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Factors influencing occurrence of passerines in the reed archipelago of Lake Velence (Hungary)

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Abstract. Bird census data from the reed archipelago (109 islands) of Lake Velence, Hungary, were used to assess the relative importance of habitat scale variables (island area and shape, reed stand density and reed height) and landscape scale variables (distance to the nearest reed island and nearest large reed island, percentage of reed-, water- and land-cover around the islands). Habitat and landscape scale variables played a similar general role in explaining the presence of the eight observed reedbed passerines. Reed island area was the most important factor; however, owing to the small average island area (1.74 ha), this simply indicates that too small reed patches were not occupied. A preference for an elongated shape (reedbed edges) was important for half of the species, and no other variables were included into the model of more than two species. The important practical conclusion is that both habitat and landscape scale factors should be considered in nature conservation management of reedbeds.

Key words: Hungary, Lake Velence, logistic regression, passerines, habitat scale, landscape scale, *Acrocephalus* sp.

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INTRODUCTION

The rules governing birds occurrences were always in the focus of avian researches (e.g. Böhning-Gaese & Oberrath 2003). On the local scale, bird-habitat associations were evaluated (Graveland 1998, Poulin et al. 2002, Melles et al. 2003). On the landscape scale the role of landscape structure, including edge effect and fragmentation was studied (Báldi & Kisbenedek 1999, Moskát & Báldi 1999, Foppen et al. 2000, Batáry & Báldi 2004). However, less is known about the relative importance of both scales in the organisation of bird assemblages, although it was shown that both patch and landscape characteristics should be included in models investigating the distribution and abundance of vertebrates (Mazerolle & Villard 1999). In addition, this knowledge is largely based on forest birds (e.g. Hinsley et al. 1995), while open area birds are less studied (Winter et al. 2006). Whited et al. (2000) showed that landscape scale factors are important in shaping wetland bird communities in a North American case study. Surmacki (2004, 2005) found that both habitat patch quality and surrounding landscape composition influences the habitat use of four reed bird species in Poland.

Reed is a perennial grass, often growing in large homogeneous and monospecific stands. Therefore, it is a simple habitat that provides a good model system (Báldi & Kisbenedek 2000). Not surprisingly, reedbed-associated birds provided popular model species for basic evolutionary and ecological studies (e.g. Leisler et al. 1989, Hoi & Winkler 1994, Hoi 2001). Less is known about their habitat selection on a landscape scale, and the relative importance of habitat vs landscape scale factors (Celada & Bogliani 1993, Foppen et al. 2000, Fairbairn & Dinsmore 2001, Surmacki 2004, 2005); in addition, most of these studies were conducted in reed archipelago within agricultural land, thus highly influenced by human habitat modifications. The aims of this study were: 1) to find the most important factors that influence the presence of eight reedbed-breeding bird species in a reed archipelago within a large lake,

2) to evaluate the relative importance of habitat and landscape scale factors, and 3) to provide conservation guidelines for the protection of reedbed birds. This latter point is rather timely, because many West-European populations of reedbed birds are declining (Graveland 1998, Poulin 2001).

MATERIALS AND METHODS

The study area was Lake Velence, a 24 km^2 large shallow lake in Hungary (47° 10' N 18° 32' E). Approximately 40% part of the lake area was covered with reed *Phragmites australis* The reed formed a large reed-belt on the western part of the lake, and formed ca 150 homogeneous reed islands and patches of various sizes in the central and eastern part of the lake. Reed islands were evenly flooded and were almost entirely composed of reed. All the reed islands which were visited on the lake, were surrounded by water, and were not connected to the lake bank (n = 109 reed islands; mean = 1.74 ha; range: 0.0025–25.71 ha). Birds were censused by boat slowly moving around reed islands in 1993 and 1994 (Báldi & Kisbenedek 1999). There were two censuses in both years (in April and May) to detect both early and late arrivals. We considered a reed island to be occupied by a given species if it was present in both years on the island.

We used 1:10 000 scale maps, airphotos and field visits to measure or estimate the environmental variables for each of the 109 reed islands (Table 1) (Báldi & Kisbenedek 2000). The shape was defined as the ratio of edge length of a reed island to the length of edge of a circle with the same area. The habitat structure of each island was categorised as being a dense, or a less dense, clumped, tussocks like reed stand. The height of the whole reed island was estimated separately for the old (dry) reeds in April and the new sprouting reed in May. The isolation of each reed island was measured as the distance to the nearest reed island and to the nearest large (> 0.65 ha) reed island. The proportion of reed cover, open water surface, and the cover of all other land types (shore bank, bushes, recreational areas, houses, etc.) were estimated in circles around the middle of each reed island. A series of four steps were applied, where the area of the circle roughly doubled in each step.

Logistic regression models were built for each species using the environmental variables as independent variables. This method is increasingly used in ecology due to the much smaller number of data assumptions than in linear regression

Table 1. List of environmental variables measured or estimated for the 109 reed islands in Lake Velence, Hungary.

	Variable	Mean	SD
patch spatial scale	Patch characteristics		
	Area (in hectares)	1.714	3.717
	Shape	1.38	0.39
	Vegetation structure		
	Clumped (=1) or dense (=2) reed stand type	1.27	0.44
	Height of old reed shoots (in meters)	1.08	0.34
	Height of new reed shoots (in meters)	1.07	0.22
landscape spatial scale	Isolation		
	Distance to nearest reed stand (in meters)	34.7	37.0
	Distance to nearest large reed stand (in meters)	44.0	51.0
	Landscape structure		
	Percent of reeds within 350m radius	35.0	18.5
	Percent of reeds within 500m radius	34.1	18.1
	Percent of reeds within 700m radius	34.5	19.2
	Percent of reeds within 860m radius	33.9	19.3
	Percent of water within 350m radius	58.9	17.1
	Percent of water within 500m radius	55.8	15.4
	Percent of water within 700m radius	51.4	15.1
	Percent of water within 860m radius	49.5	13.4
	Percent of land within 350m radius	6.1	10.1
	Percent of land within 500m radius	10.1	12.8
	Percent of land within 700m radius	14.1	14.6
	Percent of land within 860m radius	16.7	15.2

methods (Hosmer & Lemeshow 2000). The forward stepwise method, based on the likelihood ratio was used for variable entry. I present the *R* values and their significance for variables incorporated into the model. *R* is the partial correlation between the dependent variable and each of the independent variables. A positive *R* indicates that as the variable increases, so does the chance of the event occurring. A large *R* value indicates that the variable has a large partial contribution to the model. The SPSS 10.0 was applied (SPSS 1999).

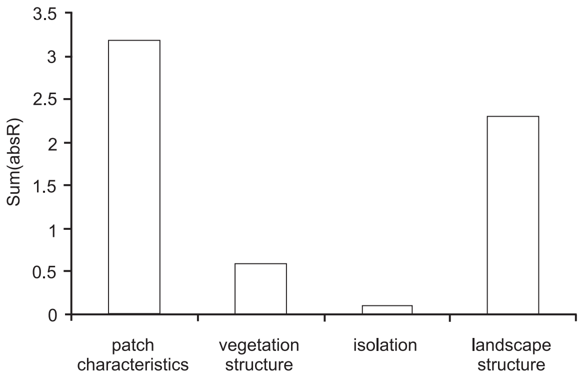

Fig. 1. The relative importance of patch, vegetation, isolation and landscape composition variables in habitat selection of reedbed birds (see Table 1 for details) at Lake Velence, Hungary. The absolute R values of the logistic regression models were summed to indicate relative importance.

RESULTS

There were eight breeding passerine bird species detected on 55 of the 109 reed islands (Table 2). All the models were highly significant, although there was a tendency of lower significance if number of islands (sample size) decreased (Table 3). Patch and landscape variables had similar general role in explaining the presence of reedbed passerines (Mann-Whitney U = 88.00, n = 31, p = 0.218; Fig. 1). Vegetation and isolation variables had much weaker explanatory power (Fig. 1). There was only one species, the Bluethroat *Luscinia svecica*, for which variables of only one spatial scale had non-zero *R* values, indicating that only the patch scale has important role in habitat selection (Table 2). When comparing species, two species, the Moustached Warbler *Acrocephalus melanopogon* and the Reed Bunting *Emberiza schoeniclus*, were more influenced by landscape scale (isolation and landscape variables), than by patch scale variables, while the presence of other species was mostly explained by patch scale factors, including vegetation structure measures (Table 2).

The model for the Bearded Tit *Panurus biarmicus* indicated that the presence of the species is increasing with increasing reed patch area and relative length of edges (shape), and decreasing if the proportion of non wetland habitats is increasing at large scale, that is when the reed island was close to the lake shore (Table 3). In addition, reed density and proportion of land within 500 m had positive, but not significant *R* values. The Reed Warbler *Acrocephalus scirpaceus* model suggested that this species is a real reed bird, preferring large and elongated reed islands, within a reed dominated landscape (although these landscape variables are not significant), and avoids too dense reed stands (Table 3). Savi's Warbler *Locustella luscinioides* had similar preferences for large reed island area, edges, and reed dominated landscape, but it prefers high new reed stands (Table 3).

Table 2. List of bird species included into the analysis, and the number of occupied reed islands (total number of islands was 109) at Lake Velence, Hungary. The absolute *R* values of the logistic regression models were summed to indicate relative importance of variables at the patch and landscape scales (see Table 1).

Species	N of occupied reed islands	Size of smallest occupied reed island (ha)	*R*: patch scale	*R*: landscape scale
Locustella luscinioides	18	0.02	0.639	0.223
Acrocephalus schoenobaenus	27	0.75	0.384	0.172
Acrocephalus scirpaceus	32	0.11	0.606	0.171
Acrocephalus arundinaceus	25	0.17	0.509	0.265
Acrocephalus melanopogon	5	0.64	0.394	0.547
Panurus biarmicus	37	0.03	0.358	0.238
Luscinia svecica	5	4.14	0.482	0.0
Emberiza schoeniclus	21	0.32	0.392	0.789

Table 3. Variables of the logistic regression model for the eight studied reedbed passerine bird species. All statistically significant variables were graphed. See Table 1 for variable descriptions. *** — $p < 0.001$, ** — $p < 0.01$, * — $p < 0.5$, (*) — $p < 0.1$.

Variable	Bearded Tit	Reed Warbler	Savi's Warbler	Sedge Warbler	Bluethroat	Moustached Warbler	Great Reed Warbler	Reed Bunting
Area	0.194 **	0.242 **	0.224 **	0.264 **	0.482 ***		0.386 ***	0.272 **
Shape	0.081 (*)	0.190 **	0.201 *	0.120 (*)		0.394 **	0.123 (*)	
Reed density	0.083 (*)	-0.174 *						
Height of old reed								0.120 (*)
Height of new reed			0.214 *					
Distance to reed stand								
Distance to large reed stand								-0.105 (*)
Water within 350m								0.208 *
Water within 500m						0.185 (*)		-0.238 **
Water within 700m								0.238 **
Water within 860m						0.185 (*)		
Land within 350m								
Land within 500m	0.099 (*)						0.265 **	
Land within 700m								
Land within 860m	-0.139 *							
Reeds within 350m			0.223 **					
Reeds within 500m								
Reeds within 700m		0.091 (*)		-0.172 **		0.177 (*)		
Reeds within 860m		0.080 (*)						
Model χ^2(p)	35.347 ***	68.608 ***	56.770 ***	75.290 ***	17.562 ***	12.988 **	60.466 ***	76.074 ***

Sedge Warbler *Acrocephalus schoenobaenus* also preferred large reed island patches, but it showed an avoidance of reed dominated landscape on a larger (700 m radius) scale of this study. The relative length of edges had positive, but not significant effect on the occurrence of the species. The Bluethroat had the simplest model. It includes only the area. Therefore, the Bluethroat is a species of large reed islands (Table 3). The relative length of edges was the most important variable that predicts the presence of the Moustached Warbler on a reed island (Table 3). Besides, the percent of reed habitat at a larger spatial scale of the study was important, together with other landscape variables. Interestingly, area was not included into the model. The Great Reed Warbler *Acrocephalus arundinaceus* preferred large reed islands not too far from the lake bank (Table 3). Long edges had also some effect. The model of the Reed Bunting is rather complex, including area, but not shape, proportion of water at 350 m and 700 m as positive predictors, although water within 500 m was a negative predictor with isolation (Table 3).

DISCUSSION

A key issue in the understanding of the presence of breeding birds is the relative importance of different factors. In this study, I assessed the relative importance of variables at two spatial scales, the habitat (or reed island) scale, and the landscape scale within the reed archipelago. Generally, both scales had influence on the presence of breeding reed birds, although there was variation among species (Fairbairn & Dinsmore 2001).

All species except one preferred large reed islands. It is not a surprise, since the size of the reed islands is often less than the territory size of the species (Báldi 2004). The model for the Bearded Tit is in accordance with the expectation of preference for large reed patches, and edges (Cramp 1998, Báldi & Kisbenedek 1999). The Reed Warbler is a typical reed species (Leisler 1975). At Lake Velence, it prefers the less dense reeds, which seems to contradict to other studies (Cramp 1998). However, it is simply a problem of the meaning of “relative”. The less dense reed stands in Lake Velence are still denser than the stands in other sites (Báldi 1999). The Savi's Warbler seems to prefer not only large reed islands, but also reed dominated landscape in a larger area (Báldi 2004). The Sedge Warbler preference for large reed islands, but avoidance of pure reed dominated landscape is in accordance with the species habitat selection (Leisler 1975). The Bluethroat is a “simple” species in this system, it is a clear indicator of large reed islands (Báldi & Kisbenedek 1999, Báldi 2004). In other regions of Europe, however, it breeds in more heterogeneous, bushy areas

(Cramp 1998). The Moustached Warbler seems to prefer extensive wetlands, but reed stand edges (Cramp 1998). The Great Reed Warbler nests in pure reed stand edges, even along channels (Cramp 1998, Moskát & Honza 2000, Batáry & Báldi 2005), but often forages in habitats other than reed, which can be even several hundreds meter apart from the nest (Csörgő 1995, Cramp 1998). This may explain its preference for the non-wetland landscape. The model for the Reed Bunting did not provide clear results, probably as a result of the fact that this species has the largest home range among the studied species, and breeds in wet and dry habitats.

The isolation of habitat patches usually has a strong influence on the presence of birds (Fahrig 2003), but here only a minor effect was detected, similarly to its effects on species richness (Báldi & Kisbenedek 2000). This can be a simple consequence of the reed archipelago size. The whole lake is 24 km^2, with 40% reed cover, where the average distance between reed islands is 30–40 m (Table 1). This small distance probably does not play a significant role as a barrier in selecting reed islands for breeding (Bosschieter & Goedhart 2005). I found that some species in this system (Savi's Warbler, Bearded Tit) seem to share several reed islands within the breeding territory (Báldi 2004).

It seems to be a general rule that both habitat and landscape scale factors influence bird species presence; even their weight is relatively similar (Drapeau et al. 2000, Fairbairn & Dinsmore 2001, Melles et al. 2003, Cleary et al. 2005). There is, however, species specific variation in the role of the habitat versus landscape scale factors, suggesting that different mechanisms may be responsible for the patterns. The identification of these mechanisms may help to find the underlying general ecological law.

The important practical conclusion is that both the scales should be considered in conservation of wetlands and probably other habitats. I showed that it is not possible to give one simple management scheme even for pure reed habitat, and for a few taxonomically and/or ecologically closely related species (Báldi & Kisbenedek 2000). Although the large reed island area was preferred by all but one species, it may simply indicate that very small reed islands (much smaller than territory sizes) were not occupied. Reed islands with long edges seem to be preferred by most species, and no edge avoidance was found. However, this conclusion is true only for water — reedbed edge in a lake ecosystem; other reedbed edges (e.g. reedbed — bushes) may not be preferred by these species (Báldi & Kisbenedek 1999). Effective management guidelines require the inclusion, or at least the evaluation of both scale and habitat selection of target species.

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STRESZCZENIE

[Czynniki wpływające na występowanie ptaków wróblowych w płatach trzcinowisk jeziora Velence (Węgry)]

Celem pracy było scharakteryzowanie wpływu czynników środowiskowych i krajobrazowych na występowanie ptaków w niewielkich płatach trzcinowisk. Badaniami objęto 109 "wysp", dla których opisano zarówno zmienne środowiskowe (takie jak wielkość i kształt płata oraz struktura roślinności) jak i krajobrazowe (izolację od innych płatów czy strukturę krajobrazu) (Tab. 1). Obserwacje ptaków prowadzono dwukrotnie w sezonie lęgowym w kwietniu i maju w latach 1993-1994.

Czynniki rozpatrywane w skali krajobrazowej i środowiskowej w podobny sposób tłumaczyły występowanie ośmiu obserwowanych gatunków ptaków trzcinowisk (Tab. 2, Fig. 1). Stwierdzono, że ich wpływ różnił się dla poszczególnych gatunków (Tab. 3). Wielkość płata trzcin była najważniejszym czynnikiem wpływającym na występowanie gatunków (mniejsze nie były zasiedlane). Preferencje do wydłużonych kształtów płatów były stwierdzone dla połowy gatunków. Na podstawie uzyskanych wyników można stwierdzić, że oba rodzaje czynników zarówno środowiskowe jak i krajobrazowe powinny być brane pod uwagę przy planowanych zabiegach konserwatorskich.