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HABITAT SELECTION AND SIMILARITY OF THE FOREST SONGBIRD COMMUNITIES IN MEDVEDNICA AND ŽUMBERAK – SAMOBORSKO GORJE NATURE PARKS

IZBOR STANIŠTA I SLIČNOSTI ZAJEDNICA PTICA PJEVICA U ŠUMAMA PARKOVA PRIRODE MEDVEDNICA I ŽUMBERAK – SAMOBORSKO GORJE

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ABSREACT: The effect of floristic and structural characteristics of vegetation on the forest songbird communities in two Nature Parks: Medvednica and Žumberak – Samoborsko gorje was studied. The point-count method was used for analyzing songbird communities and circular plot method for habitat mapping, on 101 points at both sites. Non-parametric test were used (Kruskal–Wallis and Kendal Tau). The tree basal area was used to classify studied points into five forest types (beech, oak, mixed deciduous, coniferous and mixed coniferous forests) and as indication of the stand maturity. The total of 27 and 32 songbird species were recorded on Medvednica and Žumberak – Samoborsko gorje respectively. Diversity was higher on Žumberak – Samoborsko gorje due to greater habitat fragmentation, while population density of songbirds was greater on Medvednica. Among structural characteristics, those related to forest age (average tree basal area and number of the small trees) had the most pronounced effect to the total songbird density and densities of different ecological groups of birds. Sørensen index showed that in spite of the differences in floristic composition between particular forest types in two studied areas (0.475 ± 0.120), songbird communities showed high similarity (0.872 ± 0.070). The highest similarity of songbird communities between Parks was recorded in beech and oak stands. Oak stands showed the lowest similarity in tree species composition and no significant difference in structural characteristics, while beech stands had many different structural features and several differences in densities of ecological groups of birds. The greatest difference of bird densities in the particular forest type between two Parks was found in beech and mixed coniferous stands. High structural differences between these two forests were the result of the forest age; bird populations had higher densities in older stands.

Key words: songbird communities, forest habitat, vegetation structure, Nature Parks

INTRODUCTION – Uvod

Habitat choice in birds is affected by two groups of factors: species requirements and inter- and intraspecific competition (Pielou 1978). Birds have greater potential for habitat selection than other taxonomic groups, due to their extreme mobility and diversity of ranges. Great seasonal changes in forest habitats force forest birds, especially migratory insectivores, to re-establish their residence annually and quickly in appropriate habitats. This has probably resulted in strong selective pressures on their patterns on habitat choice (Cody 1985, Sherry and Holmes 1985).

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Abundance of forest birds is largely dependent on the forest types. Studies which relates habitat characteristics to species abundance often has a goal to find out whether structural or floristic characteristics of vegetation has more impact to species distribution abundance. While MacArthur and MacArthur (1961) and Blondel et al. (1973) considered that physiognomic structure of forest has major impact on small insectivorous forest birds, Moskát (1988) found that floristic structure is the most important factor affecting bird population densities. These studies do not explain why birds occupy particulate habitats, but they identify habitat characteristics which appear regularly in bird territories and which may be correlated with proximate factors in habitat selection (Bertin 1977). Bird-habitat correlations are just one segment of the analysis of habitat selection (Sherry and Holmes 1985). Although they do not give information about the processes or dynamics of habitat selection, they have a value as a tool in the forest management. Forest bird communities are, unlike many plants and invertebrates, relatively little affected by historical factors (Fuller 1990) and changes in forest management practice can quickly affect breeding bird communities.

In this study, we compared bird communities and floristic and structural characteristics of forests in two Nature Parks in northwest Croatia. Our aim was to identify the most important habitat characteristics that influence the diversity of songbird communities and density of ecological group of birds in different forest stands. We also test whether higher similarity of physiognomic or floristic structure results with higher similarity of bird communities between two studied areas.

METHODS – Metode

Study Area – *Područje istraživanja*

Study area covers the territory of two Nature Parks, Medvednica (45˚51'N 15˚51'E – 46˚01'N 16˚12' E) and Žumberak – Samoborsko gorje (45˚43'N 15˚15'E – 45˚47'N 15˚41'E) situated in NW Croatia, only 15 km apart (Fig1), on altitudes from 100 to 1178 meters above sea level. Climatic and geological characteristics and vegetation cover of the two mountains are similar. Both mountains are part of Croatian continental karst. Average annual temperature is around 6 ºC and annual precipitation around 1200 mm with the rain maximum from April to September. Forests cover over 60 % of area in both Nature Parks, but they are mostly continuous on Medvednica and more fragmented on Žumberak – Samoborsko gorje. Forests of sessile oak and common hornbeam *Epimedio-Carpinetum betuli* (Ht. 1938) Borhidi 1963 are predominant in the lower mountain area, forests of sessile oak and chestnut *Querco petraeae-Castanetum sativae* Ht. 1938 grow on more acid soils, while forests of pubescent oak and hop hornbeam *Ostryo-Quercetum pubescentis*, (Ht. 1950) Trinajstić 1979 cover steeper and warmer slopes. The beech forests *Aremonio-Fagion* (Horvat 1938) Borhidi in Török et al. 1989 and *Luzulo-Fagion* Lohm et R.Tx. in R.Tx. 1954 predominate in the higher mountain area. The highest parts of Medvednica are covered with fir-beech forests *Festuco drymeiae-Abietetum* Vukelić et Baričević 2007, while on Žumberak – Samoborsko gorje fir-beech forests are not present (Trinajstić 2001) and coniferous trees (fir *Abies alba* Mill., spruce *Picea abies* (L.) Karsten, pine *Pinus sylvestris* L. and larch *Larix decidua* Mill.) are only cultivated (Jelaska et al 2005, Nikolić and Kovačić 2008).

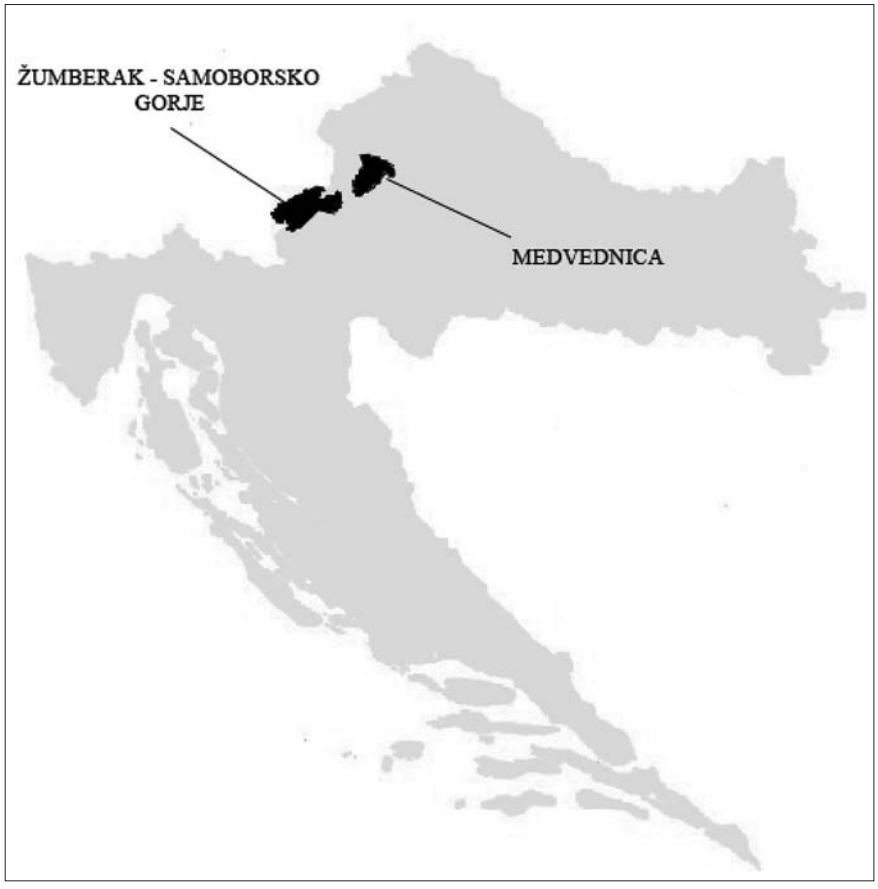

Figure 1 Position of the study area.
Slika 1. Položaj istraživanih područja.

Bird Community Sampling – *Metode istraživanja ornitofaune*

The study was carried out during breeding seasons 2006 and 2007. Standard point count method was used (Bibby et al. 1992), with 10 minutes counting period. Two counting bands were used: inner – with the diameter of 50 m and outer close to the infinity. The research was carried on 49 points on Medvednica and 52 on Žumberak – Samoborsko gorje. Counting points were situated inside the forest, at least 500 m apart. Every point was visited three times during the breeding season: in April, May and June. Visits started after the sunrise and lasted up to three hours, covering the period of the highest bird activity. Singing males were considered as representing breeding territories. For quantitative analysis, only birds recorded in the inner band were used. Songbird species with large breeding territories (as Jay – *Garrulus glandarius* and Raven – *Corvus corax*) were excluded from the analyses.

For detailed analyses of bird communities, species were grouped according to their breeding and foraging ecology. Regarding the nest site, birds were divided into four groups: i) canopy nesting species, ii) species nesting in the shrub layer, iii) hole-nesting species and iv) ground nesting species. Regarding the layer where birds feed they were divided into five groups: i) canopy feeding species, ii) species feeding in shrub layer, iii) bark gleaning species, iv) ground feeding species and v) aerial feeders (Table 1). Species recorded with only one specimen during the study were excluded from analyses of ecological groups.

Habitat Sampling – *Metode istraživanja staništa*

At each counting point, habitat mapping was carried out by the circular plot method (James and Shugart 1970, Cyr and Oelke 1976, Bibby et al. 1992). Plot size was 0.04 ha. The tree species and tree diameter (DBH) were recorded for each tree inside the plot. Tree diameter was measured with the calibrated ruler and is given in eight classes: A 7.5–15 cm, B 15–23 cm, C 23–38 cm, D 38–53 cm, E 53–68 cm, F 68–84 cm, G 84–101 cm, H > 101 cm. Tree height was not measured. Basal area was calculated for trees in each diameter class, according to Cyr and Oelke (1976). The average tree basal area was calculated by dividing the total basal area with the total number of trees on the plot and was used as indication of the stand maturity (Bibby et al. 1992). For further analyses, trees from group A and B were pooled together as "small trees", C, D and E – as "medium sized trees" and F, G and H – as "large trees".

The shrub density was recorded along two transects of outstretched armlength across the circular plot, each equals to approximately 0.008 ha. The percentages of ground cover and canopy cover were calculated basing on 20 readings made through a sighting tube with cross threads taped across one end of a tube. Detailed floristic structure of the shrub and ground layers was not studied, only the dominant species were noted.

We didn't attempt to determine the forest community for every counting point. Instead, the proportion of tree basal area per species was used to classify studied points into five forest types (Delahaye and Vandevyvre 2008) (beech, oak, coniferous, mixed deciduous and mixed coniferous forests). Counting points with more than 70 % of total basal area belonging to the beech (*Fagus sylvatica* L.) and those with more than 50 % belonging to the oak (*Quercus* sp.) were classified as beech and oak stands, respectively. If more than 70 % of total basal area referred to coniferous trees of any species (fir, spruce, pine and larch), counting point was classified as coniferous stand. Other points were classified as mixed stands, either deciduous or coniferous, depending on presence of coniferous trees. Habitat sampling methods and classification of forest types differ from standarised methodology used in forestry. Applied methods thus were not comparable with methods used in systematic forest inventory in Croatia.

Data Analyses – *Analiza podataka*

Shannon-Weiner (H') index was used for calculating diversity of communities (Odum 1971). Sørensen index was used for comparison of similarity in structural characteristics of forests and bird communities between two study areas communities (Odum 1971).

Shapiro-Willks W test showed that variables were not normally distributed. Therefore, non-parametric tests (Chi-square, Kruskal–Wallis and Kendal Tau) were applied. All statistical analyses were performed using Ecological Methodology (Krebs 2003) and STATISTICA v.7.0 (StatSoft 2004) software.

RESULTS – Rezultati

During this study, 27 songbird species were recorded in the forests of Medvednica and 32 in Žumberak – Samoborsko gorje, with 27 species present in both Parks (Table 1). Densities of birds in all forest types, except in the beech stands, were higher in Medvednica. Contrary, Shannon – Wiener index of diversity of bird communities in almost all forest types was higher in Žumberak – Samoborsko gorje (Fig 2).

Table 1 Ecological groups of songbirds regarding their breeding and foraging niche and densities in different forest types. A presence of species recorded only in the outer band is showed with a sign *. Nest site: c – canopy nesting species, s – species nesting in the shrub layer, h – hole-nesting species, g – ground nesting species. Foraging site: c – canopy feeding species, s – species feeding in shrub layer, b – bark gleaning species, g – ground feeding species and a – aerial feeders. The number of study points per forest type is given in the parenthesis.

*Tablica 1. Ekološke skupine ptica pjevica obzirom na mjesto gniježđenja i hranjenja te gustoća populacije u različitim tipovima šuma. Prisutnost vrsta zabilježenih samo u vanjskom pojasu prikazana je znakom *. Prema mjestu gniježđenja; c – gnjezdarice krošnji, s – gnjezdarice grmlja, h – dupljašice, g – gnjezdarice na tlu. Prema mjestu hranjenja: c – vrste koje se hrane u krošnji, s – vrste koje se hrane u grmlju, b – vrste koje se hrane na deblu, g – vrste koje se hrane na tlu i a – vrste koje hranu hvataju u zraku. Broj točaka na kojima je izvršeno istraživanje naveden je u zagradama za svaki tip šume.*

	Ecological group / *ekološka grupa*		Density (pairs/km^2) / *gustoća (parova/km^2)*									
			Medvednica (N=49)					Žumberak-Samoborsko gorje (N=52)				
Species / *vrsta*	Nest site	Foraging site	beech (15)	oak (6)	mixed decid. (16)	conifer. (4)	mixed conifer. (8)	beech (24)	oak (6)	mixed decid. (11)	conifer. (7)	mixed conifer. (4)
Tree Pipit /*prugasta trepteljka* (*Anthus trivialis*)	g	g				0.32			0.42			
Wren / *palčić* (*Troglodytes troglodytes*)	g	g	0.76	0.21	0.24	0.64	1.43	1.06	0.21	0.46	0.91	0.32
Robin / *crvendać* (*Erithacus rubecula*)	g	g	1.78	2.12	2.07	1.59	2.23	1.75	1.70	1.74	2.00	1.27
Blackbird / *kos* (*Turdus merula*)	s	g	0.34	1.06	1.19	0.95	0.80	0.80	1.06	1.16	0.91	0.95
Song Thrush / *drozd cikelj* (*Turdus philomelos*)	s	g	0.25	1.06	0.95	1.27	0.48	0.69	0.64	0.69	1.27	1.27
Mistle Thrush/*drozd imelaš* (*Turdus viscivorus*)	c	g	0.08	0.21	0.16	*	0.16	0.48	0.42	0.12	0.18	0.32
Garden Warbler / *siva grmuša* (*Sylvia borin*)	-	-								0.12		
Blackcap /*crnokapa grmuša* (*Sylvia atricapilla*)	s	s	1.36	1.06	1.11	1.91	1.59	0.85	0.64	1.39	1.46	1.27
Wood Warbler / *šumski zviždak* (*Phylloscopus sibilatrix*)	-	-		*	*					0.12		
Chiffchaff / *zviždak* (*Phylloscopus collybitus*)	g	c	0.76	0.42	0.24	0.95	0.48	0.53	1.27	1.39	1.09	0.95
Goldcrest / *zlatoglavi kraljić* (*Regulus regulus*)	c	c	0.17			1.59	0.64	0.16		0.12	1.09	0.32
Firecrest / *vatroglavi kraljić* (*Regulus ignicapilla*)	c	c	0.08			*	0.32	*			0.18	0.32
Collared Flycatcher / *bjelovrata muharica* (*Ficedula albicollis*)	h	a	0.25	0.64	0.8	0.32	0.48	0.74	0.64	0.23	0.18	
Red-breasted Flycatcher / *mala muharica* (*Ficedula parva*)	-	-					*			0.12		
Long-tailed Tit / *dugorepa sjenica* (*Aegithalos caudatus*)	s	c	0.08		0.08			0.05	0.42	0.35	0.18	
Marsh Tit /*crnoglava sjenica* (*Poecile palustris*)	h	c	0.42	0.42	0.72	0.64	0.32	1.01	0.85	0.69	0.55	0.32
Willow Tit /*planinska sjenica* (*Poecile montanus*)	h	c									0.18	0.64
Coal Tit / *jelova sjenica* (*Periparus ater*)	h	c	0.34		0.08	0.95	0.8	0.42			0.73	0.32
Blue Tit / *plavetna sjenica* (*Cyanistes caeruleus*)	h	c	0.34	1.49	0.95	0.32	0.32	0.69	0.85	0.58	0.18	0.32
Great Tit / *velika sjenica* (*Parus major*)	h	c	0.76	1.49	0.95	0.64	0.8	0.85	0.85	0.69	0.18	0.64
Nuthatch / *brgljez* (*Sitta europaea*)	h	b	0.34	1.06	0.95	0.32	0.48	0.64	0.85	0.46	0.18	
Treecreeper / *kratkokljuni puzavac* (*Certhia familiaris*)	h	b	0.08	0.21	*	*	0.95	0.27	0.21	0.12	0.18	
Short-toed Treecreeper / *dugokljuni puzavac* (*Certhia brachydactyla*)	h	b	0.08	0.64	0.56	0.32		0.16	0.42			
Red-backed Shrike / *rusi svračak* (*Lanius collurio*)	-	-								0.12		
Golden Oriole / *vuga* (*Oriolus oriolus*)	c	c	*	*	0.08			*	*	0.12	*	
Starling / *čvorak* (*Sturnus vulgaris*)	h	g	0.08	0.21	0.24			*	0.21	0.12	0.18	
Chaffinch / *zeba* (*Fringilla coelebs*)	c	g	1.61	2.12	2.55	2.55	3.34	1.75	1.49	1.62	1.64	1.91
Greenfinch / *zelendur* (*Carduelis chloris*)	-	-	0.08					*				
Common Crossbill / *krstokljun* (*Loxia curvirostra*)	-	-								0.12		
Bullfinch / *zimovka* (*Pyrrhula pyrrhula*)	-	-					0.16	*				
Hawfinch / *batokljun* (*Coccothraustes coccothraustes*)	c	c	0.25	1.49	0.48	0.32	0.32	0.11	0.21	0.58	0.18	
Yellowhammer / *žuta strnadica* (*Emberiza citrinella*)	-	-							*	0.12		
Total density / *ukupna gustoća*			10.29	15.92	14.4	15.6	16.07	13.0	13.37	13.35	13.64	11.14

The highest bird population densities were found in oak and mixed coniferous stands.

Four the most abundant species (that include Chaffinch *Fringilla coelebs* and Robin *Erithacus rubecula* in all forest types, and eight other species depending on the forest type) made 45–53 % of songbird population in Medvednica and 41–50 % in Žumberak – Samoborsko gorje. They had the lowest percentage in oak stands and the highest in mixed stands. The differences between the proportion of four the most abundant species in particular forest type between two study areas were not significant (χ^2 test). Six bird species showed the preference for the particular forest type (with more than 40 % of pairs recorded in one forest type). Those were Willow Tit (*Poecile montanus*), Firecrest (*Regulus ignicapilla*) and Eurasian Treecreeper (*Certhia familiaris*) in mixed deciduous stands, Goldcrest (*Regulus regulus*) and Coal Tit (*Periparus ater*) in coniferous stands and Short-toed Treecreeper (*Certhia brachydactyla*) in oak stands. The association between the

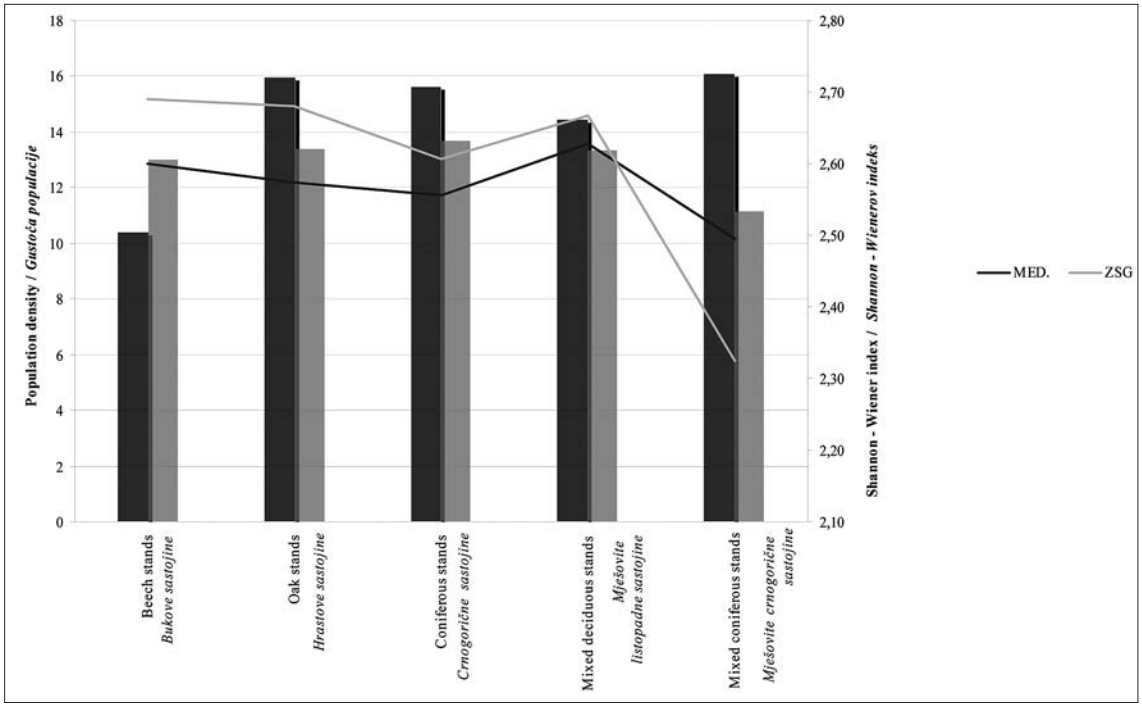

Figure 2 Average population densities (bars) and Shannon-Wiener biodiversity index (lines) of bird communities in forest types of two studied areas.

Slika 2. Gustoće populacija (stupci) i Shannon – Wienerov indeks raznolikosti (linije) zajednica ptica u različitim tipovima šuma na dva istraživana područja.

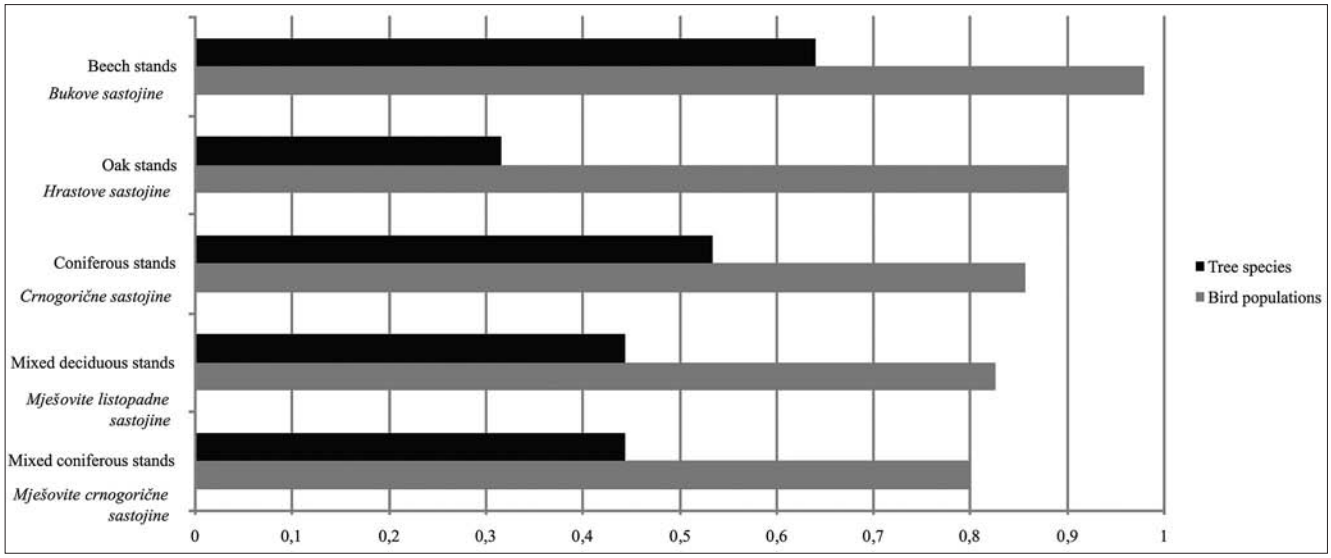

Figure 3 Sørensen index of similarity of tree species and bird species composition of particular type of forest between two studied areas.

Slika 3. Sørensenov index sličnosti vrsta drveća i ptica u pojedinom tipu šuma između dva istraživana područja.

Goldcrest and coniferous forests was very strong: Goldcrest was one of the four the most abundant species in that forest type.

Similarity of songbird communities of particular forest types between two study areas was high (0.872 ± 0.070), while floristic similarity of tree species was relatively low (0.475 ± 0.120) (Fig 3). Contrary to floristic structure, structural characteristics of forests showed much higher differences between two study areas. Only oak stands didn't show any significant difference in measured structural characteristics. The average tree basal area and ratio of small trees showed that studied beech stands were older on Žumberak, while other forest stands were older in Medvednica. Forests in Medvednica generally had higher shrub layer density (Table 2). Significant differences among ecological groups of birds breeding in particular forest types was found only in beech, mixed deciduous and mixed coniferous stands, for ground and hole nesters and birds feeding on the ground, on the bark and in the scrub layer (Table 3). Densities of almost all ecological groups were higher on Medvednica, with the exception of those in beech stands.

Table 2 Structural differences of forest types between two studied areas. Differences were tested by Kruskal – Walllis test. *p*: * < 0.05, **< 0.01, ***< 0.005. There were no significant differences for any structural characteristic in the oak stands.

*Tablica 2. Razlike u strukturi pojedinih tipova šuma između dva istraživana područja. Razlike su testirane Kruskal – Wallisovim testom. p: * < 0.05, **< 0.01, ***< 0.005. U hrastovim sastojinama nije bilo statistički značajnih razlika između istraživanih područja.*

	Beech stands (N=39) / *bukove sastojine*			Coniferous stands (N=11) / *crnogorične sastojine*			Mixed deciduous stands (N=27) / *mješovite listopadne sastojine*			Mixed coniferous stands (N=12) / *mješovite crnogorične sastojine*		
	Med	ZSG	H	Med	ZSG	H	Med	ZSG	H	Med	ZSG	H
Number of trees/ha / *broj stabala/ha*	678	466	8.444***	488	1071	7.097**	905	968	0.929	372	1425	7.385**
Scrub density (stems /ha) / *gustoća grmlja (stabljika/ha)*	4883.3	1244.8	8.796***	1750.0	928.6	1.310	835.9	3227.3	6.502**	1531.3	1218.8	0.117
Ground cover (%) / *pokrovnost tla (%)*	45	29	3.335	61	19	4.422*	36	38	0.138	59	25	6.173**
Tree cover (%) / *pokrovnost (sklop) krošnji (%)*	86	94	3.953*	65	82	3.045	83	91	4.768*	78	91	3.684
Ratio of small trees (%) / *udio tankih stabala (%)*	66	47	8.613***	41	69	5.166*	66	75	1.650	37	73	6.490**
Average tree basal area (m^2/ha) / *prosječna temeljnica (m^2/ha)*	0.063	0.099	6.601**	0.110	0.041	5.143*	0.050	0.036	3.334	0.140	0.038	7.385*

Table 3 Differences among densities (in pairs/km^2) of ecological group of birds between two study areas. Differences were tested by Kruskal – Wallis test. p: * < 0.05, **< 0.01.

*Tablica 3. Razlike u gustoćama (parovi/km^2) pojedinih ekoloških grupa ptica između istraživanih područja. Razlike su testirane Kruskal – Wallisovim testom. p: * < 0.05, **< 0.01.*

	Beech stands (N=39) / *bukove sastojine*			Mixed deciduous stands (N=27) / *mješovite listopadne sastojine*			Mixed coniferous stands (N=12) / *mješovite crnogorične sastojine*		
	Med	ZSG	H	Med	ZSG	H	Med	ZSG	H
ground nesters /*gnjezdarice tla*	3.31	3.34	0.015	2.55	3.59	5.161 *	4.14	2.55	6.417 **
hole nesters / *dupljašice*	2.72	4.77	7.425 **	5.25	2.89	4.535 *	4.14	2.23	3.113
feeding on the ground / *hranjenje na tlu*	4.92	6.53	4.225 *	7.40	5.90	3.392	8.44	6.05	4.071 *
feeding in scrub layer / *hranjenje u grmlju*	1.36	0.85	4.446 **	1.11	1.39	0.614	1.59	1.27	1.100
bark gleaning / *hranjenje na deblu*	0.51	1.06	2.322	1.51	0.58	4.213 *	1.43	0.00	3.618

The total songbird density was positively correlated with the average tree basal area (Table 4). Hole nesters and bark gleaning species preferred the same forest characteristics and both had the densest populations in oak stands. They were both negatively correlated with the number of small trees and number of trees on the plot and positively correlated with average tree basal area. Canopy-feeders showed positive and ground-feeders negative correlation with shrub layer density. Birds nesting in the canopy showed positive correlation with the number of the large trees, and average tree basal area and had the highest density of population in mixed coniferous stands.

Table 4 Kendall Tau correlation between several ecological groups of songbirds and structural characteristics habitat in study area. Significant values are given in bold.

Tablica 4. Kendall Tau korelacija između nekih ekoloških skupina ptica i strukturalnih svojstava vegetacije na istrživanom području. Značajne korelacije označene su masno.

	total songbird / *pjevice ukupno*	hole nesters / *dupljašice*	bark gleaning / *hranjenje na deblu*	canopy nesters / *gniježđenje u krošnji*	canopy feeder / *hranjenje u krošnji*	ground feeder / *hranjenje na tlu*
Number of trees/ha – *broj stabala/ha*	-0.097 p=0.14	**-0.150 p<0.05**	**-0.159 p<0.05**	-0.094 p=0.16	-0.049 p=0.46	-0.077 p=0.24
Average tree basal area (m^2/ha) – *prosječna temeljnica (m^2/ha)*	**0.150 p<0.05**	**0.191 p<0.005**	**0.193 p<0.005**	**0.141 p<0.05**	0,040 p=0.54	0.129 p=0.05
Number of large trees/ha – *broj velikih stabala/ha –*	0.126 p=0.06	0.116 p=0.08	0.092 p=0.16	**0.143 p<0.05**	0.084 p=0.21	0.118 p=0.08
Number of small trees/ha – *broj malih stabala/ha*	-0.122 p=0.06	**-0.168 p<0.05**	**-0.160 p<0.05**	-0.119 p=0.07	-0.029 p=0.66	-0.109 p=0.10
Scrub density (stems /ha) – *gustoća grmlja (stabljika/ha)*	-0.084 p=0.21	-0.020 p=0.76	-0.040 p=0.55	-0.157 **p<0.05**	**0.168 p<0.05**	**-0.30 p<0.001**

DISCUSSION – Rasprava

Two Nature parks, Medvednica and Žumberak – Samoborsko gorje are situated in the same region and are covered with similar forest types. Main differences are less continuous forest cover and lack of natural coniferous forest on Žumberak – Samoborsko gorje. Higher number and diversity of songbird species on Žumberak – Samoborsko gorje might be a result of greater habitat fragmentation on that mountain (Jelaska et al. 2005). This might also be a reason why several edge species were recorded in the study (as Red-backed Shrike and Yellowhammer). Habitat fragmentation can cause higher diversity of birds species and also the increase of population density (Odum 1971), but in our study population densities were higher in Medvednica. The reason is the fact that we studied only birds of forest interior. Continuous forests on Medvednica and older age of forest represent better habitat for forest interior species.

In regards to the floristic structure of tree layer, similarity between these two areas is relatively low. It is the result of the low proportion of the silver fir in Žumberak – Samoborsko gorje that is replaced by the spruce and other cultivated species (Trinajstić 2001). Oak stands covered with this study dominated with the Sessile Oak *Quercus petraea* on Medvednica and with Turkey Oak *Quercus cerris* on Žumberak – Samoborsko gorje.

Number of birds was restricted to particular forest type. These are species dependent on coniferous trees (as some tits, Goldcrest and Firecrest) or oak trees (Short-toed Treecreeper). On larger spatial scale, the floristic composition has an important effect to songbird communities, determining the presence or absence of particular species. The most abundant birds in all forest types were Chaffinch and Robin, the commonest bird species in almost all types of European forests and therefore considered as forest generalists (Moskát and Szekely 1989).

In spite of relatively low similarity of floristic structure, similarity of bird communities between two studied areas was very high. The highest similarity of bird communities was recorded in beech and oak stands. Oak stands showed the lowest floristic similarity, but no significant differences in any structural variable of habitat and no significant differences in the density of any ecological group of birds. On the contrary, beech stands had medium floristic similarity (0.64), many different structural features (number of trees, shrub density, the ratio of small trees and the average basal area) and several differences in densities of ecological groups. Therefore, it can be concluded that quantitative structure of bird communities was more dependent on structural characteristics of habitat than on floristic structure of forest stands.

The highest densities of birds were found in oak and mixed coniferous stands in Medvednica. Oak forests are generally characterized with a vertical complexity resulting with the high number of ecological niches (Moss 1978), while mixed coniferous stands of Medvednica had high ratio of large trees (20 %) indicating older age. The assumption that in managed forest the limitation factor for bird density could be number of old trees (Berg 1997) was confirmed by our research as the same forest type in Žumberak – Samoborsko gorje has the lowest species richness and is the only stand with no large trees and 73 % of small trees.

Bark gleaning species showed the preference for the old forest and highest densities in oak stands (1.49 – 1.94 pairs/km^2) which both can be explained with number of the insects on the bark. Number of in-

sects is greater on older trees and significantly greater on the oak trees in comparisons to other tree species (Southwood 1961). Species feeding in canopy were positively correlated with quantity of shrub proving that their feeding area is equally canopy and higher shrub layer. Species feeding on ground avoided forest stands with rich shrub layer because reduce the availability of open ground. Positive correlation with densities of species nesting in the canopy and average tree basal area was explained by Sherry and Holmes (1985). They state that the tree basal area is a good index for estimating the leaf surface of the tree which should be important factor for species inhabiting canopy.

It can be concluded that for habitat selection of forest birds on the larger spatial scale both floristic and structural composition are important, while on smaller scale the differences in structural characteristics had higher impact to bird communities than floristic differences. Structural characteristics related to forest age had the most pronounced effect to the densities of different ecological groups of birds.

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SAŽETAK: Istraživanja zajednica ptica pjevica šumskih staništa ukazuju da na njihovu strukturu i gustoću populacija mogu utjecati floristička i strukturalna svojstva vegetacije. U ovom istraživanju željeli smo, usporedbom zajednica ptica šumskih staništa dvaju parkova prirode, utvrditi utjecaj floristićkih i strukturalnih svojstava vegetacije na zajednicu ptica gnjezdarica. Istraživanje je provedeno tijekom 2006. i 2007. u Parkovima prirode Medvednica i Žumberak – Samoborsko gorje. Šume pokrivaju oko 60 % površine u oba parka, ali su kontinuirane na Medvednici i nešto rascjepkanije na Žumberku. Istraživanje ptica provedeno je metodom prebrojavanja u točki, a uzorkovanje staništa metodom kružnih ploha. Istraživanje je provedeno na ukupno 101 točki: 49 na Medvednici i 52 na Žumberku. Pri statističkoj obradi korišteni su neparametrijski testovi (Kruskal–Wallis i Kendal Tau). Udio temeljnice stabala korišten je za određivanje pripadnosti pojedinom šumskim tipu: bukovoj, hrastovoj, mješovitoj listopadnoj i mješovitoj crnogoričnoj šumi. Prosječna temeljnica stabla korištena je kao indikator starosti šume. Istraživanjem je zabilježeno ukupno 27 vrsta ptica pjevica u šumama Medvednice i 32 na Žumberku (Tablica 1). Šest vrsta ptica bilo je vezano uz određeni tip šume, s više od 40 % parova zabilježenih u tom šumskom tipu. Diverzitet vrsta bio je viši na Žumberku, dok je gustoća populacija ptica pjevica bila veća na Medvednici (Slika 2). Sørensenov indeks pokazao je da zajednice ptica istog tipa šume između dva područja pokazuju znatno veću sličnost nego floristički sastav (Slika 3). Najveća sličnost u zajednicama ptica između dva Parka zabilježena je u bukovim i hrastovim sastojinama. Hrastove sastojine pokazuju najmanju floristićku sličnost, ali nemaju značajnih razlika u strukturalnim svojstvima niti u ekološkim skupinama ptica. Bukove sastojine naprotiv pokazuju značajne strukturalne razlike i u njima je, kao i u mješovitim crnogoričnim sastojinama, zabilježena najveća razlika među ekološkim skupinama ptica između dva Parka. Strukturalne razlike tih šuma između dva Parka su rezultat različite starosti sastojina, a ptice su imale veće gustoće u starijim šumama. Među strukturalnim svojstvima vegetacije, ona vezana uz starost šume (prosječna temeljnica i broj mladih stabala) bile su značajno korelirane s ukupnom gustoćom populacija pjevica i s gustoćom različitih ekoloških skupina. Zaključak je ovog istraživanja da floristički sastav šuma ima utjecaj na odabir tipa šume u kojoj će se neke vrste ptica pjevica gnijezditi, dok na odabir samog područja gniježđenja veći utjecaj imaju strukturalna svojstva šume.

K l j u č n e r i j e č i : zajednice ptica pjevica, šumska staništa, struktura vegetacije, Parkovi prirode