

HABITAT SELECTION OF SECONDARY HOLE-NESTING BIRDS IN RIVERINE FORESTS ALONG DRAVA RIVER IN CROATIA

IZBOR STANIŠTA SEKUNDARNIH DUPLJAŠICA U POPLAVNIM NIZINSKIM ŠUMAMA UZ RIJEKU DRAVU U HRVATSKOJ

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SUMMARY

The correlation between secondary hole-nesters community characteristics and floristic and structural characteristics of their habitat was studied in riverine forest stands near river Drava in Croatia. Standard point count method was used for bird community sampling and circular plot method for habitat sampling. Sampling was carried out on 66 points. PCA analysis that included 28 independent habitat variables was used, followed by Spearman rank correlation between principal component scores and bird community variables (number of species and number of pairs). Tree basal area was used as an indication of stand maturity and to classify studied points into four forest types (ash, poplar, alder and mixed). Eight secondary hole-nesting species and 14 tree species were recorded. The average forest age was 59.8 ± 20.5 years, with ash and mixed stands being on average older than alder and poplar stands. Shannon-Wiener index of secondary hole-nesters diversity was highest in stands with dominant ash and was increasing with stand maturity. A significant positive correlation was found between number of bird species as well as number of pairs and older stands with lower number of tree species and lower relative number of poplar and alder. It can be concluded that diversity of secondary hole-nesting bird species as well as their abundance is correlated with structural habitat characteristics and that older stands show greater bird biodiversity and abundance.

KEY WORDS: bird community, forest habitat structure, forest age

INTRODUCTION

UVOD

Hole-nesting species represent an important part of forest bird communities. Although hole-nesters can breed in different substrates, including ground, among rock crevices or even in buildings, the majority of them commonly nest in trees. Many of obligatory hole-nesters are secondary hole-nesters which cannot excavate the wholes. Therefore, they rely on existing holes, produced by woodpeckers or by fungal decay (Newton 1994). In the forest habitats, the shortage of nesting cavities is most important factor for limiting the number of hole-nesting birds (Newton 1994).

Holes are mostly situated in rotten or dead wood (Ćiković *et al.* 2014), therefore the abundance and diversity of hole-nesting birds increase with the forest age (Haapanen 1965). In studies of forest bird communities, it was often discussed whether physiognomic or floristic structure of forest has major impact on population densities of small insectivorous birds, including secondary hole-nesters (Blondel *et al.* 1973, Mac Arthur and MacArthur 1961, Moskat 1988).

Recent studies dealing with species-specific responses of woodland birds to stand-level habitat show that both the habitat structure and the floristic composition of woodland are relevant when trying to explain the distribution of birds

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across woodland stands of different kinds (Hewson *et al.* 2011). Kirin *et al.* (2011) also concluded that for habitat selection of forest birds on the larger spatial scale both floristic and structural composition are important.

In Croatia, studies of bird communities in lowland pedunculate oak, hillside and mountain forests have been conducted (Kralj 2000, Kirin *et al.* 2011). Among lowland forest associations beside dominant pedunculate oak, there are still preserved alder, poplar and ash stands near river Drava belonging to the Subpannonian and Pannonian vegetational zone (Trinajstić 1998). Hole-nesting birds play a very important role in all forest ecosystems due to their specific nesting preferences and habitat selection (see Pakkalaa *et al.* 2018, Dolenc *et al.* 2005, Dolenc 2006, Kralj *et al.* 2009). According to recent literature, woodpeckers (Čiković *et al.* 2006, Čiković *et al.* 2014) and flycatchers (Kralj *et al.* 2009) are well investigated hole-nesters in Croatia.

Data on habitat selection in birds can be a valuable tool in forest management. Research by Schulze *et al.* (2019) showed that changes in forest management can considerably affect bird biodiversity, especially forest bird specialists. Therefore, we need to significantly improve our understanding of how landscape perspective fosters a multiscale approach to landscape management and landscape/conservation planning. This knowledge is especially important for large lowland riverine forests; areas which have been impacted by humans for centuries (Prpić and Milković 2005). De Zan *et al.* (2016) showed that the structure of the beech forest fragments, i.e. density and abundance of large trees and the diversity of fallen large branches and standing dead trees are important variables that influence positively the presence and abundance of hole-nesting birds. Furthermore, for secondary hole-nesting birds the diversity of dead wood is an essential resource for nesting, and for some species also for foraging. Hence, bird diversity can be used as a decision support tool for the application of sustainability principles in landscape management (Kubalikova *et al.* 2019).

This study includes secondary hole-nesting birds in riverine forest stands near river Drava in Croatia. The aim was to determine the correlation between secondary hole-nesters community characteristics and floristic and structural characteristics of their habitat. We propose these hypotheses: the number of secondary hole-nesting bird species as well as their abundance is correlated with structural habitat characteristics and older forest stands show greater bird biodiversity and abundance.

STUDY AREA

PODRUČJE ISTRAŽIVANJA

The study area is situated in the North Croatia covering riverine forests along the Drava river. In total, five study

sites (Figure 1) were covered in four years research: riverine forests north of city Varaždin (16°19'N 46°38'E – 16°33'N 46°34'E, Fig 1-locality 1), Pažut forest quite near mouth of the river Mura in the river Drava (16°82'N 46°31'E – 16°88'N 46°30'E, Fig 1- locality 2), Repaš forest north of the river Drava (17°06'N 46°18'E – 17°17'N 46°13'E, Fig 1-locality 3), Repaš forest south of the river Drava in (16°99'N 46°15'E – 17°04'N 46°13'E, Fig 1- locality 4), and riverine forest near city of Đurđevac (17°11'N 46°1'E – 17°25'N 46°00'E, Fig 1- locality 5). Study was conducted in state forests in even aged stands.

Continental Croatia has a temperate continental climate and throughout the year it is in a circulation zone of mid-latitudes, where the atmospheric conditions are very variable. According to the Thornthwaite climate classification in the largest part of lowland, Continental Croatia prevails a humid climate with mean annual temperature in the study area of 10–11°C and mean annual precipitation between 700 and 1000 mm (Zaninović *et al.* 2008).

From the vegetation point of view, the study area is situated in the Eurosiberian – North American region and belongs to two vegetation zones: Mid-European and Subpannonian (Trinajstić 1998). Based on the majority of the cited authors, the systematisation of floodplain forests is presented in three classes, three orders and four alliances. Eleven associations have been described. A thicket of purple willow *Salicetum purpureae* Wendelberger-Zelenika 1952 forms a marginal forest community towards swampy phytocoenoses. The forest of almond willow *Salicetum triandrae* Malcuit 1929 grows on the lowest positions of the sandbanks, islands and marshes in the rivers Drava and Danube. The forest of white willow *Salicetum albae* Issler 1926 covers depressions on alluvial calcareous, undeveloped soils in the interior of the marshes. The forest of white willow and black poplar *Salici albae-populetum nigrae* Tüxen 1931 is the most widely distributed phytocoenosis, taking up central positions of the Danube islands and banks, as well as central positions in Podravina. The forest of white and black poplar *Populetum nigro-albae* Slavnić 1952 occupies higher positions of the Danube islands and shores, as well as high positions of the river Drava terraces. The forest of black alder with elongated sedge *Carici elongatae-Alnetum glutinosae* W. Koch 1926 is a distinctly relict community in the Croatian Podravina region growing on peat and base-rich humus gleyic soils saturated with water. The forest of black alder with alder buckthorn *Frangulo-Alnetum glutinosae* Rauš 1968 where it inhabits suitable sites of smaller, mosaic-like areas. The forest of narrow-leaved ash with autumn snowflake *Leucoio-Fraxinetum angustifoliae* Glavač 1959 is distributed over clayey alluvial terrains. The forest of black alder and narrow-leaved ash with European birdcherry *Pruno-Fraxinetum* Oberdorfer 1953 is found in Podravina near Đurđevac and in small areas around Varaždin, and

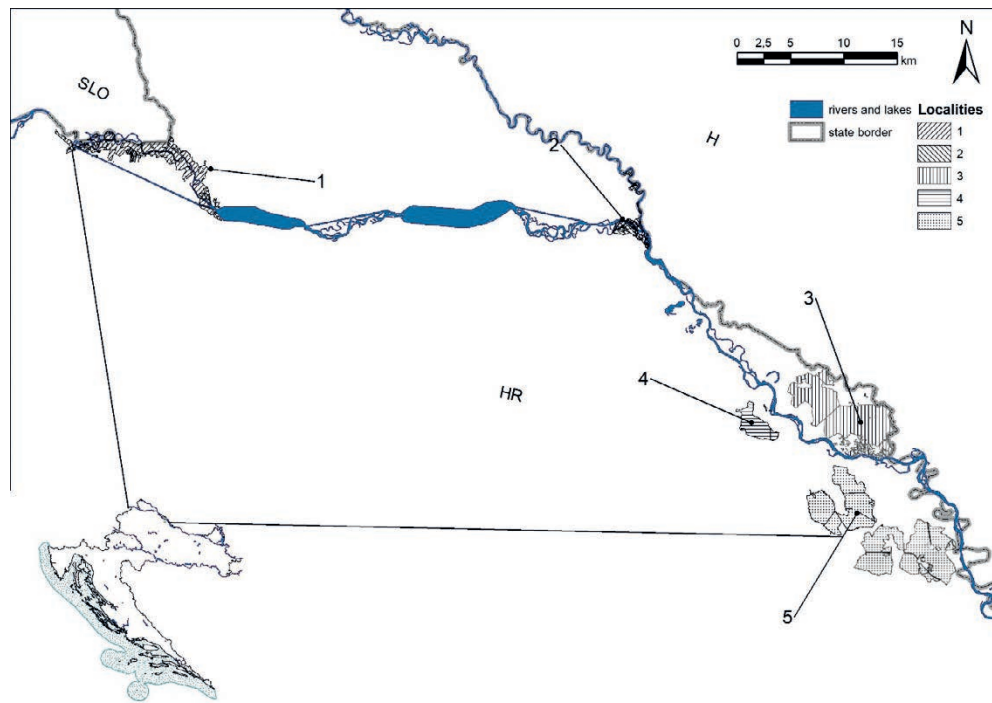


Figure 1. Position of the study sites: 1 - Varaždinske nizinske šume; 2 - Pažut; 3 - Repaš forest north of river Drava; 4 - Repaš forest south of river Drava; 5 - Đurđevac nizinske šume

Slika 1. Položaj istraživanih područja: 1 – Varaždinske nizinske šume; 2 – Lokalitet Pažut; 3 – Šuma Repaš sjeverno od Drave, 4 – Šuma Repaš južno od Drave, 5 – Đurđevačke nizinske šume

Pažut. The forest of spreading elm and narrow-leaved ash *Fraxino-Ulmetum laevis* Slavnić 1952 inhabits the highest positions of floodplain areas along large rivers. The forest of grey alder *Alnetum incanae* Luedi 1921 is distributed along the entire course of river Drava (Vukelić *et al.* 2005.)

MATERIALS AND METHODS

MATERIJALI I METODE

Fieldwork was carried out from February to May during breeding seasons 2016, 2017, 2018 and 2019. For bird community sampling standard point count method was used (Bibby *et al.* 1992). The research was carried out on 66 counting points at least 300 m apart. All counting points were at least 300 m from the forest edges to avoid the edge effect. Every counting point was visited five times during the breeding season. To cover the period of highest bird activity, each visit started after the sunrise and ended three hours later. Singing males were considered as representing breeding territories. Non-singing birds were noted but excluded from the final analysis. Counting period was five minutes. Two counting bands were used: inner band with a diameter of 50 m from the observer and outer band outside the diameter of 50 m. Birds were recorded separately for inner and outer band. Only birds recorded in the inner bands were used for quantitative analysis. A digital voice recorder was used during the counting in order to

improve the determination of species with similar songs (eg. tits).

Habitat sampling described here differs from standardised forestry methodology and therefore is not comparable with methods used in systematic forest inventory in Croatia. The sampling was carried out at each counting point using the circular plot method (Bibby *et al.* 1992, Cyr and Oelke 1976, James and Shugart 1970). Plot diameter was 11.28 m. For each tree inside the plot tree species and tree diameter (DBH) was recorded. Tree diameter was measured using a calibrated ruler and is given in nine classes: S < 7.5 cm, 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. In each diameter class basal area was calculated by multiplying the number in each class with factors provided by Cyr and Oelke (1976). To determine the relative stand maturity total basal area in a plot was divided by the number of trees. The data for stand age was obtained using Croatian forestry inventory and pooled into four age groups: <40 years, 40-60 years, 60-80 years and >80 years. Also, trees from groups S, A and B were pooled together as “small” and C to H as “large” trees. Additionally, the proportion of tree basal area per species was used to identify counting points with dominant poplar (*Populus* sp.), alder (*Alnus glutinosa*) and ash (*Fraxinus angustifolia*). Counting points with more than 60% of tree basal area belonging to each of the species were classified as poplar, alder or ash stands. Counting points

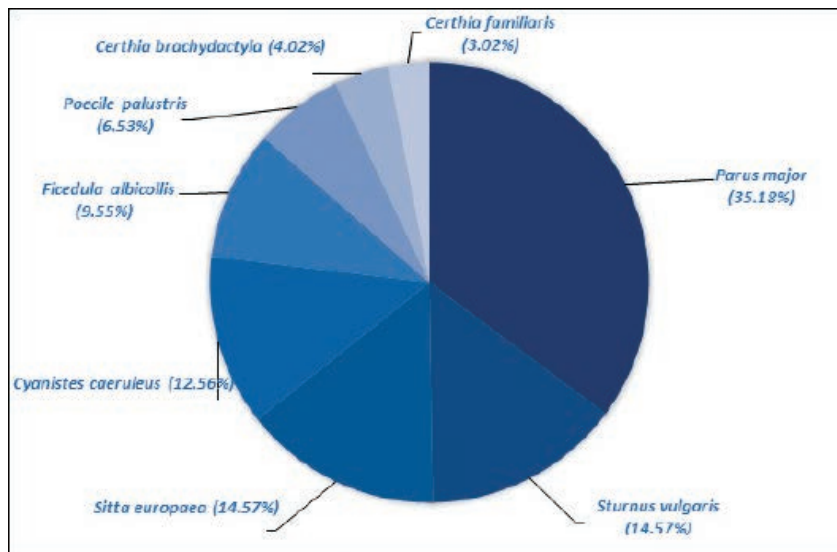


Figure 2. Share of counted species in researched territory

Slika 2. Udio vrsta zabilježenih na istraživanom području

with no domination were classified as mixed forests. The percentages of ground cover and canopy cover were measured using a sighting tube with a diameter of 5 cm and cross threads taped across one end of the tube. The presence of vegetation at the intersection was recorded as a positive reading. In each plot, 20 measurements were conducted along four small transects inside the plot (to the N, E, S and W). The shrub coverage was determined using detailed photographs taken from the centre of the plot in four directions. It was then expressed as a percentage of plot covered by shrubs and pooled in four categories: 0-25%, 25-50%, 50-75%, 75-100%. The number and diameter of dead trees was recorded on each plot.

Shapiro-Wilks W test showed that variables were not normally distributed. Therefore, non-parametric correlation

tests were used. PCA analysis with 28 independent structural and floristic habitat variables was conducted. They include relative number of trees and relative basal area for dominant tree species, total number of trees and tree species per point, total number and ratio of “small” and “large” trees, stand age, canopy and ground cover and percentage of shrubs (Table 1). Factor scores greater than [0.7] were considered to be significant.

Spearman rank correlation between primary components and number and abundance of secondary hole-nesting bird species was conducted. Shannon-Weiner index was used to calculate the diversity of communities. Statistical analyses were performed using Past v.3.14. and STATISTICA v.8.0. software.

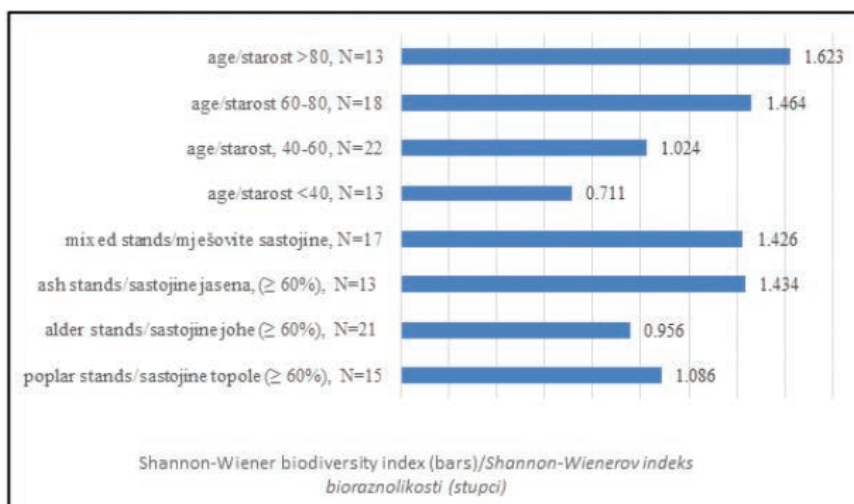


Figure 3. Shannon-Wiener biodiversity index of secondary hole-nesting birds in different age groups and forest types

Slika 3. Shannon-Wienerov indeks bioraznolikosti sekundarnih dupljašica u sastojinama različitih starosti i različitim tipovima šuma

RESULTS REZULTATI

Secondary hole-nesters community / *Zajednice sekundarnih dupljašica*

In total, eight secondary hole-nesting species were recorded during the study (Figure 2): Marsh Tit (*Poecile palustris*), Eurasian Blue Tit (*Cyanistes caeruleus*), Great Tit (*Parus major*), Short-toed Treecreeper (*Certhia brachydactyla*), Eurasian Treecreeper (*Certhia familiaris*), Eurasian Nuthatch (*Sitta europaea*), Common Starling (*Sturnus vulgaris*), Collared Flycatcher (*Ficedula albicollis*). On average 3.02 pairs were recorded on each counting point. Most common species recorded was the Great Tit (35.18%). Shannon-Wiener index of diversity was highest in stands with dominant ash and was also increasing with stand maturity (Figure 3).

Habitat structure/*Struktura staništa*

In total, 14 tree species were recorded: common alder (*Alnus glutinosa*), narrow-leaved ash (*Fraxinus angustifolia*), common hornbeam (*Carpinus betulus*), field maple (*Acer campestre*), white willow (*Salix alba*), white poplar (*Populus alba*), black poplar (*Populus nigra*), pedunculate oak (*Quercus robur*), white elm (*Ulmus laevis*), field elm (*Ulmus minor*), black locust (*Robinia pseudoacacia*), bird cherry (*Prunus padus*), wild cherry (*Prunus avium*) common beech (*Fagus sylvatica*). The nine most common species were included in the analysis, with merged data for black and white poplar as well as on white and field elm (Table 1, habitat variables). The average forest age was 59.8 ± 20.5 years, with ash and mixed stands being in average older than alder and poplar stands (Figure 4).

PCA analysis resulted with three principal components which accounted for 53.8% of the total variance (Table 1). PC1 accounted for 22.0% of the variance and was positively correlated with ratio of large trees and average tree basal area and negatively with total number of trees, ratio of small trees and number of small trees; and described the forest age. PC2 was negatively correlated with relative poplar number and basal area while PC3 was negatively correlated with relative alder number and basal area.

A significant positive correlation was found between number of bird species as well as number of pairs and all three axes showing preference to older stands and lower relative number of poplar and alder.

DISCUSSION RASPRAVA

Riverine forests near Drava appear in narrow stripes along the river in the otherwise open agricultural landscape and represent a dynamic and ever-changing system. Some studies show the importance of riverine forests discovering high density and diversity of breeding birds in, or along, these forest stripes (Tworek 2002, Hågvar and Bækken 2005). Also, Rem *et al.* (2006) argued that riverine areas may be important centres of cavity supply in forested regions because old live trees with natural cavities provide a long-term and preferred nest-supply for hole-nesting passerines.

Structure of the secondary hole-nester communities recorded in this study are consistent with the research done so far in deciduous and mixed forests (Diaz 2005, Kirin *et al.* 2011, Kralj 2000, Sakhvon 2009). As was expected Great Tit is by far the most abundant secondary hole-nester. Altho-

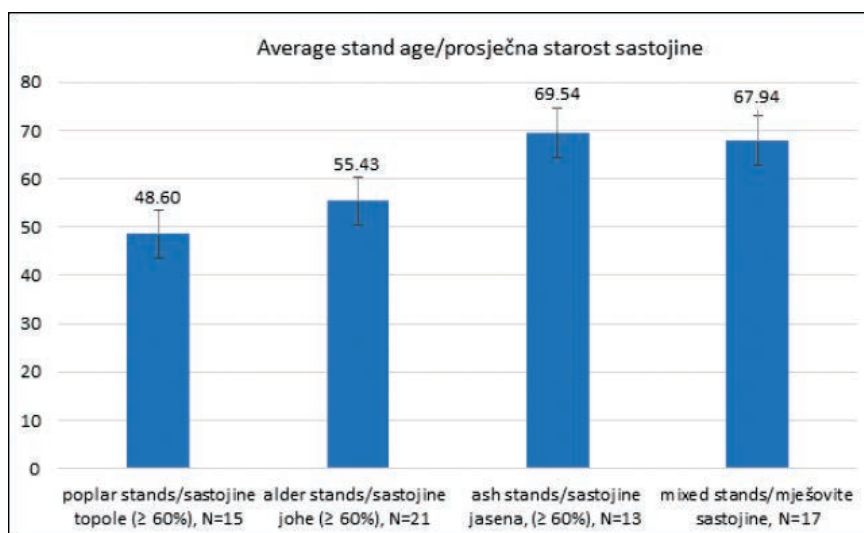


Figure 4. Average forest type age in researched territory

Slika 4. Prosječna starost različitih tipova šuma na istraživanom području

Table 1. PCA analysis using 28 different independent habitat variables; columns showing five principal component scores (PC1-PC3) and correlations with habitat variables. Significant values are given in bold.

Tablica 1. Analiza primarnih komponenti koristeći 28 nezavisnih varijabli staništa; stupci pokazuju pet skorova glavnih komponentata (PC1-PC3) i korelacije s varijablama staništa. Značajne korelacije otisnute su masno.

Habitat variables/varijable staništa	PC1	PC2	PC3
<i>Populus sp.</i> relative tree number /% udio broja stabala topole	0.248	-0.743	0.338
<i>Salix alba</i> relative tree number /% udio broja stabala bijele vrbe	-0.467	-0.313	0.480
<i>Alnus glutinosa</i> relative tree number /% udio broja stabala crne johne	-0.422	-0.025	-0.854
<i>Quercus robur</i> relative tree number /% udio broja stabala hrasta lužnjaka	0.385	0.090	0.274
<i>Fraxinus angustifolia</i> relative tree number /% udio broja stabala poljskog jasena	0.167	0.559	-0.037
<i>Carpinus betulus</i> relative tree number /% udio broja stabala običnog graba	0.313	0.593	0.314
<i>Ulmus sp.</i> relative tree number /% udio broja stabala brijesta	0.279	-0.363	0.106
<i>Acer campestre</i> relative tree number /% udio broja stabala klena	0.065	0.575	0.218
Total number of trees/point/ ukupan broj stabala po točki	-0.827	0.252	-0.038
Total number of species/point/ ukupan broj vrsta po točki	0.067	0.130	0.694
Stand age/ starost šume	0.599	0.494	0.006
Number of small trees (S-B)/ broj malog drveća (S-B)	-0.897	0.196	0.128
Ratio of small trees (S-B)/ udio malog drveća (S-B)	-0.864	0.174	0.329
Number of large trees (C-H)/ broj velikog drveća (C-H)	0.404	0.092	-0.467
Ratio of large trees (C-H)/ udio velikog drveća	0.866	-0.191	-0.315

Habitat variables/varijable staništa	PC1	PC2	PC3
Average tree basal area/ prosječna temeljnica	0.821	-0.332	0.039
Number of dead trees Broj mrtvih stabala	-0.566	-0.208	0.446
Shrub cover Pokrovnost sloja grmlja	0.142	-0.618	-0.151
Ground cover Pokrovnost prizemnog sloja	-0.275	0.189	-0.339
Canopy cover Pokrovnost krošnji	0.022	0.181	0.089
<i>Populus sp.</i> relative basal area /%/ udio temeljnica topole	0.134	-0.794	0.447
<i>Salix alba</i> relative basal area /%/ udio temeljnica bijele vrbe	-0.489	-0.250	0.409
<i>Alnus glutinosa</i> relative basal area /%/ udio temeljnica crne johne	-0.398	-0.020	-0.863
<i>Quercus robur</i> relative basal area /%/ udio temeljnica hrasta lužnjaka	0.364	0.204	0.274
<i>Fraxinus angustifolia</i> relative basal area /%/ udio temeljnica poljskog jasena	0.157	0.740	0.098
<i>Carpinus betulus</i> relative basal area /%/ udio temeljnica običnog graba	0.343	0.618	0.312
<i>Ulmus sp.</i> relative basal area /%/ udio temeljnica brijesta	0.202	-0.413	0.036
<i>Acer campestre</i> relative basal area /%/ udio temeljnica klena	0.151	0.557	0.204
Eigenvalue/ svojevna vrijednost	6.168	4.975	3.916
Variance explained/ varijanca	0.220	0.178	0.140

Table 2. Spearman-rank correlation between number of pairs of secondary hole nesting birds and number of species of secondary hole nesting birds; principal component scores (PC1-PC3) extracted using PCA analysis with 28 different independent habitat variables as principal components (N = 66). Significant values are given in bold.

Tablica 2. Spearman-rank korelacija između broja parova sekundarnih dupljašica i broja vrsta sekundarnih dupljašica; skorovi primarnih komponenti (PC1-PC3) dobiveni analizom primarnih komponenti koristeći 28 nezavisnih varijabli staništa (N=66). Značajne vrijednosti otisnute su masno.

	Spearman	t(N-2)	p-level
Number of pairs & PC1/ broj parova i PC1	0.297	2.486	<0.05
Number of pairs & PC2/ broj parova i PC2	0.355	3.040	<0.005
Number of pairs & PC3/ broj parova i PC3	0.337	2.861	<0.01
Number of species & PC1/ broj vrsta i PC1	0.324	2.739	<0.01
Number of species & PC2/ broj vrsta i PC2	0.409	3.583	<0.001
Number of species & PC3/ broj vrsta i PC3	0.307	2.580	<0.05

ugh some bird species show a preference for the particular forest type (Diaz 2005, Kirin *et al.* 2011) this preference was not discovered in our study area. Species recorded in this study have wide ecological valence and can inhabit different types of forest habitats. In this study, we recorded both Short-toed Treecreeper and Eurasian Treecreeper, which rarely breed in sympatry. Short-toed Treecreeper is considered to be the dominant species, therefore constraining Eurasian Treecreeper towards higher altitudes (Gil 1997). Southwood (1961) concluded that oak trees have the highest number of insect species which could be very important for hole nesters, especially bark feeding species such as tree-creeper. In riverine oak forests in Croatia, Eurasian Treecreeper is almost never recorded (Kralj 2000). However, in stands of lower quality with less feeding opportunities, such as the riverine forests in our research, it is evidently present along with its competitor or even alone (Sakhvon 2009). Furthermore, forest patches frequently occupied by Eurasian Treecreeper are characterized by a higher amount of

old forest cover and trunks with a large circumference (Suorsa *et al.* 2005).

Hole-nesting birds in general show preference to older forest stands and structural characteristics related to forest age (ratio of large trees and average tree basal area) have the most pronounced effect to the densities of different ecological groups of birds (Kirin *et al.* 2011). This was confirmed by studies showing that size of trees and abundance of dead trees are important habitat factors especially for hole nesting birds (Berg 1997, De Zan *et al.* 2016, Suorsa *et al.* 2005). This was also the hypothesis which was confirmed in our study. Our analysis of the biodiversity index of secondary hole-nesting birds in different age groups shows an increasing abundance of birds with stand maturity, which is also in line with previous study of Blondel *et al.* (1973) and Mac Arthur & Mac Arthur (1961).

In our study, the floristic composition of the forest also had an impact on secondary-hole nesters. The importance of floristic composition was also found by Moskat (1988) in beech forest bird communities in Hungary.

In Southwood's (1961) study of insect species associated with various trees, oak trees had the greatest number of insect species. Many hole-nesting birds feed on insects such as caterpillars during the breeding season (Moeed 1980, Török 1986, Wilkin *et al.* 2009) so trees with higher diversity of insects should be favourable for them. In our study, forest stands classified as mixed have a large ratio of pedunculate oak in eight counting points which can explain their higher diversity index (Figure 3). On the other hand, our study showed lower abundance and number of secondary hole nesting species in stands with dominant poplar and alder. This can be related to their age, since average stand age was lower in stands with dominant poplar and alder (Figure 4) or with the floristic structure (as number of tree species was lower in poplar and alder stands compared to mixed stands). The effects of floristic structure and forest age should be further studied, to provide valuable data for establishing sustainable principles in forestry management.

It can be concluded that our hypotheses are confirmed. We showed that in riverine forests, diversity of secondary hole-nesting bird species as well as their abundance is correlated with structural habitat characteristics and that older stands show greater bird biodiversity and abundance.

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SAŽETAK

Korelacija između karakteristika zajednica sekundarnih dupljašica te florističkih i strukturalnih karakteristika staništa istražena je u nizinskim poplavnim šumama uz rijeku Dravu u Hrvatskoj. Standardna metoda prebrojavanja u točki korištena je za istraživanje zajednica ptica, a metoda kružnih ploha za istraživanje staništa. Mjerenja su provedena na ukupno 66 točaka. Korištena je analiza primarnih komponenti sa 28 varijabli staništa te Spearman rank korelacija između skorova primarnih komponenti i varijabli zajednica ptica (broj vrsta i broj parova). Bazalna površina stabala korištena je kao indikator starosti, ali i za klasifikaciju istraživanih točaka u četiri skupine (sastojine jasena, topole, johe i miješane sastojine). Zabilježeno je ukupno osam vrsta sekundarnih dupljašica i 14 vrsta drveća. Prosječna starost istraživanih točaka bila je $59,8 \pm 20,5$ godina. Sastojine jasena i miješane sastojine u prosjeku su bile starije od sastojina johe i topole. Shannon-Wiener indeks raznolikosti bio je veći u sastojinama s dominantnim jasenom i povećavao se sa starosti šume. Značajna pozitivna korelacija dobivena je između broja vrsta te brojnosti ptica i starijih sastojina s manjim brojem vrsta drveća i manjim relativnim brojem jedinki topole i johe. Možemo zaključiti da sastav zajednica sekundarnih dupljašica u nizinskim poplavnim šumama ovisi o strukturnim karakteristikama šuma, pri čemu stare sastojine pokazuju veću brojnost i raznolikost.

KLJUČNE RIJEČI: zajednice ptica, struktura šumskog staništa, starost šume