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Breeding bird assemblage of a fir-oak natural forest in Ponická dúbrava – the oldest Slovak nature reserve

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Abstract

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The bird assemblage of the Ponická dúbrava National Nature Reserve (13.3 ha), preserving a mixed nature forest composed mainly of fir, oak, spruce and beech was studied using a modified mapping method during the breeding period in 2015. The site is rather unique, containing elements of both lowland and mountain forests. The aims of the study were to determine the structure of the bird assemblage, compare it with other bird assemblages from oak-beech and mixed natural forests, and define the most important habitat indicator species. Altogether, 37 breeding bird species were recorded and the estimated rarefaction species number per 10 ha was 30.9. Total bird density reached 63.0 pairs/10 ha. Five species were found to be dominant (>5% of the total density): *Fringilla coelebs*, *Erithacus rubecula*, *Periparus ater*, *Regulus regulus* and *Ficedula albicollis*, representing 42.6% of the total density. Comparing with other eight bird assemblages from natural forests using a cluster analysis, the assemblage from the Ponická dúbrava clearly fits into those from mixed beech-fir-spruce forests. Factor analysis revealed six species separating the assemblage from oak-beech stands: *Regulus regulus*, *Poecile montanus*, *Periparus ater*, *Pyrrhula pyrrhula*, *Prunella modularis* and *Turdus viscivorus*. Based on our data, the reserve represents a valuable rare natural habitat of very high bird species diversity.

Key words

diversity, indicators, mixed forest, Western Carpathians

Introduction

In Europe, forest biodiversity conservation is high priority because woodland habitats used to dominate the continent before massive human effect on the landscape took place. At the continental scale, only about one-third of the original post-glacial forest cover is still present (Mikusiński et al., 2001). Primeval forest is the forest community that emerged in a natural way, under the effect of spontaneous factors and developed without any significant human effect (Korpeľ, 1995). The terms "primeval forest", "primary forest" or "pristine forest" are often used as a synonymous with "virgin forest" (Schuck et al., 1994), or the "forest undisturbed by man" (Parviainen, 2005). The forests undisturbed by man are rare in the European temperate zone due to the historical continuous use of forests. Thus, the term "natural forest" (the less strict category) is more relevant in practice, as some levels of human impact can nearly always be found in European forests (Parviainen, 2005). Within Europe, Slovakia is a country with the highest forest cover and the highest proportion of strictly protected forest areas with no active intervention in relation to its overall forest area (MCPFE,

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1993). Bird assemblages of several natural forests have been studied in the Slovak territory. Bird assemblages of natural or semi-natural broad-leaved forests were studied by Turček (1955), Feriancová-Masárová et al. (1987, 1991), Krištín (1991, 1996, 1999), Kropil (1993), Bohuš (1993), Bohuš et al. (1999), Lešo (2001, 2003a, 2003b), Lešo and Kropil (2007, 2014), Korňan (2009). Bird assemblages of natural mixed and coniferous forests were studied by Topercer (1989, 1997), Kropil (1992a, 1996a, 1996b), Saniga (1994, 1995, 2011), Krištín (1991, 1999), Pochopová and Kropil (2002), Ceľuch and Kropil (2004), Saniga and Saniga (2004), Korňan (2004), Baláž and Kocian (2006), Baláž (2008), Baláž and Balážová (2012), Korňan and Adamík (2014). In central and eastern Europe, the Białowieża Forest protected in the Białowieża National Park is considered to be the best preserved large area of natural forests, where bird assemblages were studied by Tomiałojć et al. (1984), Tomiałojć and Wesołowski (1990, 1996), and Wesołowski et al. (2002, 2006). Forest reserves represent important refugia for biodiversity conservation, and their study can contribute to better understanding of anthropogenic changes undergoing in managed forests. The Ponická dúbrava belongs to the first two natural reserves established in the territory of Slovakia. It was established in 1895 to protect natural beech-oak forest stand on acid bedrock composed of quartzite. No forest management has been performed there up to the present. From that aspect, the forest occurring there can be considered as a natural one and its tree structure is rather unique. Despite the fact, that the reserve was declared 120 years ago, no faunistic survey has been performed there. The aims of this study were to: 1) determine the structure of the bird assemblage; 2) evaluate the relationship with other bird assemblages from selected oak-beech and mixed natural forests; 3) define the most important habitat indicator species; and 4) evaluate the importance of the reserve for biodiversity conservation.

Material and methods

Study plot

The reserve (13.3 ha) is situated in central Slovakia (centre of the reserve 48°41′38″N; 19°18′36″E; Fig. 1), geomorphologically belonging to the Zvolenská kotlina Basin (Western Carpathians). The lower parts of the reserve belong to the intramontane basin climate, upper parts to the montane climate (Špánik et al., 2006). The mean annual temperature is 7.2–7.7 °C, mean annual precipitation is 770–820 mm (Škvarenina et al., 2004). The altitude ranges from 500 to 650 m asl, orientation is south-east, slope inclination is 50–100%. The mean age of trees is over 150 years; mean height of the tree layer, depending of tree species, 12–30 m; mean breast-height diameter of trees 30–67 cm. The forest stand has very diverse tree composition. Fir (*Abies alba*), spruce (*Picea abies*) and beech (*Fagus sylvatica*) compose the stand in periphery and in the western part of the reserve. The Sessile oak (*Quercus petraea*; with an admixture of *Q. polycarpa* and *Q. dalechampii*) dominates the central part of the reserve where it is being intermixed with fir, Scots pine (*Pinus sylvestris*), hornbeam (*Carpinus betulus*) and some other rare tree species. The shrub layer, composed mainly of fir natural regeneration, is moderately developed. Multi-storeyed stand structure prevails (Fig. 2). Quartzite rocks stick out of the ground surface and create various rock structures.

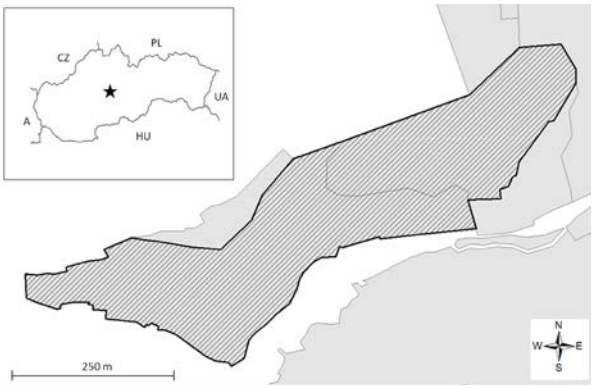

Fig. 1. The Ponická dúbrava NNR (13.3 ha) and its localization within Slovakia; area of the reserve is hatched; white colour – open and semi-open habitats (fields, orchards, meadows, urban area); grey colour – forests.

Bird census

A modified mapping method was used to census breeding birds (breeding pairs). Nine census visits were performed between 12 April and 1 June 2015. During each visit around 15 minutes per ha were spent for observations (approximately 3–4 hours per whole study plot). Most controls started from sunrise. To map bird species active during dusk and after sunset, two census visits started 1–2 hours before sunset. Censuses were carried out during favourable meteorological conditions, not during periods of heavy rain and wind. During each visit, all visual and acoustic registrations with emphasis on simultaneous records, nest findings and other data related to bird occurrence were plotted onto a map (scale 1:1,500) and the total numbers of pairs belonging to all registered species were estimated. At the end of the season the number of breeding pairs of each species was estimated as the maximum value of species abundance during nine census visits considering also spatial distribution of records obtained during the nine census visits. That manner brings some risk of overestimating of migratory species during waves of

Fig. 2. The forest stand structure in the centre of the reserve.

their migration, but I preferred this modification over the combined mapping procedure (Tomiałojć, 1980) due to difficult passability over the whole reserve arising from the steep slope and occurrence of crags. Bad passability complicated tracing of territorial birds, what is one of the principles of the mapping method. Only birds with at least two records of territorial behaviour (during two different controls) or those verified by finding nests were counted as breeding pairs. In other cases they were considered as accidental 'visitors'.

Data analysis

For estimating the total abundance, only territories with at least one half of their area situated within the study plot were included. In cases where part of the territory within the study plot represented less than an estimated 0.5 of the territory area (edge territories or large territories), a '+' sign was attributed and it was excluded from total breeding pairs amount (not from the breeding species list). Diversity (*H´*) and equitability (*J´*) were calculated according to the Shannon formula (Krebs, 1989) using the binary logarithm. Rarefaction following Krebs (1989) was calculated to standardize sample size for comparison of species richness. Cluster analysis using unweighted pair-group average clustering of Euclidian distances was used to compare the bird assemblage with other bird communities from selected oak, oak-beech and fir-beech-spruce natural forests in Slovakia. Selection of certain bird assemblages for the analysis was subjective, based on the representativeness of forest stand structure. Factor analysis was used to reveal bird species which contributed mostly to the separation of ornithocenoses in the dendrogram. Species with loadings higher than 0.7 to unrotated first two factors (principal components) were considered as important indicator species. Statistical analyses were performed in the package Statistica for Windows 10.0 (StatSoft, 2001). Rarefaction was calculated using online Rarefaction Calculator (http://www.biology.ualberta.ca/jbrzusto/rarefact.php).

Results and discussion

Basic cenological characteristics

In total, 37 breeding species were detected within the reserve during one breeding season (Table 1). Besides several visitors, also another two potential breeders were recorded within the reserve (*Bonasa bonasia*, *Phoenicurus ochruros*), but their registrations did not fulfil criteria for considering them as breeding species. Standardised species number after rarefaction procedure reached 30.09 species per 10 ha (Fig. 3). Shannon index of species diversity reached 4.64 bits and equitability 0.89. Comparing with results from some other natural mixed forests of the Central Europe, ascertained by similar census methodology (Pavelka and Pevelka, 1990; Glowaciński and Profus, 1992; Kropil, 1996a, 1996b; Krištín, 1999; Korňan, 2009; Korňan and Adamík, 2014) and natural oak-beech forests (Kropil, 1993; Lešo and Kropil, 2014), the number of bird species per 10 ha and bird species diversity reached the highest values in the Ponická dúbrava. These cenological parameters even exceed values from the Białowieza National Park (Tomiałojc et al., 1984; Tomiałojć and Wesołowski, 1996; Wesołowski et al., 2006), as well as mean species richness and diversity of 14 mixed forests and 35 deciduous forests from the Czech Republic (Storch and Kotecký, 1999). Apart from the high heterogeneity of the habitat and tree composition, the edge

effect undoubtedly plays some role, since the reserve is surrounded by open or semi-open habitats from three sides. Although no ecotonal specialists, perhaps except for *Sturnus vulgaris*, enriched the bird assemblage. The overall diversity of forest birds may depend on microclimatic stability, tree replacement and demography (Segura et al., 2014). Tits can be used as appropriate and easy-interpretable indicators of general character of habitats, since they are adapted to different forest types. High structural heterogeneity of the habitat and diverse tree composition conditioned presence of all six tit species occurring within central Europe. This finding is rather rare, above all, regarding small area of the reserve. Considering other results taken in the natural forests of the Central Europe, only Kropil (1996a) and Krištín (1999) recorded all tit species within one study plot, namely in the Dobročský prales and the Mláčik. That is to say, the area of their study plots was considerably higher (24 ha study plot in the Dobročský prales; transects across 147 ha of the Mláčik).

Table 1. Structure of breeding bird assemblage of the Ponická dúbrava National Nature Reserve (13.3 ha)

Species	Pairs	Density (pairs/ 10 ha)	Dominance %
Fringilla coelebs	12	9.0	14.2
Erithacus rubecula	9	6.7	10.7
Periparus ater	5	3.7	5.9
Regulus regulus	5	3.7	5.9
Ficedula albicollis	5	3.7	5.9
Sylvia atricapilla	4	3.0	4.7
Certhia familiaris	3	2.2	3.6
Turdus merula	3	2.2	3.6
Parus major	3	2.2	3.6
Sitta europaea	3	2.2	3.6
Cyanistes caeruleus	3	2.2	3.6
Phyloscopus collybitta	3	2.2	3.6
Sturnus vulgaris	2	1.5	2.4
Turdus philomelos	2	1.5	2.4
T. troglodytes	2	1.5	2.4
Phylloscopus sibilatrix	2	1.5	2.4
Dendrocopos major	2	1.5	2.4
Columba palumbus	2	1.5	2.4
Prunella modularis	1.5	1.1	1.8
Muscicapa striata	1	0.7	1.2
Poecile palustris	1	0.7	1.2
Poecile montanus	1	0.7	1.2
Lophophanes cristatus	1	0.7	1.2
Regulus ignicapillus	1	0.7	1.2
Turdus viscivorus	1	0.7	1.2
Garrulus glandarius	1	0.7	1.2
Phylloscopus trochilus	1	0.7	1.2
Cuculus canorus	1	0.7	1.2
Streptopelia turtur	1	0.7	1.2
Columba oenas	1	0.7	1.2
Pyrrhula pyrrhula	1	0.7	1.2
Dendrocopos leucotos	0.5	0.4	0.6
Dryocopus martius	+	+	0.0
Strix aluco	+	+	0.0
Picus canus	+	+	0.0
Accipiter nisus	+	+	0.0
Buteo buteo	+	+	0.0
Total	83.5	63.0	100

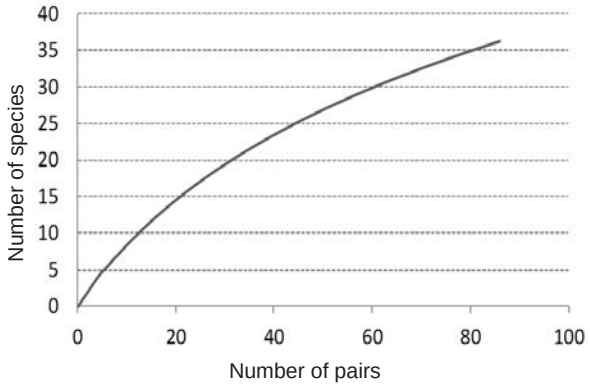

Fig. 3. Estimated number of bird species depending on their abundance in the Ponická dúbrava NNR (13.3 ha) calculated by rarefaction.

Overall density estimated in the Ponická dúbrava reached 63.0 breeding pairs per 10 ha. Five species were found to be dominant (>5% of the total density): *Fringilla coelebs*, *Erithacus rubecula*, *Periparus ater*, *Regulus regulus* and *Ficedula albicollis*, representing 42.6% of the total density. Relatively small portion of dominant species reflects a high diversity of the ornithocenosis (Magurran, 2004), confirming the conclusions mentioned above. High diversity and equitability is apparent also from the species rank (Fig. 4). Habitat generalists (*Fringilla coelebs* and *Erithacus rubecula*) and specialists related to coniferous forests (*Periparus ater* and *Regulus regulus*) prevailed among dominant species, being supplemented by an oak forest specialist *Ficedula albicollis*. This combination of dominant species is rather unique, and has no parallel in published results at least from Slovakia. Overall density does not differ markedly from other mixed forests of the Central Europe (54–76 pairs/ 10 ha; Pavelka and Pavelka 1990; Saniga, 1994, 1995; Kropil, 1996a, 1996b; Krištín, 1999; Korňan, 2009, 2013; Korňan and Adamík, 2014), but is substantially lower when comparing with oak-beech forests (70–100 pairs/10 ha; Lešo and Kropil, 2014), or oak-dominated natural forest stands in the Białowieza National Park in eastern part of Europe (82–118 pairs/ 10 ha; Wesołowski et al., 2002, 2006).

Hole-nesters represented 38.9% of the overall density. Comparing with the studies conducted in oak-beech natural forests (Lešo and Kropil, 2014), the relative portion of the hole-nesters is lower in the Ponická dúbrava by ca. 10%. The higher difference is apparent in absolute density of the hole-nesters reaching 24.3 pairs/10 ha in the Ponická dúbrava NNR vs. ca. 35–45 pairs/10 ha in oak-beech natural forests. Higher absolute density of this nesting guild differentiates mixed and coniferous forests from deciduous forests in general (Tomiałojc et al., 1984, Wesołowski et al., 2006). High tree holes supply was a characteristics feature of the site, especially in the central part of the reserve with dominant portion of oak. Virkkala et al. (1994) considered hole-nesting bird species as good indicators of conservation value of nature reserves in southern Finland. They confirmed a positive effect of nature reserves on hole-nesting birds if the area of old-growth forests was larger than 5 km^2. However, the abundance of hole-nesters might be used as a rough indicator of the general conservation value of forests in nature reserves.

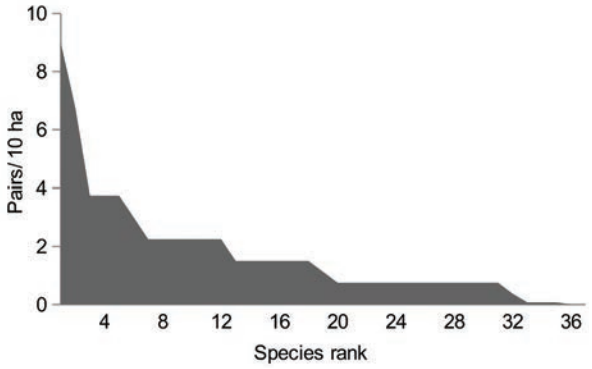

Fig. 4. Descending curve of bird species' density (N = 37) in the Ponická dúbrava NNR.

Classification of bird assemblage and determining of indicator species

Comparing with other eight bird assemblages from natural forests using a cluster analysis, the bird assemblage from the Ponická dúbrava NNR ranks among those from mixed beech-fir-spruce forests (Fig. 5).

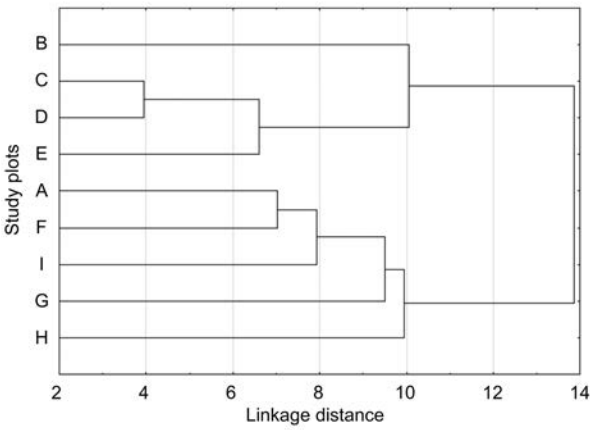

Fig. 5. Classification of bird assemblages from selected natural forests of Slovakia. A – Ponická dúbrava, B – Kováčovské kopce (Lešo, 2001), C – Kokošovská dubina (Lešo and Kropil, 2014), D – Malé brdo (Lešo and Kropil, 2014), E – Bujanov (Lešo and Kropil, 2014), F – Dobročský prales (Kropil, 1996a), G – Badínsky prales (Kropil, 1996b), H – Šútovská dolina (Korňan and Adamík, 2014), I – Mláčik (Krištín, 1999).

Classification separated bird assemblages from deciduous forests (oak and oak-beech forests B–E) and the second cluster represents bird assemblages from mixed forests (A, F–I). Despite the name of the reserve emphasizing occurrence of oak, the classification procedure clearly assigned the bird assemblage from the Ponická dúbrava to mixed forests' bird assemblages.

Two first axes generated in factor analysis explained 39.9% of the total variance. The first axis can be clearly interpreted, drawing the line between broad-leaved and coniferous (or mixed) forests. Interpretation of the second axis is impossible. Totally, 22 bird species reached loadings to the first two factors higher than 0.7 and were considered to be important for separating bird assemblages from broad-leaved versus coniferous (or mixed) forests. These bird species were ordinated on the first two PC axes, creating two distinct clusters representing indicators of lowland (deciduous) and mountain (coniferous) forests (Fig. 6). Of them, six species occurring in our study plot separated the bird assemblage from oak-beech stands: *Regulus regulus, Poecile montanus, Periparus ater, Pyrrhula pyrrhula, Prunella modularis* and *Turdus viscivorus*.

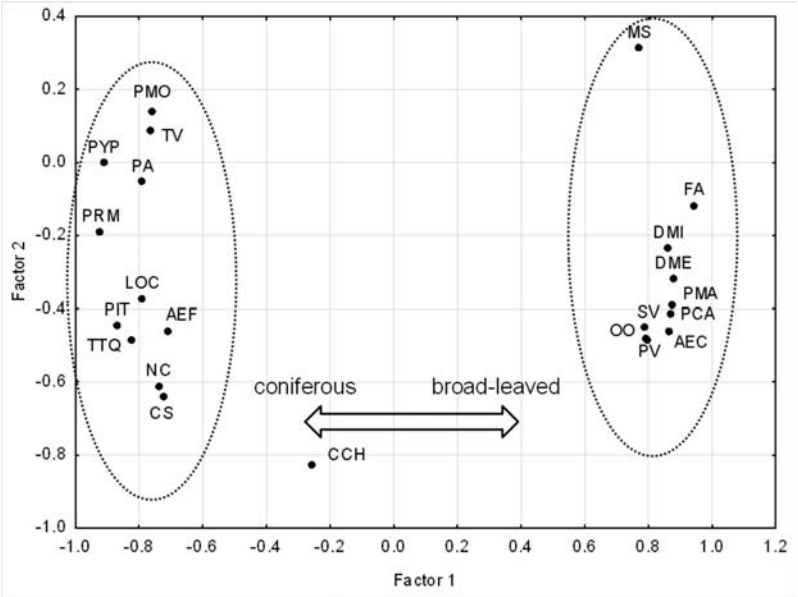

Fig. 6. Ordination diagram – projection of indicator species on the first two PCA-axes. Bird species abbreviations (according to Kropil 1992b): AEC – *Aegithalos caudatus*, AEF – *Aegolius funereus*, CCH – *Carduelis chloris*, CS – *Carduelis spinus*, DME – *Dendrocopos medius*, DMI – *Dendrocopos minor*, FA – *Ficedula albicollis*, LOC – *Loxia curvirostra*, MS – *Muscicapa striata*, NC – *Nucifraga caryocatactes*, OO – *Oriolus oriolus*, PA – *Periparus ater*, PCA – *Parus caeruleus*, PIT – *Picoides tridactylus*, PMA – *Parus major*, PMO – *Poecile montanus*, PRM – *Prunella modularis*, PV – *Picus viridis*, PYP – *Pyrrhula pyrrhula*, SV – *Sturnus vulgaris*, TTQ – *Turdus torquatus*, TV – *Turdus viscivorus*.

Importance of the natural reserve for diversity conservation

Natural forests of a sufficient area preserve bird diversity at local and regional scale, what can reduce effect of biotic homogenization occurring over large areas of Europe (Reif et al., 2012). It is crucial to describe and analyze structure of natural forests for the management of other managed forest ecosystems and nature conservation aims (Korňan, 2004). Within central Europe, several tens of natural forests were the subject of ecological studies, most of them within the territory of Slovakia. The natural forest occurring in the Ponická dúbrava is specific by its rare tree-species structure. Due to hard-passable terrain, the site has remained almost unspoiled for more than a century with well preserved native structure of the forest stand despite very small area of the reserve. Stable tree composition conditioned by successful natural regeneration of tree species, including oak, indicates native character of the forest stand. Contrariwise, several reserves in Slovakia with dominant share of oak, where natural regeneration of oak is difficult, indicate modification of tree composition by forest management in the past (Korpeľ, 1995). Apart from questionable natural character of some reserves, also small area of reserves located in lowlands causes lower stability of their tree composition. The minimal recommended area for establishing natural reserves in oak-beech forests is about 50 ha, while only 10 ha in mixed forests (Bücking, 2003). The Ponická dúbrava belongs to the network of the special areas of conservation (SAC) meeting the criteria of NATURA 2000 sites. Despite the fact that its small area does not allow us to consider it as important bio centre for bird

diversity conservation on the large scale, its importance lies in preserving rare, valuable and stable forest site containing elements of both lowland and mountain forests, providing refuge for specific bird assemblage of remarkable high diversity.

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