych krajobrazu rolniczego i reakcje ptaków na zmiany w środowisku. (Island and holm bird communities in agricultural regions and the responses of birds to changes in their habitat). Działalność naukowa PAN – wybrane zagadnienia 12: 74–76 (in Polish with an English summary).

Villard M.-A., Merriam G., Maurer B.A. 1995. Dynamics in subdivided populations of neotropical migratory birds in a fragmented temperate forest. Ecology 76: 27–40.

VIRKKALA R. 1987. Effects of forest management on birds breeding in northern Finland. Ann. Zool. Fenn. 24: 281–294.
WIENS J.A. 1994. Habitat fragmentation: island *vs* landscape perspectives on bird conservation. Ibis 137: 97–104.
WITKOWSKI J., ORŁOWSKA B., RANOSZEK E., STAWARCZYK T. 1995. Awifauna doliny Baryczy (The avifauna of the Barycz River valley). Not. Orn. 36: 5–74 (in Polish with an English summary).
WUCZYŃSKI A. 1995. Charakterystyka awifauny lęgowej drobnych zadrzewień śródpolnych na Równinie Wrocławskiej (An analysis of the breeding avifauna of the small mid-field woodlots in the Wrocławska Plain). Not. Orn. 36: 99–117 (in Polish with an English summary).
WYSOCKI D. 1997. Ugrupowania ptaków lęgowych buczyn pomorskich pod Szczecinem (Breeding bird communities of the Pomeranian beech woods near Szczecin). Not. Orn. 38: 273–289 (in Polish with an English summary).

APPENDIX

Species composition and domination of breeding birds in for types of habitat islands: W = woody, M = mixed, S = scrubby, FM = field-meadow. Numbers of breeding species on particular types of plots are given in brackets.

Species	W	M	S	FM
	(73)	(68)	(45)	(32)
Sparrowhawk *Accipiter nisus*	*			
Sedge Warbler *Acrocephalus schoenobaenus*		0.3	0.3	
Reed Warbler *Acrocephalus scirpaceus*		0.1	0.4	0.3
Marsh Warbler *Acrosephalus palustris*	3.2	15.7	34.6	22.1
Skylark *Alauda arvensis*		2.4	0.9	25.3
Kingfisher *Alcedo atthis*		0.1		
Mallard *Anas platyrhynchos*	0.4	0.5	1.6	0.9
Meadow Pipit *Anthus pratensis*		0.7	1.3	3.5
Tree Pipit *Anthus trivialis*	1.2			
Long-eared Owl *Asio otus*				0.1
Buzzard *Buteo buteo*	0.5	*		
Linnet *Carduelis cannabina*	1.2	3	3.2	1.9
Goldfinch *Carduelis carduelis*	3.4	4.7	1.1	0.6
Greenfinch *Carduelis chloris*	1.1	1.5	0.5	
Scarlet Rosefinch *Carpodacus erythrinus*		0.5	1	
Short-toed Treecreeper *Certhia brachydactyla*	0.2			
Treecreeper *Certhia familiaris*	0.3			
White Stork *Ciconia ciconia*	0.1		0.1	0.2
Marsh Harrier *Circus aeruginosus*			0.2	
Hawfinch *Coccothraustes coccothraustes*	1	*		
Stock Dove *Columba oenas*	*			
Woodpigeon *Columba palumbus*	2	2.1	0.9	0.4
Raven *Corvus corax*	0.1			
Carrion Crow *Corvus corone*	0.7	0.4	0.1	
Quail *Coturnix coturnix*		0.2		0.8
Corncrake *Crex crex*		0.5	2.6	0.4
Cuckoo *Cuculus canorus*	0.5	0.5	0.4	0.1
Great Spotted Woodpecker *Dendrocopos major*	0.8			
Middle Spotted Woodpecker *Dendrocopos medius*	*			
Lesser Spotted Woodpecker *Dendrocopos minor*	0.3	0.1		
Syrian Woodpecker *Dendrocopos syriacus*		0.1		
Black Woodpecker *Dryocopus martius*	*			

Appendix cont.

Yellowhammer *Emberiza citrinella*	3.7	3.2	1.1	0.3
Reed Bunting *Emberiza schoeniclus*		2.7	7.1	2.8
Robin *Erithacus rubecula*	4.8			
Hobby *Falco subbuteo*	0.2			
Kestrel *Falco tinnunculus*	0.2	0.7		0.4
Collared Flycatcher *Ficedula albicollis*	0.3			
Pied flycatcher *Ficedula hypoleuca*	0.4			
Chaffinch *Fringilla coelebs*	7.9	2.9	1.3	
Snipe *Gallinago gallinago*		0.2		
Moorhen *Gallinula chloropus*			0.2	
Jay *Garrulus glandarius*	0.8			
Icterine Warbler *Hippolais icterina*	2.6	2	0.4	
Wryneck *Jynx torquilla*	0.2			
Red-backed Shrike *Lanius collurio*	1.2	2.3	1.2	0.5
Great Grey Shrike *Lanius excubitor*		*		0.1
River Warbler *Locustella fluviatilis*	0.3	1	3.1	
Grasshopper Warbler *Locustella naevia*	0.2	0.9	4.6	0.9
Thrush Nightingale *Luscinia luscinia*	*	*		
Nightingale *Luscinia megarhynchos*	1.1	1.3	0.2	
White Wagtail *Motacilla alba*	0.2	0.5	0.2	
Yellow Wagtail *Motacilla flava*		1.6	1.3	8.6
Spotted Flycatcher *Muscicapa striata*	0.2	0.2		
Wheatear *Oenanthe oenanthe*		0.2		
Golden Oriole *Oriolus oriolus*	1.2	0.9		
Coal Tit *Parus ater*	0.7			
Blue Tit *Parus caeruleus*	3.9	1.2	0.4	
Great Tit *Parus major*	6.1	1.8	0.4	
Willow Tit *Parus montanus*	0.6	0.4	0.2	
Marsh Tit *Parus palustris*	0.2	*		
House sparrow *Passer domesticus*	0.7	0.9		0.1
Tree sparrow *Passer montanus*	1.1	1.3		0.1
Grey Partridge *Perdix perdix*		0.6		2
Pheasant *Phasianus colchicus*	1.1	2.1	2.2	1.7
Black Redstart *Phoenicurus ochruros*		0.3		
Redstart *Phoenicurus phoenicurus*	0.1			
Chiffchaff *Phylloscopus collybita*	4.3	*		
Wood Warbler *Phylloscopus sibilatrix*	1.5	*		
Willow Warbler *Phylloscopus trochilus*	4.1	2.8	1.8	
Magpie *Pica pica*	1.3	2.7	1.2	2.7
Grey-headed Woodpecker *Picus canus*	0.1			
Green Woodpecker *Picus viridis*	*			
Spotted Crake *Porzana porzana*		*		

Appendix cont.

Dunnock *Prunella modularis*	0.7			
Bullfinch *Pyrrhula pyrrhula*	*			
Goldcrest *Regulus regulus*	0.1			
Penduline Tit *Remiz pendulinus*		0.1	0.1	
Whinchat *Saxicola rubetra*		2.8	6.3	8.5
Stonechat *Saxicola torquata*		1.5	1.6	2.1
Woodcock *Scolopax rusticola*	*			
Serin *Serinus serinus*	0.5	0.6	0.4	
Nuthatch *Sitta europaea*	1			
Collared Dove *Streptopelia decaocto*	0.5	0.6		
Turtle Dove *Streptopelia turtur*	0.3	0.5	0.7	
Tawny Owl *Strix aluco*	0.2			
Starling *Sturnus vulgaris*	3.2	2.6	0.1	
Blackcap *Sylvia atricapilla*	7.3	3.1	1.1	0.1
Garden Warbler *Sylvia borin*	2.4	1.5	0.5	
Whitethroat *Sylvia communis*	3.8	10.1	9.9	6.6
Lesser Whitethroat *Sylvia curruca*	0.5	0.6	0.5	
Barred Warbler *Sylvia nisoria*	0.3	0.1		
Redshank *Tringa totanus*		*		0.2
Wren *Troglodytes troglodytes*	0.4			
Blackbird *Turdus merula*	5.2	2	0.6	
Song Thrush *Turdus philomelos*	1.9	0.1		
Fieldfare *Turdus pilaris*	3	4.9	2.1	0.7
Lapwing *Vanellus vanellus*		0.5		5

* domination < 0.1%.