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Habitat use of breeding birds in Central European reed beds

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Abstract To date, there have been few comprehensive studies on habitat preferences of wetland bird communities focusing on European reed bed avifauna. During the years 2016–2017, we collected data on bird communities from 79 observational points distributed within 34 wetlands in the northeast of the Czech Republic ranging in size from 0.76 to 70.42 ha, and relevant environmental factors. We compared habitat use among wetland bird species in relation to these factors and tested their effect on species diversity and the proportion of specially protected species. We found that (1) the number of bird species as well as the number of wetland species were positively correlated with the area of the whole wetland. We also uncovered (2) a significant effect of wetland vegetation cover, percentage of open water surface, vegetation wetness index and distance to road to species abundances. There was a clear gradient along distance from water body/open water surface/vegetation wetness index between the species of water surface and species inhabiting wetland vegetation. The second independent gradient was found along distance of observational point to road. (3) Bush cover and Common Reed cover were positively correlated with diversity index and distance to water body was negatively correlated with diversity index. (4) Percentage of specially protected species increased with distance to road and vegetation wetness index, but decreased with tree cover. (5) We recommend this multi-comparison approach for other wetland areas and propose management practices that may increase attractiveness of wetlands for birds.

Keywords Bird community · Diversity · Habitat use · Management · Protected species · Wetland

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Introduction

Wetlands are important ecosystems providing many functions and ecosystem services (e.g. Turner et al. 2011). Unfortunately, more than 90% of wetlands in Europe have been already lost and therefore wetlands are often considered as areas of conservation interest (e.g. Jenkins and Ormerod 2002; Mitsch and Gosselink 2000). Wetlands have disappeared even faster than most other landscape types (Chapman et al. 2001; Junk 2002) and thus they represent one of the most endangered ecosystems around the world (Ma et al. 2010; Verones et al. 2013). Inland wetlands are potentially threatened mostly by drainage and changing land use, inappropriate vegetation management and the introduction of non-native species (Tucker and Evans 1997) since they are extremely endangered by drought as a response to climate change (Pearce-Higgins and Grant 2006; Middleton and Kleinebecker 2012).

Around 20% of the world's bird species depend on wetlands as habitats for feeding, breeding, resting or overwintering (Lévêque et al. 2005) since wetlands host high numbers of bird species with high conservation priority (Tucker and Evans 1997). Overall, biodiversity conservation is one of the main aims of wetland management (Bobbink et al. 2006) and birds are good indicators of environmental stress (Buckton and Ormerod 1997; Tucker and Evans 1997; Fuller et al. 2005). The increasing intensity of human use of the environment have led to the decline of particular bird species populations (BirdLife International/European Bird Census Council 2000; Cooper and Moore 2003; Nergis and Durmuş 2017) .

A key for understanding the presence of breeding birds in a particular habitat is the knowledge of the relative importance of different factors at local and regional scales (Báldi 2006) as well as understanding the relationships between birds and vegetation cover (Pearce-Higgins and Grant 2006) or specific characteristics of water reservoirs (Sebastián-González et al. 2010). The authors usually stressed that different groups of wetland birds showed different habitat requirements. However, comprehensive studies on habitat preferences (see Hawthorne et al. 2010 for definition) of wetland bird communities and those focused specifically on European reed bed (*Phragmites* sp.) avifauna are still quite scarce. Tews et al. (2004) reviewed studies based on the relationship between habitat heterogeneity and animal species diversity. The authors found a high proportion of studies dealing with avian communities (35%), but studies on wetlands represented less than 5% of all studies. The previous studies mainly focused on habitat preferences within a landscape of different habitats (e.g. Fuller et al. 2005). Studies that dealt with wetland ecosystems often showed the crucial role of several environmental factors such as size of wetland (Celada and Bogliani 1993; Sebastián-González et al. 2010), connectivity among wetlands (Moreno-Mateos et al. 2009), structure of reed bed growth (Báldi and Kisbenedek 1999; Báldi 2006) or effect of artificially developed water bodies (Sánchez-Zapata et al. 2005; Pérez-García et al. 2014) on wetland bird communities.

We focused on wetlands of different size, vegetation structure and landscape characteristics in north-eastern Bohemia. The area of wetlands within the study area is nowadays considerably smaller than in the past mainly due to the influence of amelioration in the twentieth century, a common occurrence not only in the Czech Republic, but throughout Europe as well as the rest of the world (Dugan 1993; Van der Putten 1997; Mitsch and Gosselink 2000; Millennium Ecosystem Assessment 2005). Therefore, the wetlands within the study area often represent leftovers within a fragmented woodland–agricultural landscape.

We test (1) the effect of wetland size on bird species numbers to assess the minimal size of wetland for maintaining sufficient bird diversity. Further, we (2) test the effect of complex group of environmental factors related to vegetation structure and landscape characteristics to bird community structure. Moreover, (3) we test the effect of above mentioned environmental factors on species diversity and (4) the proportion of specially protected species to assess which factors are important for future management plans. Based on our results, (5) we propose some major guidelines usable in nature conservation management plans in order to prepare optimal management for reed bed wetlands, where birds are of conservation interest. They are applicable to wetland creation as well.

Materials and methods

Study area

The study was performed in 34 wetlands in northeast Bohemia (Czech Republic, Fig. 1). The study area was 378.1 km^2. The studied wetlands represented only 4.2 km^2 (1.1%) of the whole surface and the area of all observational points covered 56.75 ha (13.6%) of these wetlands. The altitude of the observational points ranged between 210 and 341 m a.s.l. Precipitation varies between 600 and 1000 mm per year and the mean annual temperature ranges from 7 to 9 °C (743 mm and 7.7 °C in Turnov).

The wetlands were mostly situated in or near the Český ráj (Bohemian Paradise) Protected Landscape Area (PLA). Three of them were situated separately

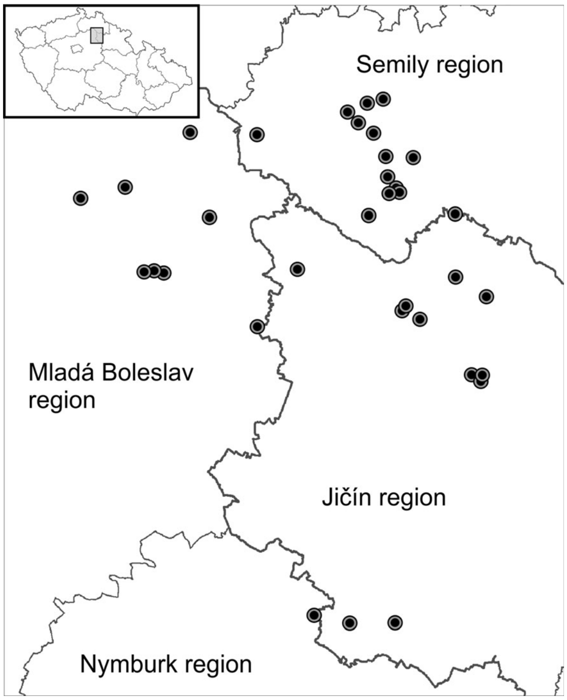

Fig. 1 Map of the study area with the 34 studied wetlands

approximately 15 km from the others in the Rožd'alovické rybníky (Rožd'alovice Ponds) Special Protection Area—Important Bird and Biodiversity Area (IBA) that is part of the NATURA 2000 network. The Bohemian Paradise PLA is composed of a cultural hilly landscape with typical sandstone rock towns and a significant representation of forests. In comparison, the Rožd'alovice Ponds IBA is situated within a flat landscape with very low human population density and is essentially formed by a complex of forests and ponds. Particular wetland types of different sizes were selected based on aerial maps and knowledge of the area. The wetlands were represented by artificial fishponds (n = 13) or associated with a reservoir (n = 1), wetlands formed by isolated reed beds situated along watercourses within forest or as residues within the agricultural landscape (n = 16) and peatlands (n = 4) (ESM3). The wetland vegetation consisted predominantly of Common Reed (*Phragmites* sp.) with median reed cover of 70% at observational point. The areas of the chosen wetlands differed greatly, ranging from 0.76 to 70.42 ha (median: 3.88 ha; 25 wetlands were smaller than 10 ha).

Field work

We used a modified method of Šálek (2012) to monitor observational points within a 50 m radius (area 7854 m^2). The shortest distance between the edges of two observational points was 50 m to eliminate pseudo-replications, because most passerines nesting in wetlands have a relatively small territory (e.g. Báldi and Kisbenedek 1999). In total, we collected data from 79 observational points. The number of points in a wetland depended on its size (median: 2, range 1–5 with a maximum of nine observational points). In general, each hectare of wetland vegetation in one wetland comprised one observational point, but in the case of larger wetlands only several representative points were placed (n = 6 wetlands). The exact locations of the points were selected to capture the most representative parts of the wetlands.

Data on the bird communities were collected during 2016 (n = 40 observational points) and 2017 (n = 39 observational points). Each point was visited only in the first or second year and three times during the breeding season (20 and 30 April, 10 and 20 May, and 1 and 10 June) and thus we could not assess between-year variability (Lõhmus 2003). Birds were observed from the centre of each observational point. The approximate position of every individual bird, which had been heard or sighted within an observational point during the 15 min observation, was immediately written down on an aerial photograph of the observational point. Bird observations were performed between dawn and 10:30 a.m. The sequence of visits in the particular wetlands and also observational points within each wetland were changed during the three observations to capture the activity of different bird species. For each species, we assessed the number of territories at observational points, which was determined based on the activity of individuals (e.g. presence of pair, singing or other behaviour related to nesting such as food carrying to the nest). The observations were made predominantly during rainless days with minimal wind speed.

Assessment of environmental factors

Environmental factors related to observational points were expressed either as categorical levels or continuous variables. We monitored consequent factors: name of wetland, x- and y-coordinates (S-JTSK Krovak) of an observational point, elevation (m a.s.l.), area of the whole wetland (ha), distance to open water surface/watercourse/road/railway/buildings (m), vegetation wetness index (1–3), open water surface (%), tree/bush/herb cover (%), Common Reed (*Phragmites australis*) cover (m^2), wetland vegetation cover (%) and non-wetland area (%).

Data for most of the environmental factors were gathered using a geographic information system (software ArcGIS), while the rest were assessed in the field. Values for factors were gathered once, only values of vegetation wetness indices were gathered during each particular visit of an observational point. Vegetation wetness indices were of three following categories that were estimated in the field: 1—almost dry without standing water, 2—standing water in depressions, 3—standing water within vegetation. In general, each observational point consisted of three main parts—wetland vegetation cover, open water surface and non-wetland vegetation (in the cases of narrow or small wetlands when the observational point had a larger radius than the width or size of the wetland) (Fig. 2). The distance factors were measured from the centre of the observational point to the nearest point (edge) of the relevant object.

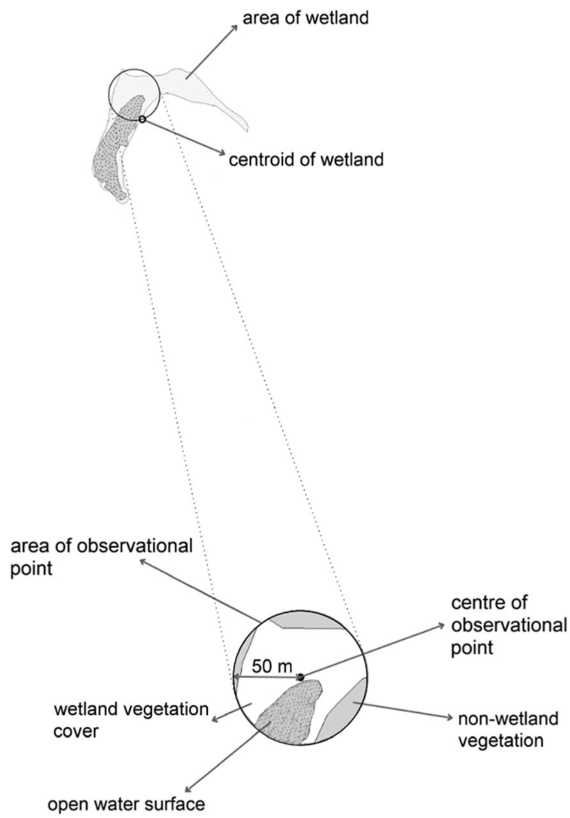

Fig. 2 Methodology of sampling areas for the birds dataset and the environmental factors used in the analyses

Data analyses

First, the original birds dataset based on three visits to the observational points (n = 237 rows) was transformed into the observational points dataset (n = 79 rows). To produce this, data from the three observations were summed to get the maximum number of territories per observational point. Subsequently, we calculated the proportion of specially protected species according to Czech law (Act No. 114/1992 Coll.) and the Shannon diversity index (Shannon 1948). Lastly, we excluded species that had no territory (n = 38) and rare species with only one territory (n = 9) in the whole dataset (for wetland species, e.g. Eurasian Penduline Tit *Remiz pendulinus*, Gadwall *Anas strepera*, Black-headed Gull *Chroicocephalus ridibundus* and Garganey *Anas querquedula* with no territories and Common Snipe *Gallinago gallinago* and Bearded Reedling *Panurus biarmicus* with a single territory). Then we performed regressions between the number of all bird species and only wetland species to the area of the whole wetland using Statistica 13 (Dell Inc. 2016).

Further analyses were performed only for wetland species according to their ecological requirements described in Šťastný et al. (2006). The list of wetland species is available in ESM2. Multivariate data on the effect of environmental factors on the bird community composition at the observational points were calculated using variance partitioning by principal coordinate analysis of neighbour matrices (PCNM) in Canoco 5 (ter Braak and Šmilauer 2012), as recommended by Marrot et al. (2015). This multivariate variance partitioning analysis enabled us to separate the effect of space predictors (i.e., geographical position of nest box) from the effect of primary predictors, or environmental factors (Legendre and Legendre 2012). The analysis included nine steps: (1) a primary predictor test (i.e. preliminary test of the overall effect of the primary predictors on the dataset), (2) primary predictor selection by partial redundancy analysis (RDA) using forward selection based on partial Monte-Carlo permutation tests, (3) principal coordinate analysis (PCoA) based on Euclidean distances (i.e., finding the main space predictors based on coordinates), (4) a PCNM for all predictors (i.e., preliminary test of the overall effect of space predictors on the dataset), (5) PCNM selection (i.e., the choice of space predictors based on coordinates using forward selection and partial Monte-Carlo permutation tests), (6) spatial effects analysis (i.e., assessing the amount of variability explained by the space predictors), (7) primary predictor effects analysis (i.e., assessing the amount of variability explained by the primary predictors), (8) joint effects analysis (i.e., assessing the amount of variability explained by both predictor types) and (9) removal of spatial effects (Šmilauer and Lepš 2014). The data unit was represented by each observational point. The response variables were the numbers of territories of each bird species within an observational point (ESM2). The area of an entire wetland and percentage of non-wetland area at a particular observational point were used as covariates. The x- and y-coordinates (S-JTSK Krovak) of the centres of the observational points were used as the variables representing the spatial coordinates. The following factors were used as explanatory variables: elevation, distance to open water surface, distance to watercourse, distance to road, distance to railway, distance to buildings, vegetation wetness index, percentage of open water surface, tree cover, bush cover, herb cover, Common Reed cover and wetland vegetation cover. Statistical significance was obtained by Monte-Carlo permutation tests with 499 permutations. Since elevation was negatively correlated with distance to road (Spearman rank correlation, $r_s = -0.27$, $P < 0.050$), we excluded this factor from analyses.

The effect of the factors on the Shannon diversity index and the proportion of specially protected species (dependent variables) was analysed using generalized linear mixed models (GLMM) in R 2.14 (R Core Team 2013) using the lmer function in package LME4. Because the distribution of the Shannon diversity indices did not significantly differ from a Gaussian distribution (Kolmogorov–Smirnov test, maximal $P = 0.356$), we used the identity link function in these analyses. The distribution of the proportions of specially protected species differed from a Gaussian distribution (Kolmogorov–Smirnov test, P at least 0.002) and thus we used quasi models. We calculated means ± s.d. in cases when the dependent variable did not differ from the Gaussian distribution, but we used medians and related parameters (25–75% of data, non-outlier range) in other cases. In the analyses the name of the wetland and covariate percentage of non-wetland area within an observational point were used as the random factors. We used the following independent variables: elevation, distance to open water surface, distance to watercourse, distance to road, distance to railway, distance to buildings, vegetation wetness index, percentage of open water surface, tree cover, bush cover, herb cover, Common Reed cover and wetland vegetation cover. We used forward selection of factors based on AIC values, starting with a null model containing only random factors/covariates.

Results

In total, 94 bird species were observed (56 species with a minimum of one territory within an observational point), including 30 species that were specially protected (4 critically endangered, 11 endangered and 15 vulnerable) according to Czech law and 33 wetland species (ESM2). The number of wetland bird species within the wetlands reached a median of five (range 0–20). Within the observational points, we recorded a median of 14 bird species (range 6–23). In total, 791 territories of birds were counted within all wetlands of which 14.7% were territories of the specially protected species (median 6.3%, range 0.0–33.3). The three most frequent species within an observational point were Common Reed Bunting *Emberiza schoeniclus* (n = 66), Common Starling *Sturnus vulgaris* (n = 55) and Reed Warbler *Acrocephalus scirpaceus* (n = 50). The Reed Warbler, Sedge Warbler *Acrocephalus schoenobaenus* and Common Reed Bunting (ESM2) reached the highest density of territories within an observational point. The number of bird species ($R^2 = 0.45$, $F_{(1,32)} = 26.6$, beta = 0.67, $P < 0.001$) as well as the number of wetland species ($R^2 = 0.59$, $F_{(1,32)} = 45.9$, beta = 0.76, $P < 0.001$) were positively correlated with the area of the whole wetland (Fig. 3). In both cases, the sufficient area of wetland to cover at least 90% of maximal number of recorded species was approximately 10 ha. Number of species on very small

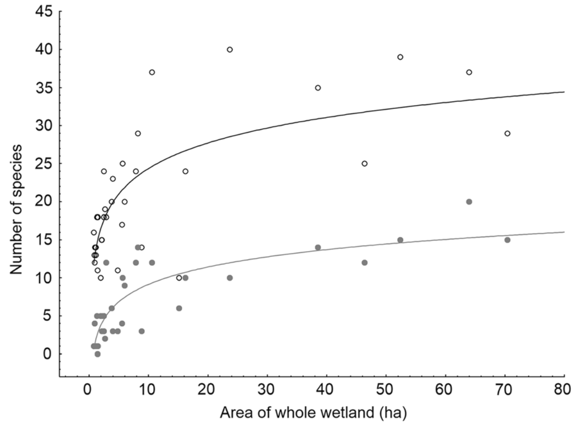

Fig. 3 Relationship between the number of bird species (all species—empty dots/wetland species—full grey dots) and area of a whole wetland (ha)

wetlands (< 2 ha, e.g. Doubravice, Zámostí, Blata) did not exceed 16 species, but large wetlands (> 20 ha, e.g. Rybník Žabakor, Rybník Zrcadlo, Ostruženský rybník) usually hosted more than 30 species.

Further analysis was performed only for abundances of wetland species. Using multivariate PCNM analysis, we found that environmental factors explained 10.2% of the variability, the two spatial predictors (PCO 1 and 11) explained 4.4% while the shared fraction explained 3.4% of the variability. We found significant effect of wetland vegetation cover (pseudo-F = 6.9, P = 0.002), percentage of open water surface (pseudo-F = 5.8, P = 0.002), vegetation wetness index (pseudo-F = 3.3, P = 0.006) and distance to road (pseudo-F = 2.2, P = 0.010) to species abundances. Percentage of wetland vegetation cover was negatively correlated (correlation coefficient − 0.95) and percentage of open water surface was positively correlated (0.92) with the scores on the first ordination axis. Distance to road was negatively correlated (− 0.60) with the scores on the second ordination axis. The vegetation wetness index at the observational point was also positively related to the first ordination axis (Fig. 4a). Bird species were clearly arranged along the first and second ordination axis. Along first ordination axis, the species were arranged based on the two negatively correlated variables—proportion of wetland vegetation and percentage of open water surface (Spearman rank correlation, $r_s = -0.42$, $P < 0.050$). Increased abundances of species inhabiting water surface were commonly

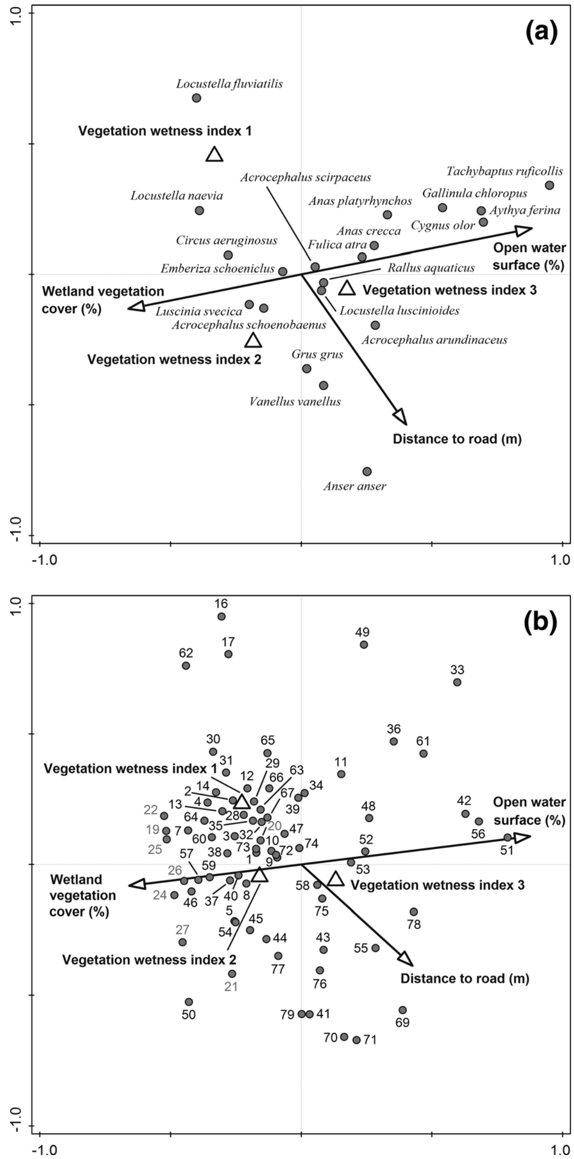

Fig. 4 Projection scores for the number of bird species territories (**a**) and wetland localities (**b**) in relation to environmental factors (n = 74 observational points). Observational points of the case wetland Sedmihorské slatiny are in grey. PCNM analysis (I and II canonical axes explain 14.7% of variability). Five observational points (6, 15, 18, 23 and 68) were without any territories and were excluded from the analysis. For locality numbers see ESM1

associated with increased percentage of open water surface (e.g. Mute Swan *Cygnus olor*, Common Moorhen *Gallinula chloropus,* Mallard *Anas platyrhynchos*, Common Pochard *Aythya ferina* and Little Grebe *Tachybaptus ruficollis*). Species inhabiting wetland vegetation formed the opposite group (e.g.

Water Rail *Rallus aquaticus*, Bluethroat *Luscinia svecica*, Sedge Warbler and Common Reed Bunting). The second independent gradient was found along distance of observational point from road. Typically, Common Crane *Grus grus*, Greylag Goose *Anser anser* and Northern Lapwing *Vanellus vanellus* were often found at observational points that were distant from roads. On the other hand, River Warbler *Locustella fluviatilis* and Common Grasshopper Warbler *Locustella naevia* reached higher abundances at observational points close to roads (Fig. 4a). In most cases, the observational points from one particular wetland substantially differed in bird composition in accordance with variability in vegetation cover (e.g. Sedmihorské slatiny [19–27], Červenský rybník [57–61], but see Rybník Kojetín [69–71], Fig. 4b.

The GLMM analyses showed that bush cover, distance to water body and Common Reed cover significantly affected Shannon diversity index at observational point (Table 1). Bush cover and Common Reed cover were positively correlated with Shannon diversity index (Fig. 5a, c) and distance to water body was negatively correlated with Shannon diversity index (Fig. 5b). All these variables explained comparable amount of model variability (Table 1). The proportion of specially protected species was affected by tree cover, distance to road and vegetation wetness index (Table 1). Percentage of specially protected species at observational points increased with distance to road and vegetation wetness index (Fig. 5e, f), but decreased with tree cover (Fig. 5d). Observational points with more than 30% of tree cover were completely avoided by specially protected species (e.g. Pod Rokytňákem, Rokytnice and Javornice). Tree cover explained the most of model variability and elevation explained the least amount of model variability (Table 1).

Discussion

Wetlands are considered as ecosystems with highest biodiversity (e.g. Tucker and Evans 1997). In agreement, we recorded high total number of bird species as well as the high number of specially protected species on studied wetlands. The rather overall low proportion of wetland species was probably caused by the small size of the wetlands surrounded by landscapes with non-wetland habitats and in degraded wetlands (ESM1) as they are very often remains of abandoned areas (Sánchez-Zapata et al. 2005). The great variability in the number of wetland bird species among observational points reflected the different quality within the studied wetlands. Half of the total number of species were those with a negligible number of territories (zero or one territory) and included wetland species with decreasing population trends in the Czech Republic (e.g. Common Snipe). In contrast, species with the highest density of territories within the observational points were either specially protected species (Water Rail, Savi's Warbler *Locustella luscinioides* and Bluethroat *Luscinia svecica*) or common wetland species (Common Reed Bunting, Reed Warbler and Sedge Warbler). All these species exhibit increasing population trends in the Czech Republic (Šťastný et al. 2006). According to IUCN (Birdlife International 2016) population of Water Rail and Common Reed Bunting are decreasing, while Savi's Warbler, Bluethroat, Reed Warbler and Sedge Warbler have a stable population trend.

Table 1 The effect of factors on diversity and the proportion of specially protected species based on data from observational points (GLMM analyses, Shannon diversity index—Gaussian models, % of specially protected species—quasi models, N = 79 observational points)

Dependent variable	Independent variable	df	Chi	Beta	% of explained variability	P
Shannon diversity index	Bush cover (%)	76	15.14	0.21	16.4	< 0.001
	Distance to water body (m)	75	10.26	− 0.12	11.9	0.002
	Common Reed cover (m^2)	74	9.57	0.15	11.3	0.003
% of specially protected species	Tree cover (%)	76	35.83	− 0.71	31.8	< 0.001
	Distance to road (m)	75	17.7	0.23	12.9	< 0.001
	Vegetation wetness index (1–3)	73	3.71		5	0.029

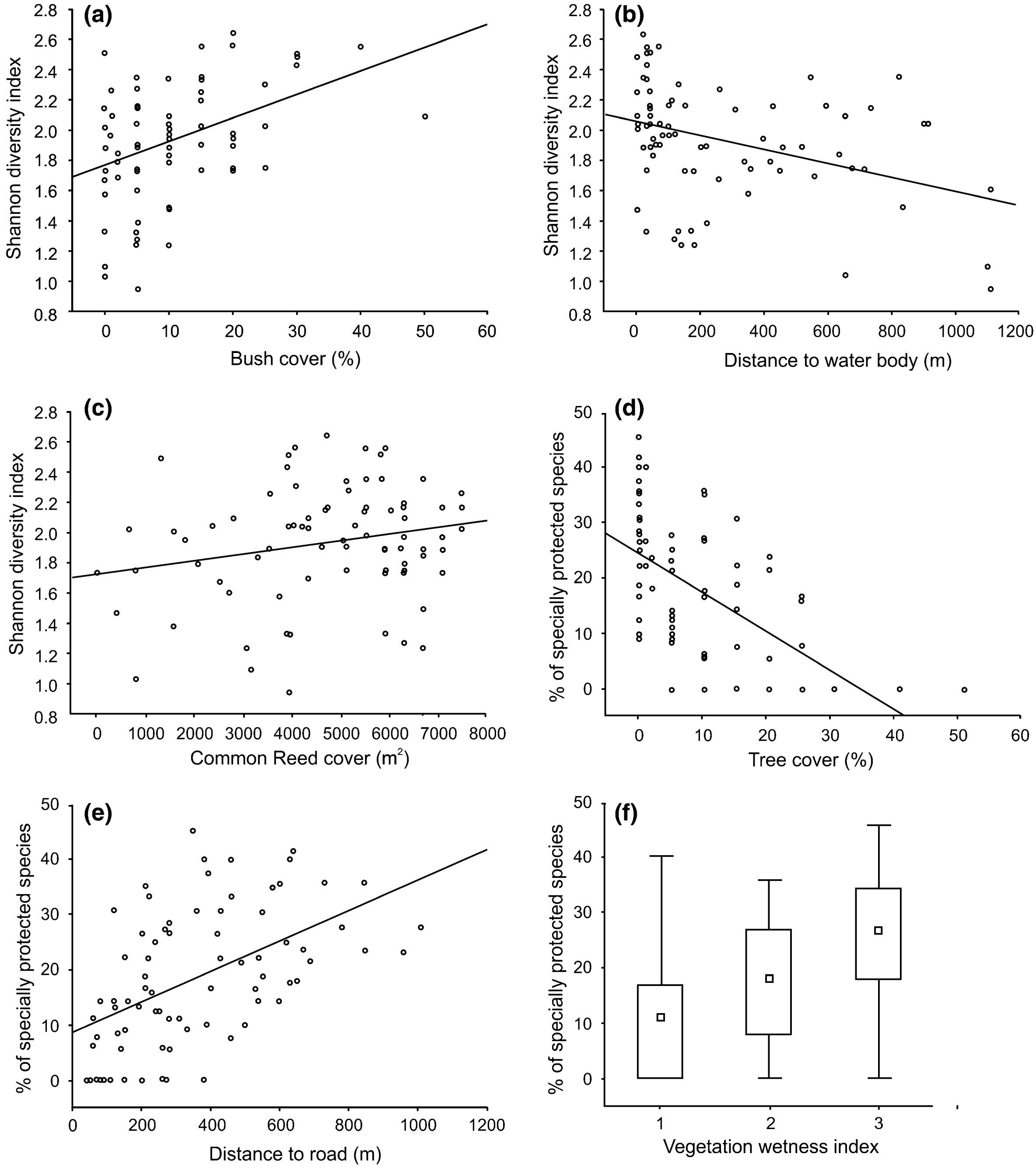

Fig. 5 The effect of bush cover (**a**), distance to water body (**b**) and Common Reed cover (**c**) on the Shannon diversity index of avian wetland community. The effect of tree cover (**d**), distance to nearest road (**e**) and vegetation wetness index (**f**) to the proportion of specially protected species. GLMM analyses based on the observational points dataset (n = 79 points)

The positive correlations between the area of a whole wetland, the total number of bird species and also wetland species are in accordance with previous results (e.g. Celada and Bogliani 1993; Sebastián-González et al. 2010). Previous research also documented that bigger bird species reach higher densities on larger wetlands (Sebastián-González and Green 2014). However, according to Johnson (2001) the habitat patches required by some species are many times larger than the size of their territories. It could also pose a problem in the case of small wetlands. The small patches within a landscape can hardly offer optimal conditions for breeding bird communities. In our study, we found that approximately 10 ha is a sufficient area of wetland for settlement for most of wetland species. On the other hand, small wetlands are important for metapopulation dynamics (Gibbs 1993).

In general, the distribution of passerines across reed beds varies greatly among species due to their different ecomorphology or habitat preferences (Báldi and Kisbenedek 1999) and the reed bed structure determines the diversity and richness of bird communities (Báldi 2006; Moreno-Mateos et al. 2009). Our results suggest the simultaneous effect of several factors, including wetland vegetation cover, open water surface, distance to road and vegetation wetness index. The most important seems to be a gradient along wetland vegetation cover, vegetation wetness and open water surface. We recorded a clear gradient between species of water surface (e.g. ducks, Little Grebe or Common Moorhen) and species that obviously inhabit wetland vegetation (e.g. Bluethroat or Common Reed Bunting). The second independent gradient along distance to road seems to be problematic for further interpretations since it is not possible to separate the effect of distance to road from elevation (i.e. observational points more distant from roads were simultaneously found at wetlands with lower elevation). However, it seems that at least several species were more often found at observational points that were located far from roads (e.g. Common Crane, Greylag Goose and Northern Lapwing). Bird communities at the observational points of one wetland often greatly differed among each other, as a result of variability in the habitat quality among the observational points (e.g. Sedmihorské slatiny, Fig. 4b. Based on these findings, we suggest that habitat heterogeneity within a wetland may substantially affect wetland avian community structure.

We found a positive effect of the proportion of bush cover and Common Reed cover on the Shannon diversity index, suggesting that increased diversity was a result of increased habitat heterogeneity. However, in the case of bush cover, further increase in diversity above a particular bush cover is unlikely due to increasing habitat homogeneity (Tews et al. 2004). Proportion of specially protected species within the observational points was negatively correlated with proportion of tree cover. Since wetland habitats, and especially reeds, host a high number of bird species with high conservation priority (Tucker and Evans 1997), an increased proportion of trees probably caused a decreased proportion of reed vegetation and other typical wetland habitats that led to a lower proportion of specially protected species. On the other hand, we recorded increased proportion of specially protected species at observational points with high index of vegetation wetness. The positive correlation between the proportion of specially protected species and distance to the nearest road is in accordance with most previous studies considering roads as an element with negative or no effects on birds due to traffic disturbance (e.g. Fahrig and Rytwinski 2009). Simultaneously, we found a negative effect of distance from water body on bird community diversity at an observational point. Surprisingly, we found a negative relationship between proportion of specially protected species and elevation. Since the elevational differences among study sites were not marked and the factor explained the lowest percentage of model variability, we suggest a minor influence of this factor at all.

Studies on habitat preferences show wetland habitats optima for particular breeding bird species and therefore pose an important background for nature conservation (Lõhmus 2003). In general, management plans that may improve habitat quality should use a holistic (whole ecosystem-based) approach assessing particular priorities and trade-offs among different species and groups of conservation concern due to different requirements on the environment. Restored wetlands benefit by having a diverse waterbird community and artificial wetlands can provide alternative or complementary habitats for these species (Ma et al. 2010; Karakaş 2017). Moreover, artificial wetlands can be even more beneficial for waterbirds than natural ones (Sebastián-González et al. 2010).

According to our results we were able to propose appropriate management improvements that would increase wetland attractiveness for birds and for the priority species in nature conservation, respectively. We suggest several key steps for the studied wetlands: (1) restoration (e.g. Sedmihorské slatiny—a meliorated wetland in the past, where great part of the wetland showed pure bird community structure in contrast to one observational point with increased diversity), (2) increase protection level (e.g. Rybník Zrcadlo, Nový rybník or Nad Novým rybníkem—the percentages of specially protected species are comparable with other protected wetlands), (3) applying partial tree felling (e.g. Pod Rokytňákem, Rokytnice and Javornice—tree cover exceeded optimum for occurrence of specially protected species) and (4) extension of some very small wetlands (e.g. Doubravice, Zámostí, Vydalov—pole and Zámostí, Blata—the size is much smaller than optimal size 10 ha). Moreover, we recommend the creation of new wetlands to improve connectivity of wetlands within the landscape and create new habitats for birds (e.g. Comín et al. 2001; Paracuellos 2006; Moreno-Mateos et al. 2009).

Finally, some major guidelines can be proposed in order to prepare optimal management for reed bed wetlands, where birds are of conservation interest. Particularly, it is important to extend small wetlands (up to 10 ha) to the maximal possible area, maintain optimal proportions of wetland vegetation (reed bed growth) and open water surface, maintain sufficient water level, increased bush cover and decreased tree cover. When creating new artificial wetlands, it would be profitable to locate them at longer distance from roads.

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