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Species richness of breeding birds at a landscape scale: which habitat type is the most important?

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Skórka P., Martyka R., Wójcik J. D. 2006. Species richness of breeding birds at a landscape scale: which habitat type is the most important? Acta Ornithol. 41: 49–54.

Abstract. The aim of the study was to compare different habitat types according to species richness and estimate their value for total species richness at a landscape level. The study was carried out in the years 1995–2001 in the Tarnów region (1400 km^2, S Poland). All bird species were classified according to broadly defined breeding habitat type. Four main, easily distinguishable habitat types were specified: forests (18% of the area), open areas (70%), wetlands (1%) and anthropogenic areas (11%). Birds were classified as habitat specialists if they bred in only one habitat type, or as habitat generalists, if they bred in two or more habitat types. Altogether, 151 species nested in the study area, and a total of 87 species were habitat specialists. There were statistically more endangered species (so called "losers") among the habitat specialists than in the habitat generalists' group. Habitat specialists were also statistically less abundant than habitat generalists. The following numbers of species were recorded in the specific habitats: forests — 70, open areas — 75, wetlands — 61, anthropogenic areas — 46. Among these, the percentages of habitat specialists were the following: forests — 41.4%, open areas — 18.7%, wetlands — 52.5%, anthropogenic areas — 26.1%. It was found that the numbers of species inhabiting the various habitat types differed from the number to be expected on the basis of their area. This was especially apparent in the case of wetlands, which constituted only a small part of the total area, but as many as 32 species (21.1% of all) occurred only there. For conservation purposes, wetlands appear to play the most important role in shaping species richness in the landscape studied here. However, each habitat type contained some species that were not noted in other habitats.

Key words: biodiversity, birds, habitat selection, landscape scale, regional studies, wetlands

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INTRODUCTION

The preservation of biodiversity is one of the fundamental aspects of current nature conservation in light of a dramatic species loss in recent decades (Thomas et al. 2004). Despite many controversies dealing with the definition of biodiversity (Levine & D' Antonio 1999, Waide et al. 1999), it is commonly believed that the human life and economy benefit from biodiversity (Tilman et al. 1996, Gaston & Spicer 1998). Species richness is one of the most important components of biodiversity, and it is shaped by many factors (Huston 1994) including the number of habitats available and degree of habitat specificity of particular species (MacArthur et al. 1966, Schluter & Ricklefs 1993). As habitat choice is an outcome of, among others, landscape structure evaluation by birds (Cody 1985), the proportion of different habitats at a larger scale should play an important role in shaping species richness. Therefore, in a changing landscape heavily influenced by anthropogenic pressure, the most important problem may be to answer the question: which type of habitat affects species richness the most, and how changes in proportion of habitats may affect species richness?

In this paper we compare different habitat types according to species richness and estimate the value of a given habitat for the total species richness at a landscape scale. We also compare abundance and occurrence of habitat specialists versus habitat generalists. Our expectations were that abundance of habitat generalists should be higher than habitat specialists, being mostly endangered species, contrary to habitat generalists.

STUDY AREA AND METHODS

The study was carried out in the Tarnów Region (50°12′N, 21°05′E; south-eastern Poland, 1400 km^2) between 1995 and 2001. For some rare species, data from the years 1990–1994 were also used (Martyka et al. 2002). We made over 200 surveys of the study area. During each survey we counted birds on transects (5–15 km long, about 400–500 m wide) conducted through a mosaic of habitats. Transects were checked one to three times during the breeding season and all seen or heard birds were noted. We put effort to check different habitat types proportionally to the share of a given habitat in the study area. We classified all species according to the habitat they nested in. If breeding was detected only in one habitat type for a given species, the species was classified as a habitat specialist, if breeding occurred in two or more habitat types, it was classified as a habitat generalist. We excluded a few cases of unusual breeding habitats (one small mid-field colony of Sand Martin *Riparia riparia* far from the water or a single observation of Corncrake *Crex crex* on a clear-cut in a forest) in order not to blur the general picture of species occurrence in established habitat types. We distinguished four broadly defined habitat types: forests, open areas, wetlands and anthropogenic areas, which were easy to recognize land cover categories.

Forests were defined as tree stands over 1 ha and covered 18% of the study area. Mixed oak-pine forest *Pino-Quercetum* and fresh pine forest *Vaccinio myrtylii pinetum* dominated, but also patches of oak-hornbean forest *Tilio-carpinetum*, alder forest *Circaeo-Alnetum* and sour oak forest *Luzulo quercetum* occurred in some parts of the study area (Zięba 1995).

Open areas covered 70% of the study area. They included all kinds of agricultural cultivation, meadows, pastures, wastelands and also small (< 1 ha) mid-field wooded areas and groups of trees.

Wetlands covered 1% of the study area and constituted fishponds, main rivers and streams, old-river beds, industrial reservoirs (gravel pits and sedimentation basins) and natural ponds. Generally, water reservoirs were small and only a few gravel pits or fishponds exceeded 50 ha.

Anthropogenic areas included towns, farmhouses in villages together with gardens, and industrial vicinities. Anthropogenic areas covered 11% of the studied region.

A detailed description of the study area is available in Martyka et al. (2002) and Kondracki (1988).

During data analysis we first checked if the number of species in a given habitat is proportional to the total share of the habitat in the study area. However, because many species occurred in more than one habitat, thus these were not independent variables. To avoid this complication two analyses were conducted. First, we restricted our analysis to habitat specialists and we tested the hypothesis that the number of habitat specialists has no connection with habitat availability in the landscape. If there were no differences between habitats in species number, we expected that species number in consecutive habitats should be proportional to the share of the habitats in the landscape, assuming species-area relationship to be linear. Obviously, the relationship between area and species richness is non-linear (May 1975, Rosenzweig 1995) but the non-linearity elicits itself at much larger spatial scales than in our study (see: Rosenzweig 1995). The goodness of fit chi-square test was used. Because habitat generalists constituted a large part of all species noted in the study area, they could not be omitted, thus we performed a second analysis including these species. However, as habitat generalists are not independent units, statistical analysis could not be done. Instead, the P_i index used by Jacobs (1974) for food preference analysis was adopted. This index was calculated for each habitat:

$$P_i = (X_i/Y_i - X/Y) / (X_i/Y_i + X/Y)$$

where X_i is the number of species noted in a given habitat, Y_i is the total number of species noted in a landscape (study area), X is the size of a given habitat and Y is the total size of the study area. The value of this index assumes values from -1 to +1. A value of 0 indicates that the number of species is equal to the share of the habitat in a landscape. A value higher than 0 indicates that there are more species in a given habitat than expected from the share of the habitat in total landscape area. Analogically, if the value is less than 0, then the number of species in a given habitat is lower than expected.

The data from field surveys were also used to estimate species population size in the studied landscape. Transects covered about 70% of the study area. Knowing transect length and width we could roughly estimate abundance of bird species. All breeding species were attributed to several categories adduced by Tomiałojć (1990) according to population size. They were: very scarce (< 1 pair/100 km^2), scarce (1–10 pairs/100 km^2), fairly numerous (10–100 pairs/100 km^2), numerous (100–1000 piars/100 km^2), and very numerous (> 1000 pairs/100 km^2). Our predictions were that habitat generalists should be more abundant in the studied landscape than habitat specialists. We used the goodness of fit chi-square statistic to test the hypothesis.

Based on Głowaciński's (1990) classification of Polish birds, we analysed the occurrence of species called "losers", endangered in Poland, which may become extinct if no special protection actions are undertaken. Similarly, we analysed the occurrence of species recognized by Głowaciński (1990) as "winners" — species which are in expansion or their populations are stable and numerous or growing. Our predictions were that the losers should be mainly habitat specialists and the winners should originate mostly from the habitat generalist group. We again used χ^2 tests.

The probability level of 0.05 for significance was adopted in all tests.

RESULTS

We noted 151 breeding species in the study area. The largest number of species occurred in forests and open areas, fewer species were noted in wetlands and anthropogenic areas (Table 1). However, after including the area occupied by consecutive habitats the highest species richness was noted in wetlands (Table 1). We found that the relative number of habitat specialists depended on habitat type (χ^2_3 = 1543.198, p < 0.0001). The P_i index reached its highest value in wetland habitats, high values were also obtained in forest and anthropogenic habitats, but had a surprisingly low value in open habitats (Table 1). Habitat specialists were most frequent in wetlands and forests as far as all species noted in a given habitat were concerned (Table 1). If only the proportion of habitat specialists in a given habitat to total number of habitat specialists in the studied landscape

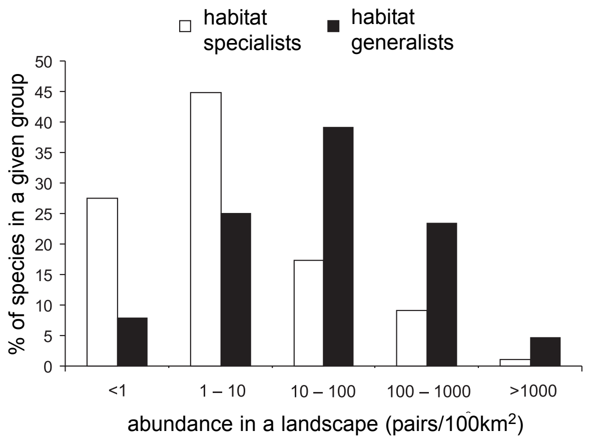

Fig. 1. Abundance distribution of habitat specialists (N = 87) and habitat generalists (N = 64) in the studied landscape.

is examined, we again find the largest percentage of habitat specialists in wetland and forest habitats (Table 1).

In the studied landscape, most species — 87 (57.6%) — belonged to habitat specialists. The number of species breeding in two, three, and four habitats was 34 (22.5%), 22 (14.6%), 8 (5.3%), respectively. The average species occurred in 1.7 habitat types. We found that population sizes of habitat specialists were generally lower than habitat generalists (χ^2_3 = 77.607, p < 0.0001, Fig. 1). From 34 species of habitat generalists that occurred in two habitats a higher number was found for forest and open areas (14 species), open and wetland habitats (13 species), open and anthropogenic habitats (five species), and the lowest number for forest and anthropogenic habitats (one species), wetlands and anthropogenic habitats (one species), and none for forest and water habitats. From 22 species that occurred in three habitats the definite majority of common species was found for forests, open and anthropogenic habitats (15 species), 4 species in wetlands, open and anthropogenic areas, 3 species were common for forests, wetlands and open areas, and no

Table 1. Characteristic of four main habitat types of the studied landscape.

	Habitat types			
	forests	open areas	wetlands	anthropogenic
Number of species	70.0	75.0	61.0	46.0
N of habitat specialists	29.0	17.0	32.0	12.0
N of habitat generalists	41.0	57.0	29.0	34.0
Habitat specialists within habitat (%)	41.4	18.7	52.5	26.1
Total number of habitat specialists within habitat (%)	33.3	16.1	36.8	13.8
P_i index	0.41	-0.17	0.95	0.47

common species for forests, wetlands and anthropogenic areas.

We found 31 species of losers and 76 species of winners. There were significantly more habitat specialists and fewer generalists than expected among losers (χ^2_1 = 6. 732, p = 0.001, Fig. 2) and among winners there were no significant differences between the expected and observed number of habitat specialist species and generalist ones (χ^2_1 = 1.805, p = 0.18, Fig. 2).

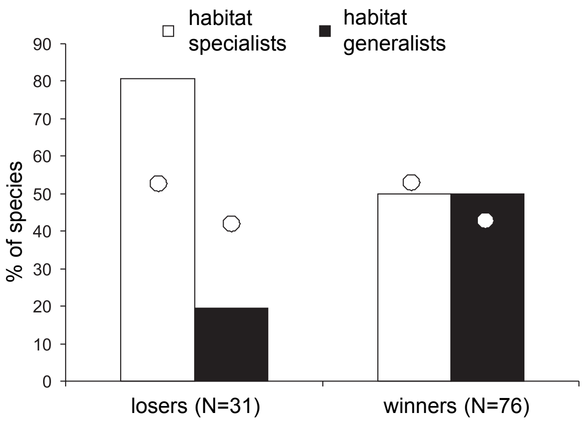

Fig. 2. Comparison of percentage shares of habitat specialists and habitat generalists in groups of losers and winners, respectively, according to the classification of Głowaciński (1990). Circles indicate expected values.

DISCUSSION

The structure of the habitat is one of the most important factors influencing species richness (MacArthur & MacArthur 1961, Huston 1994, Gaston & Spicer 1998). Structurally simplified habitats such as arable fields and meadows should be inhabited by a lower number of species than forests. We found that open areas in our study had a lower number of species than expected. Species richness in open areas is greater in mosaic landscapes (at a horizontal level) than in uniform landscapes (Roth 1976, Parish et al. 1994, 1995, Ryszkowski et al. 1996, Petersen 1998, Tworek 2002). Greater patchiness, resulting from the presence of both non-agricultural natural or semi-natural ecosystems and small size of fields with a differentiated crop rotation pattern, creates suitable conditions for more species (Ryszkowski et al. 1996, Kosiński & Tryjanowski 2000). However, in the open area category we included also small (< 1 ha) wooded areas, clumps of trees, etc. Thus, species richness in open areas was also shaped, to some extent, by the presence of vertical levels. But this does not, in our opinion, sufficiently explain the difference in species richness between open habitat and forest habitat, for example. We suggest that an additional factor enhancing species richness in forests, which elicits itself at a larger scale, is the diversification of this habitat in horizontal space. In forests, the number of vertical layers is one of the most important factors influencing bird diversity at a microhabitat scale (MacArthur et al. 1966, Karr & Roth 1971, Jayson & Mathew 2003), however, at a landscape scale forests are differentiated also in space. For example, there may be more habitats in the forest, as some parts of it may differ in age, etc. Consequently, forests are probably much more diverse in all dimensions than open habitats at a landscape scale.

A small number of habitat specialists was characteristic for open habitats (Table 1). The largest number of common species was noted in open and forest habitats. These species occur in small mid-field wooded areas and clumps of trees, well known in maintaining higher species richness in agricultural landscapes (O'Connor & Shrubb 1986, Kujawa 1997, 2004, Tryjanowski 1999, Tworek 2002, 2004). Another problem to be addressed is the size criterion needed for distinguishing between a forest and a clump of trees. Many authors define forests as wooded areas less than one hectare in size. This may cause many problems with species classification. In our study, however, the minimal size of forest was established at 1 ha. This size is a lower limit when mechanisms of intra- and interspecific competition start shaping density and species number in a forest community (Cieślak & Dombrowski 1993, Cieślak 1994). If the area of the forest is lower than 1 ha, species number is mainly influenced by stochastic processes (Cieślak & Dombrowski 1993). This also enabled us to avoid the classification problem of the species inhabiting habitat edges because they were classified mostly as habitat generalists in this study.

Our results indicate that wetlands are of high importance for species richness at a landscape scale. Almost 37% of all habitat specialists occurred in this habitat (Table 1), despite its small share in total landscape area. The high species number in this habitat type may result from many factors, especially the number of microhabitats available and area (Surmacki 1998, Kosiński 1999), sometimes food richness or structure of surrounding landscape (Elmberg et al. 1994, Whited et al. 2000, Barcena et al. 2004). In the case of wetland habitats in our study area, their small size and neighbouring open areas may be of high importance. Small water reservoirs and ponds are inhabited by relatively larger numbers of species (Dobrowolski 1995), and fields or meadows are important feeding habitats for some water species (O'Connor & Shrubb 1986, Surmacki 1998).

The interpretation of results in anthropogenic habitats may be complicated because these habitats are young (Jedicke 2000) and colonization and extinction of many species there may still be observed (Markowski 1997, Schwarz & Flade 2000, Witt 2000, Witt et al. 2005). Our findings seem to support that, because these habitats are inhabited mainly by habitat generalists. However, many species occur only there and some authors (e.g. Kubes & Fuchs 1998, Clergeau et al. 2005) argue, this habitat may be important for bird species conservation at a landscape scale.

The results indicate that consecutive habitat types are inhabited by a different number of species, even if area of the habitat is taken into account. A higher than expected number of species was particularly visible in wetland and forest habitats. Similar results were obtained by Tryjanowski (1999), but at a smaller scale — a 314 ha sample plot. The noted pattern of habitat occupation by species indicates that at a landscape scale, there are more species adapted to only one type of habitat, and less plastic species that occur in more than one habitat. We found that habitat specialists are the more vulnerable species (more losers in this group), and as expected, they were less abundant. This is important because when the availability of a given habitat type decreases then species richness should decrease as well, because more endangered species are habitat specialists. Alternately, successful species in a landscape dominated by human activity seem to be habitat generalists. They also have a wider diet, lower body mass and generally exhibit an r selection strategy (Głowaciński 1990).

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STRESZCZENIE

[Który rodzaj siedlisk ma największy wpływ na bogactwo gatunkowe ptaków lęgowych w skali krajobrazu?]

Celem badań było porównanie różnych rodzajów siedlisk pod względem bogactwa awifauny lęgowej i oszacowanie ich wartości dla całkowitej różnorodności gatunkowej na poziomie krajobrazu. Badania prowadzono w latach 1995–2001 w obszarze Ziemi Tarnowskiej (1400 km^2, płd. Polska). Wszystkie zaobserwowane ptaki przyporządkowano do poszczególnych siedlisk. Wydzielono cztery, łatwe do rozróżnienia rodzaje siedlisk: lasy (18% powierzchni badań), tereny otwarte (70%), mokradła (1%) i tereny zurbanizowane (11%). Ptaki zostały poklasyfikowane w dwie odrębne grupy: specjaliści — gnieżdżący się tylko w jednym rodzaju siedliska; generaliści — gnieżdżący się w dwu lub więcej siedliskach. Stwierdzono 151 gatunków lęgowych na terenie badań, przy czym 87 gatunków zaliczono do grupy specjalistów. Odnotowano istotnie większą liczbę gatunków zagrożonych (tzw. "losers") pośród specjalistów. W poszczególnych siedliskach odnotowaliśmy następującą liczbę gatunków ptaków: lasy — 70, tereny otwarte — 75, mokradła — 61, tereny zurbanizowane — 46. W obrębie tych siedlisk specjaliści stanowili następujący procent wszystkich gatunków: lasy — 41.4%, tereny otwarte — 18.7%, mokradła — 52.5%, tereny zurbanizowane — 26.1%. Poszczególne rodzaje siedlisk były zamieszkałe przez inną liczbę gatunków niż wynikało to z powierzchni danych siedlisk. Dotyczyło to głównie mokradeł zajmujących zaledwie niewielki fragment obszaru badań, na których jednak występowały aż 32 gatunki specjalistów (21.1% wszystkich gatunków). Tereny podmokłe pełniły więc najistotniejszą rolę w kształtowaniu bogactwa gatunkowego ptaków w badanym krajobrazie. Ma to istotne znaczenie w świetle ochrony różnorodności gatunkowej. Należy jednak podkreślić, iż w każdym z wyróżnionych siedlisk występowały gatunki nie stwierdzane w żadnym innym siedlisku.