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Overview of the bird community historical data: bird assemblage multivariate analysis of the data collected from five mountain areas in the northern Croatia

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Abstract. Authors compared bird communities living in five mountain areas in the northern Croatia (Risnjak, Papuk, Medvednica, Ivanščica and Cesargrad mountain) using multivariate explorative techniques of qualitative and quantitative historical data. Similarity matrices were prepared based on Bray-Courtis similarity among samples. Non-metric multidimensional scaling (NMDS) and complete linkage clustering on qualitative and quantitative similarity matrix respectively were made. Principal component analysis (PCA) on quantitative data revealed bird species that contributed the most to the variability of samples. First three dimensions explain 75.2% of variance in samples (53.1%, 13.5% and 8.6% respectively) while the greatest loadings are caused by abundant species like *Sylvia atricapilla, Erithacus rubecula, Turdus merula* and *Phylloscopus collybita*. Non-metric multidimensional scaling revealed clear pattern in significant similarity among communities at low altitudes and at the same time – insignificant similarity among assemblages at different altitudes above the sea level (exception from the rule applies to the Papuk community at 600 m.a.s.l.). The clustering based on similarity matrix on qualitative data has shown clear separation among communities from different mountain areas. This study suggests that monitoring bird communities in the Croatian mountains must be designed as repeated sampling of quantitative data through time.

Key words: monitoring, non-metric multidimensional scaling, principal component analysis

Introduction

According to its natural characteristics, Croatia extends over four bio-geographic regions: Alpine, Continental, Mediterranean and Pannonian (SINP 2008). Birds from the Croatian mountainous regions are considered less endangered by human activities and progress (SINP 1999) in comparison with some other habitats, like wetlands or low shores. Since birds are regarded as indicators that could reveal the status of total biodiversity in some area, different monitoring programs are being performed around the world based on their communities. This strategy in bird research is considered as "highly demanding in terms of field research, but essential for understanding the effect of habitat alteration and efficient management" (Vielliard 2000). It is reasonable to expect future human influence in mountain ecosystems in Croatia to increase, as already detected elsewhere (Storch & Liedenberger 2003). Among other, this is the reason for continuity of monitoring bird communities on mountains throughout time and space. After revealing the regularity in community habitat relationships it will make us capable to notice and/or anticipate changes as well as put us in a position to give mechanisms for sustainable usage of the resources and conservation of biological diversity (Santosa et al. 2009). There is a large amount of data about Croatian bird fauna which have been published or waiting to be published that should be analysed in terms of monitoring changes in bird assemblages in the mountain areas. These data are parts of MS theses, PhD theses, reports or studies where data collection was adjusted for the project specific purposes. The main problem with this kind of data is that it was not collected from repeated sample sites and cannot be directly used for population trend assessment without considering the spatial variations in the abundance of species and their habitats (M a s s i m i n o et al. 2008). In addition, the different sampling designs prevent easy comparison of the collected data. Historical data, nevertheless, may be an interesting data source available for elementary comparison between past and present conditions. Therefore, the purpose of this paper was comparison and quantification of the main differences among bird communities from the northern Croatian mountains based on historical data.

Materials and Methods

Data on bird communities (qualitative and/or quantitative) were extracted from PhD, MS theses and other reports from five Croatian mountain areas (Risnjak, Papuk, Medvednica, Ivanščica and Cesargrad mountain, Fig. 1); altogether, the data from seven different researches are included. The timeframe, researchers and locations of data gathering are given in Table 1. Bird data from two PhD theses (S u š i ć 1988, D o l e n e c 1991) were collected using Finish transect methodology (J ä r v i n e n & V ä i s ä n e n 1975) placing transects at different altitudes, while D u m b o v i ć used the different approach focusing on bird community structure regarding age and management activities on major forest types using point counts (B i b b y et al. 1992). D u m b o v i ć also upgraded the data using specific call playback survey for woodpecker species. Due to different data collecting schemes, those data were excluded from quantitative analysis, so only transect based studies were used in this paper. Although data from S u š i ć and D o l e n e c were obtained with the same method, they needed some adjustment since authors had not used the same transect length. The data

Fig 1. Location of the mountains studied.

Table 1. Information on a mountain, a year and a researcher responsible for data acquisition: transects used in quantitative analysis in bold and data used (together with previous ones transformed into presence/absence data) in qualitative analysis.

	m.a.s.l.	Dolenec 1991		Dumbović 2006	Rucner D. 1950	Rucner R. 1967	Kroneisl 1950	Sušić 1988	
	700							**RS700**	
	850							**RS850**	
	1000							**RS1000**	
RISNJAK	1150				RDR50	RRR67		**RS1150**	RS
	1300							**RS1300**	
	600							**PS600**	PS
PAPUK	750			PD				**RS700**	
	900							**RS850**	
	450	**MDO450**							
MEDVEDNICA	600	**MDO600**	MDO				MRK50		
	900	**MDO900**							
	450	**IDO450**							
IVANŠČICA	750	**IDO750**	IDO						
	900	**IDO900**							
CESARGRAD M.	450	**CDO450**	CDO						

from other authors (Kroneisl 1950, Rucner D. 1950, Rucner R. 1967) were used only for qualitative comparison of bird communities since no of them used the same research intensity and/or collection scheme. Quantitative analyses were performed only on the transect data of Sušić and Dolenec excluding families Accipitridae, Falconidae, Strigidae and Picidae due to non-optimal data collection methods for these groups of birds. In the qualitative analyses, families Plocidae and Sturnidae were also put aside since some authors deliberately omitted those species from the reports (see Sušić 1988). The detailed information on data collection methods can be found in original theses and papers.

Study Area

Risnjak mountain (45º 26´N and 14º 35´E) is placed in the most western part of the Dinaride mountain system (Fig.1). Its vegetation is characterised by natural plant assemblages with high number of relict and endemic plant species. The greatest part of the mountain is covered with fir forests (*Abieti-Fagetum illyricum*, *Blechno-Abietetum* and *Aceri-Fagetum subalpinum*). Risnjak is protected at national level as a National Park with more restrictions in forestry practices than other mountains included in this paper. Papuk mountain (954 m.a.s.l.) is placed in the Pannonian part of Croatia (45º 30´N and 17º 41´E). It is mostly forested area (over 96%) with high diversity of different vegetation communities due to complex climatic conditions at the area with the highest percentage of fir forests following oak forests (Samarđić 2005). Forests that cover the most of the area are *Galio odorati-Fagetum sylvaticae*, *Epimedio-Carpinetum betuli*, *Abieti –Fagetum pannonicum* and *Festuco-Quercetum petraeae*. Medvednica (45°55´N and 15°58´E), Ivanščica (46°10´N and 15°51´E) and Cesargrad mountain (46º 03'N and 15º 44'E) are placed in the northern part of Croatia with altitudes above sea level 1 032, 1 060 and 509 meters respectively. Three main types of forests (*Querco-Carpinetum croaticum*, *Fagetum croaticum montanum* and *Fagetum croaticum*) are represented in all three mountains, but *Fagetum croaticum abietetosum* type is not found in Cesargrad mountain. Medvednica and Papuk are protected at national level as Nature Parks.

Statistical Analysis

The analyses were performed on qualitative species lists present at some area as well as on quantitative data from transect studies. Data inspection and principal component analysis were performed using SAS JMP software (Version 7) of the SAS system (SAS Institute Inc.) and non-metric multidimensional scaling (NMDS) analysis was made with Premier software package version 5 (Primer-E Ltd 2002). The ordination on NMDS was based on a Bray-Curtis similarity matrix (robust measure for ecology community data) derived from quantitative data from transects as well as for the presence/absence data for all species at each transect and mountain respectively. At both NMDS analyses (for qualitative and quantitative data), the minimal stress was achieved with 3D presentation. Since the difference in stress between representations was very small, 2D presentations are given.

Results

Similarities from qualitative and quantitative data

The obtained similarities among bird communities from qualitative data sets ranged from 96% (between Medvednica and Ivanščica mountains) to 47% (between Cesargrad and

Risnjak mountain) (Table 2). The statement is also supported by graphical presentation of multidimensional data (Fig. 2). Clustering from similarity matrix (complete linkage algorithm) grouped samples from the same mountains together (Fig. 3). The same pattern is seen from the results of the quantitative data (Table 4, Fig. 4 and Fig. 5) where the bird communities from transect studies from the same altitudes are the most similar. Some exception is seen for transects from Risnjak mountain where transects placed at lower altitudes (700 m.a.s.l.) are the more similar with transect from Papuk mountain at 900 m.a.s.l. than other Risnjak transects. The obtained similarities on quantitative data ranged from 81.9% (Medvednica and Ivanščica at 450 m.a.s.l.) to 16.6% (Medvednica at 450 m.a.s.l. and Risnjak at 1 150 m.a.s.l.).

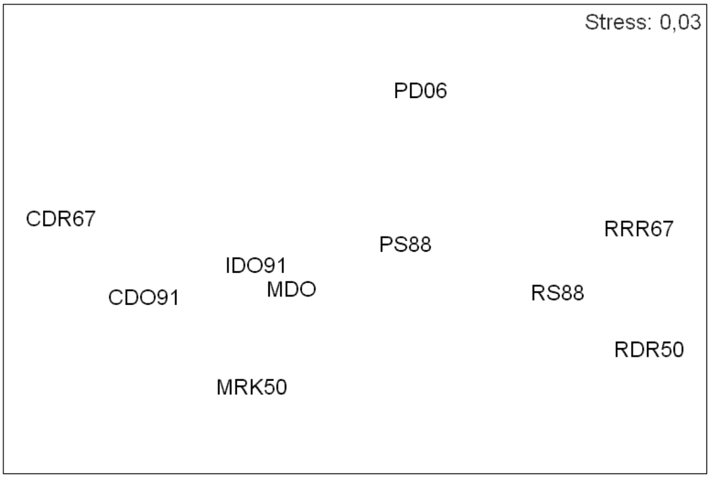


Fig. 2. Non-metric multidimensional scaling for bird communities using data in the presence/absence form. The birds from families Accipitridae, Falconidae, Picidae, Plocidae, Sturnidae, the birds of prey, woodpeckers, and swallows are excluded. See Table 3 for explanations.

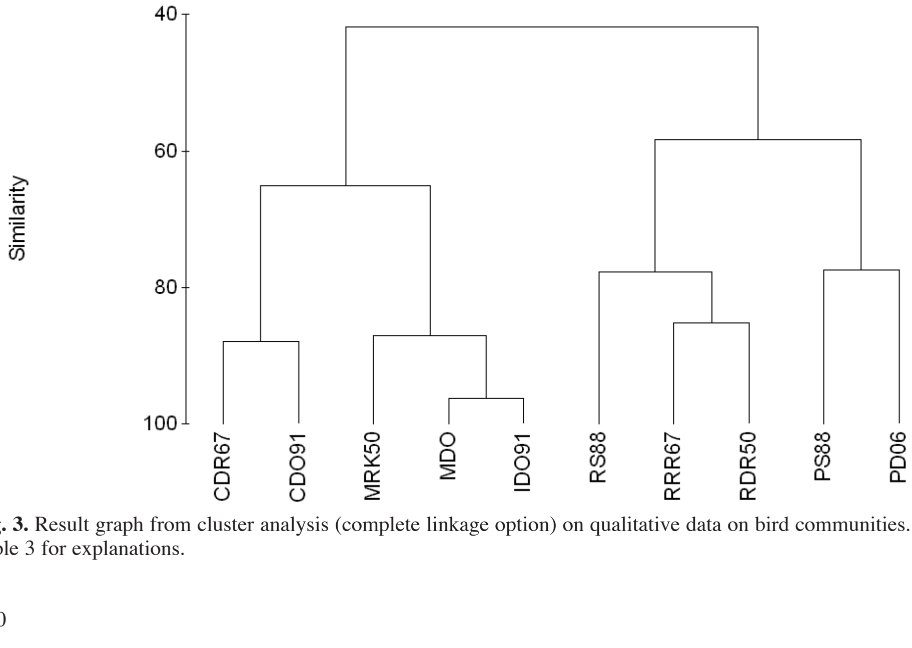


Fig. 3. Result graph from cluster analysis (complete linkage option) on qualitative data on bird communities. See Table 3 for explanations.

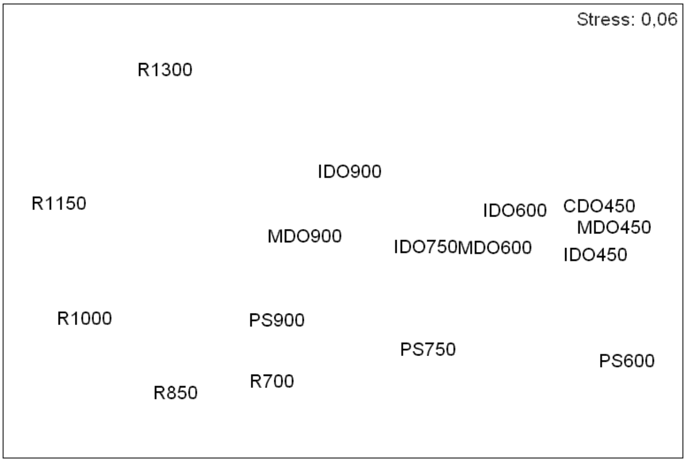


Fig. 4. Result of the non-metric multidimensional scaling for quantitative data from line transects with abundances of several bird species on transects along height gradient that contributed the most in first three PC axes. Birds of prey and woodpeckers were excluded from the analysis. See Table 3 for explanations.

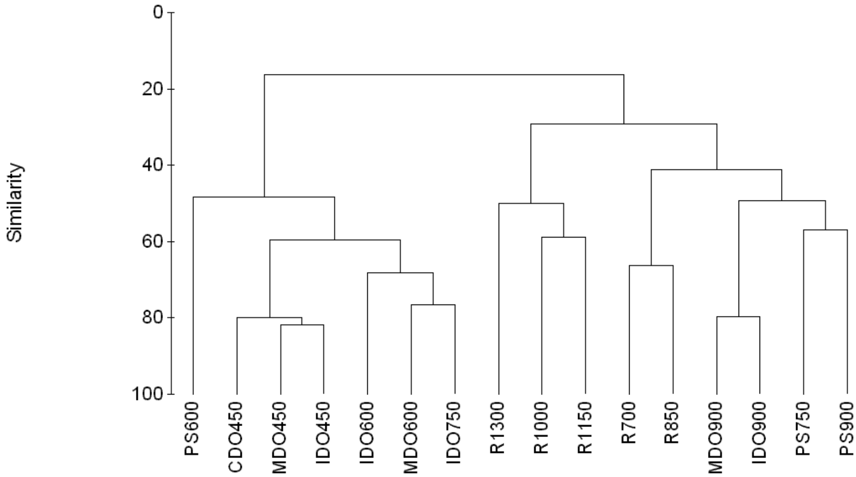


Fig. 5. Result of cluster analysis (complete linkage option) of quantitative data from bird communities from five Croatian mountains. See Table 3 for explanations.

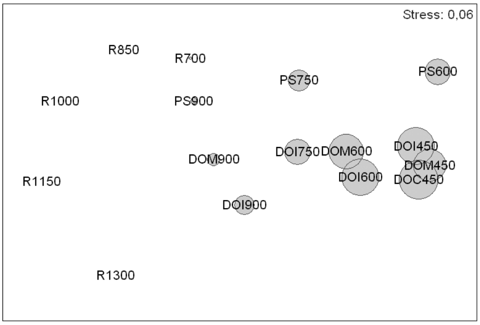
Table 2. Similarity matrix between bird communities in the northern Croatian mountains from qualitative data.

	RS88	RRR67	RDR50	PS88	PD06	MRK49	MDO91	IDO91	CDR67	CDO91
RS88										
RRR67	77,8									
RDR50	81,6	85,3								
PS88	73,8	68,4	65,0							
PD06	68,4	64,7	58,3	77,5						
MRK49	59,6	53,5	51,1	71,4	64,4					
MDO	66,7	61,4	58,7	78,0	67,4	87,3				
IDO91	63,8	58,1	55,6	77,6	71,1	87,0	96,4			
CDR67	45,3	41,8	42,3	60,8	56,3	65,2	70,3	71,9		
CDO91	52,5	47,2	50,0	66,7	57,9	72,3	81,3	83,0	88,0	

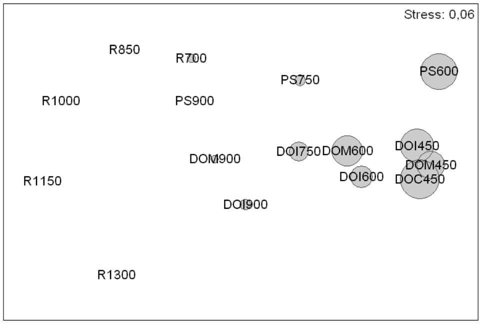
Table 4. Similarity matrix between bird communities in northern Croatian mountains from quantitative data. See Table 3 for explanations.

	R700	R850	R1000	R1150	R13000	PS600	PS750	PS900	MDO450	MDO600	MDO900	IDO450	IDO600	IDO750	IDO900	CDO450
R700																
R850	66,4															
R1000	51,9	64,8														
R1150	47,9	49,7	58,7													
R13000	36,2	34,5	50,0	55,8												
PS600	35,8	26,3	16,5	22,9	22,9											
PS750	49,9	45,6	36,7	29,1	37,2	46,9										
PS900	62,5	53,9	47,6	50,4	40,5	37,4	56,9									
MDO450	38,1	25,5	17,7	16,1	23,8	55,4	49,7	38,0								
MDO600	47,3	37,5	29,3	26,8	33,3	58,7	61,1	50,6	75,3							
MDO900	60,5	54,8	50,7	46,0	48,6	37,3	56,1	65,6	39,1	58,4						
IDO450	38,4	30,3	23,9	22,4	26,7	66,7	50,5	38,3	81,9	74,1	41,5					
IDO600	43,5	34,4	27,4	26,3	35,0	61,7	58,0	45,7	66,4	75,8	48,4	70,0				
IDO750	51,3	46,6	36,3	31,0	41,0	48,2	68,3	57,1	61,2	76,5	67,6	61,5	68,2			
IDO900	49,9	41,1	41,6	40,7	48,8	40,0	57,6	49,2	43,1	61,0	79,6	46,6	50,7	68,1		
CDO450	35,8	27,4	23,1	20,7	27,1	54,3	47,8	34,6	80,0	71,4	40,9	81,1	69,1	59,6	45,8	

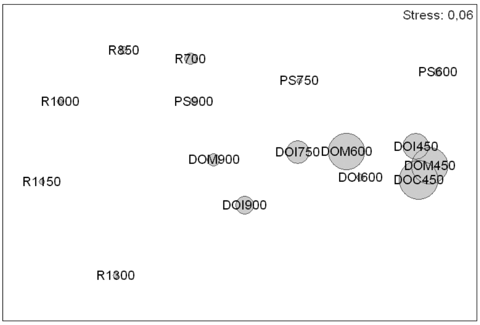
The analysis of principal component from quantitative data revealed 13 axes with eigenvalues greater than 1 (Table 5). The first three PC axes explain 75.2% of the data (53.1%, 13.5% and 8.6% respectively). The PC1 axe is giving high positive weights (> 0.18) (Table 6) to *Regulus ignicapillus* (forest bird connected with high altitudes), and with several species whose greatest abundances are at lower altitudes, resulting in weights from -0.12 (*Columba palumbus*) to -0.62 (*Sylvia atricapilla*). Clearly, PC1 represents the contrast of forest birds connected with low altitudes from few species connected with highest altitudes. PC2 has moderate negative correlation with *Sturnus vulgaris* and *Lanius collurio* (non-forest species) and *Coccotraustes coccotraustes* (forest species) where the latest species is found mostly at low altitudes. Positive loadings on the axe are obtained by three forest species whose



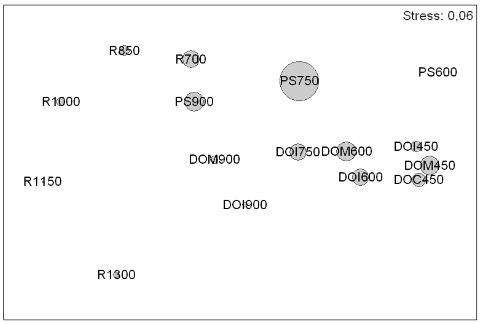
Sylvia atricapilla



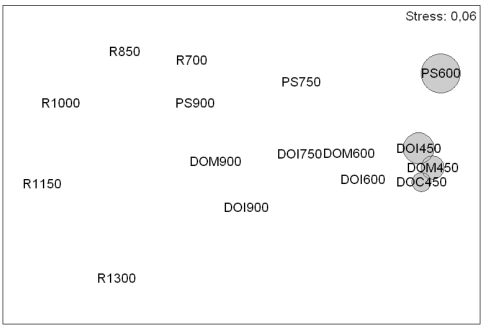
Turdus merula



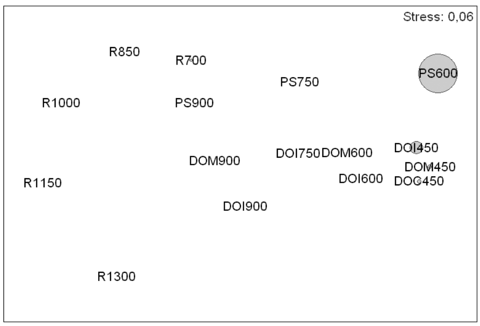
Phylloscopus collybita



Erithacus rubecula



Sturnus vulgaris



Lanius collurio

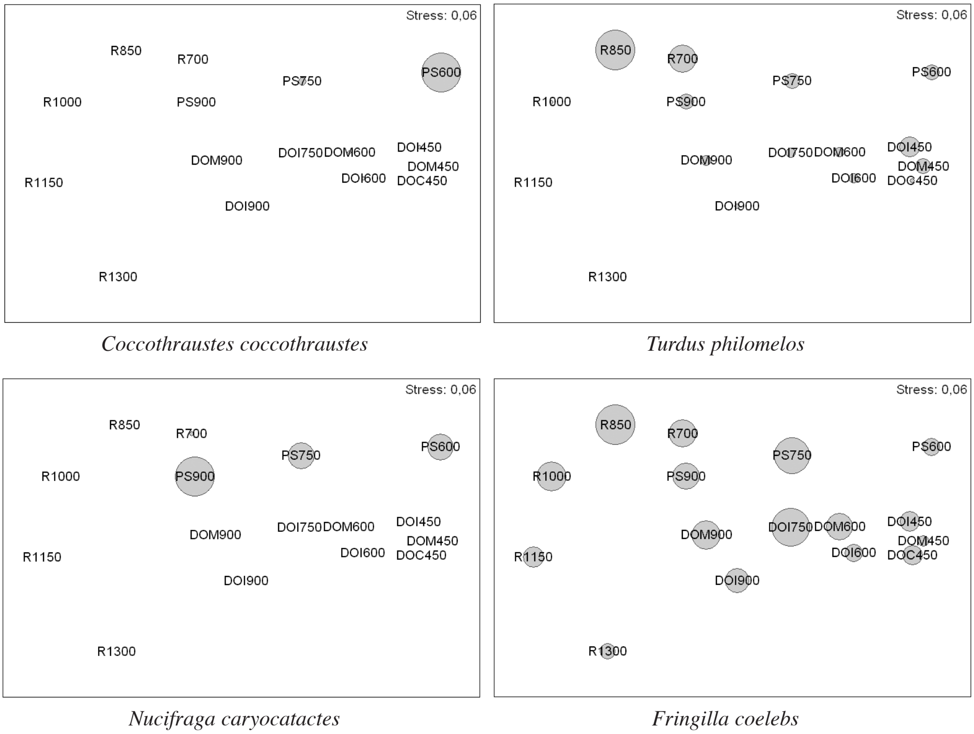


Fig. 6. NMDS bubble plots with superimposed abundance of several bird species along research transects that contributed most significantly on loadings of the first three PC axes. See Table 3 for explanations.

abundances are highest at moderate altitudes (Table 6). PC3 represents contrast between two most abundant species found at every mountain and at every altitude: *Phylloscpus collybita* (not found only at Papuk at 600 m.a.s.l. and characterised by greatest abundance at 450–600 m.a.s.l. – negative loading) and *Erithacus rubecula* (with maximal abundance at 750–900 m.a.s.l. – positive loading). The abundances of several bird species, with the greatest contribution on the loadings for the first three PC axes, are superimposed on the results of NMDS plots (Fig. 6). All these species have clear pattern in abundances along the altitude gradient like *Turdus merula* or restricted to narrow band of altitudes like *Nucifraga caryocatactes*.

Discussion

Comparison of bird assemblages with data obtained from different projects and different sampling designs is extremely difficult. None of the sources used for this study had the same sampling effort or sampling design. Despite that, similarity matrix (Table 2) among the north Croatian mountain bird communities on qualitative data revealed, as expected, highest similarity among repeated studies in the same mountain. This can be regarded as the proof of uniqueness of the bird assemblages for the specific mountain. Most of theses used in this study adequately covered only passerine species and for that reason conclusions obtained can be projected only to this part of the communities. Great part of the species with more complex demands for habitat usage and more pronounced interaction with people are completely omitted, like birds of prey (both diurnal and nocturnal) and woodpeckers, for which our knowledge on precise past distributions and abundance is scarce. Considerable part of those

Table 5. Eigenvalues, % variation and cumulative variation of all PC axes with eigenvalue greater than 1.

PC AXES	EIGENVALUES	%VARIATION	CUM.%VARIATION
1	116,8	53,1	53,1
2	29,7	13,5	66,6
3	18,9	8,6	75,2
4	15,9	7,2	82,4
5	9,6	4,4	86,8
6	7,7	3,5	90,3
7	6,2	2,8	93,1
8	3,6	1,6	94,7
9	2,7	1,2	96
10	2,7	1,2	97,2
11	1,9	0,9	98,1
12	1,7	0,8	98,8
13	1,4	0,6	99,5

Table 6. Bird species revealing the highest loadings of abundance, and the correlation to first three PC axes.

PC AXES					
R 1		R 2		R 3	
-0.62	*Sylvia atricapilla*	0.40	*Erithacus rubecula*	0.43	*Erithacus rubecula*
-0.45	*Turdus merula*	-0.38	*Sturnus vulgaris*	-0.34	*Phylloscopus collybita*
-0.33	*Phylloscopus collybita*	-0.35	*Lanius collurio*	0.30	*Turdus philomelos*
0.18	*Regulus ignicapillus*	-0.35	*Coccothraustes coccothraustes*	0.27	*Nucifraga caryocatactes*
-0.12	*Emberiza citrinella*	0.33	*Phylloscopus collybita*	0.19	*Parus major*
-0.12	*Columba palumbus*	0.30	*Fringilla coelebs*	0.14	*Cuculus canorus*

species is linked with unfavourable conservation status and some of them already vanished from mountains during last two decades (see S u š i ć 1991, D u m b o v i ć 2007). However, the comparison among mountains is in reality made only for breeding passerine species.

Not surprisingly, multidimensional comparison (Fig. 3) revealed the high resemblance of bird communities among Medvednica and Ivanščica. These two mountains are geographically closest to each other and characterised by similar altitude and vegetation cover as well as matching human activities. Much the same bird community is found in Cesargrad mountain where most of the differences come from the lower maximal mountain altitude, resulting in missing species which are connected with high altitudes and fir and beech forests. Detailed discussion on ecological conditions that dominate the specific mountains can be found in original theses. The qualitative Papuk mountain data (PS88, PD06) are farther from three previously mentioned mountains (Fig. 2) what is expected due to its geographical and ecological characteristics. Non-expected difference between these two samples probably comes from dissimilarities in data collection approach. The Risnjak bird community has its own specifics and is well separated from the other. This is not surprising since Risnjak is the highest mountain placed at the border of Alpine and Mediterranean regions with specific fir and beech forest characteristic for altitudes above 1 000 m.a.s.l. Another specificity of the Risnjak bird communities is their stability in time (73.8% to 81.6 %, Table 3) obtained from 1950, 1967 and 1988 studies (Fig. 2). This confirms the findings of S u š i ć (1988).

Non-metric multidimensional scaling (Table 4) revealed a clear pattern in significant similarity among communities at similar altitudes and, at the same time, in insignificant

Table 3. Quantitative data similarity matrix between bird communities in northern Croatian mountains. PS600, 750 and 900 are the transect from Papuk mountain (S u š i ć 1988) from 600, 7 500 and 900 meters a.s.l., respectively; R700, 850, 1000, 1150, 1300 are the transects from Risnjak mountain (S u š i ć 1988); MDO, CDO and IDO are the transects from Medvednica, Cesargradska mountain and Ivanščica mountain, respectively (D o l e n e c 1991).

	R700	R850	R1000	R1150	R13000	PS600	PS750	PS900	MDO450	MDO600	MDO900	IDO450	IDO600	IDO750	IDO900	CDO450
R700																
R850	66,4															
R1000	51,9	64,8														
R1150	47,9	49,7	58,7													
R13000	36,2	34,5	50,0	55,8												
PS600	35,8	26,3	16,5	22,9	22,9											
PS750	49,9	45,6	36,7	29,1	37,2	46,9										
PS900	62,5	53,9	47,6	50,4	40,5	37,4	56,9									
MDO450	38,1	25,5	17,7	16,1	23,8	55,4	49,7	38,0								
MDO600	47,3	37,5	29,3	26,8	33,3	58,7	61,1	50,6	75,3							
MDO900	60,5	54,8	50,7	46,0	48,6	37,3	56,1	65,6	39,1	58,4						
IDO450	38,4	30,3	23,9	22,4	26,7	66,7	50,5	38,3	81,9	74,1	41,5					
IDO600	43,5	34,4	27,4	26,3	35,0	61,7	58,0	45,7	66,4	75,8	48,4	70,0				
IDO750	51,3	46,6	36,3	31,0	41,0	48,2	68,3	57,1	61,2	76,5	67,6	61,5	68,2			
IDO900	49,9	41,1	41,6	40,7	48,8	40,0	57,6	49,2	43,1	61,0	79,6	46,6	50,7	68,1		
CDO450	35,8	27,4	23,1	20,7	27,1	54,3	47,8	34,6	80,0	71,4	40,9	81,1	69,1	59,6	45,8	

similarity among assemblages at different altitudes. Furthermore, transects from all mountains (Fig. 4) revealed similar change in community structure along altitude gradient that coincidence with the report of S u š i ć (1988) who considered the altitude as a cumulative descriptor of climatic variables at some area. Generally, low altitude bird assemblages show more homogeneity (e.g. Ivanščica-Cesargrad and Cesargrad-Medvednica mountain with 81.2% and 80 %, respectively) than communities at higher altitudes (Risnjak 1 300–1 150 m.a.s.l. and Risnjak 1 300–1 000 m.a.s.l.). From all the presented results it is evident that even simple qualitative analysis had the strength to reveal the difference between communities in different mountains, but it can not be regarded as sufficient for monitoring community changes. On the other hand, quantitative analyses gave much better insight into specific differences. However, gathering new knowledge from the data is one of the reasons why sophisticated explorative techniques are developed in the first place. The significant inconsistency in data collection, as well as in the research area selection, disabled some additional analyses of habitat qualities and preferences. More careful future monitoring design will improve our ability to detect/predict bird community responses to different threats and management activities.

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