Ichtyofauna of the upper course of Kolubara River and its tributaries

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Keywords: Ichthyofauna, Kolubara River, fish communities

Introduction

The structure of fish communities that are under the variable impacts either along the course of stream, or in the interconnected streams can serve as an indicator of the status of lentic environment and its monitoring in time might provide the useful information for various kinds of management.

The aim of this paper is to provide the basic information about the status of environment of the upper course of the Kolubara River that occurred in 1993 compared to previous assessments (Janković *et al.* 1983, 1988), as well as to point to particular species common in fish communities that can serve for better evaluation of aquatic environment of that kind.

Materials and Methods

The River Kolubara (123 km in length) is a right tributary of the Sava River, located in the northern part of the Central Serbia, with the drainage area of 3641 km^2. The investigation accomplished from 11 to 14 July 1993 by electrofishing (Suzuki-Bosch 2.1 KW, 220 V AC transformed to 220 V DC) enclosed the upper course of the River Kolubara, with two sampling spots: one (K1) in Valjevo (0 r. km) and the other (K2) near Lajkovac (about 25 r. km), as well as sampling spots on its main tributaries: River Gradac, with G1 on its spring and G2 few hundred meters upstream of its mouth into the River Kolubara; River Obnica, with O1 near the Pričević village and O2 few hundred meters upstream to its mouth into the River Jablanica and origin of the River Kolubara; River Jablanica, with J1 near the Balinović village and J2 few hundred meters upstream from its mouth with the River Obnica; Stream Banja B, from its spring to the mouth with the Brook Pocibrava; and Brook Pocibrava P, from the reservoir to the mouth with the Stream Banja (Fig. 1). A total of 602 fish were caught with the similar fishing effort (one hour) applied. The sample for comparison was generated from the literature data (Janković *et al.* 1983, 1988) obtained in 1988 (Brook Pocibrava) and 1977 (rest of localities, except the Stream Banja and locality O2 at Obnica River, which were not sampled in either 1977, or 1988) and comprised 539 fish (Appendix).

The saprobic index (S_i) by Pantle-Buck's method (Persoone & De Paw 1979), Shannon's information index (H) and index of evenness (J) (Legendere & Legendere 1983) were calculated for each sampling locality. Both 1993 and 1977/88 data sets were tested by contingency for an independence of fish community composition (Sokal & Rohlf 1981; Legendere & Legendere 1983; Petz 1985). Pairwise χ^2 testings between fish communities from localities in both 1993 and 1977/88 samples served to compare their structure and check for their mutual dependence (Sokal & Rohlf 1981). Fish communities from particular localities were clustered on χ^2 values by UPGMA (Sokal & Rohlf 1981; Pielou 1984). Wherever data from 19977/88 samplings for particular localities were available, their fish communities were compared by χ^2 tests. A qualitative analysis of fish fauna was accomplished by UPGMA clustering of values of Jaccard's similarity index (Sokal & Rohlf 1981) between each pair of localities both on 1993 and 1977/88 samples.

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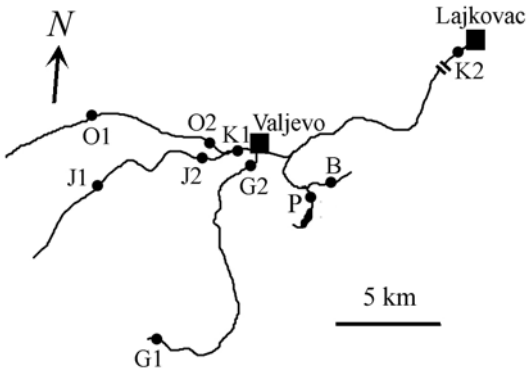


Figure 1. Sampling localities on Obnica (O), Jablanica (J), Gradac (G), Kolubara (K), Banja (B) and Pocibrava (P) Rivers.

Results

In each of two samples in concern, a total of 16 species was recorded, in total 20 species in both of them. Rainbow trout *Onkorhynchus mykiss*, common carp *Cyprinus carpio* and roach *Rutilus rutilus* were listed only in 1977/88 reports, whereas whitefin gudgeon *Gobio albipinnatus*, dace *Leuciscus leuciscus*, goldfish *Carassius gibelio* and golden loach *Sabanejewia aurata* were found in 1993 sample only. Diversity, evenness indices and saprobic indices (Table 1) were calculated from frequency of occurrence of those fish species in communities at respective localities.

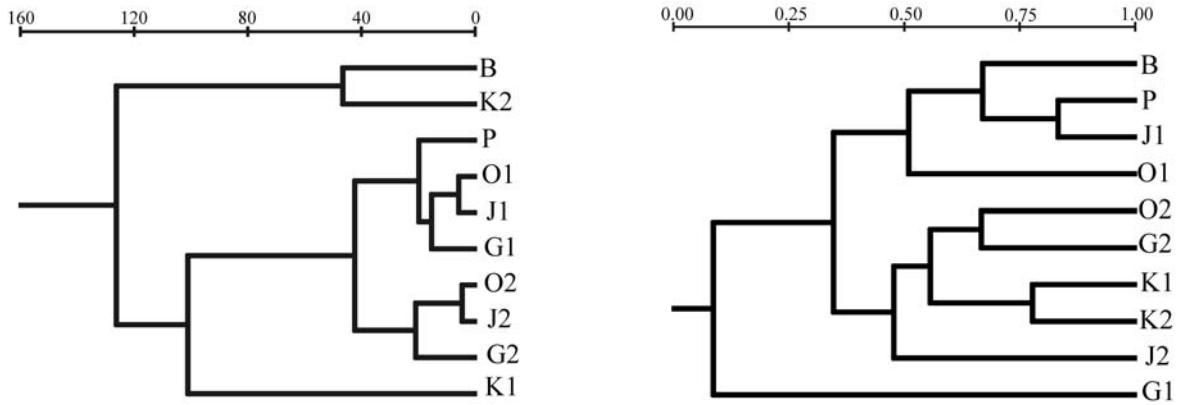
Fish communities at localities in 1993 samples were both strongly associated and significantly different ($\chi^2 = 1179.61$, df = 135, $p < 0.001$). Pairwise comparisons revealed no differences in the composition of fish communities in localities J2 and G2 ($\chi^2 = 14.55$, df = 10), and almost insignificant difference was recoded between fish communities in localities O1 and J1 ($\chi^2 = 14.49$, df = 4; $\chi^2_{(0.05)} = 14.1$). All other comparisons were significant at the level of $p < 0.05$. Two main clusters delimited, representing the tributaries of the upper section and downstream sections of the Kolubara River, respectively (Figure 2a). Only the fish community from the Brook Pocibrava (P), a tributary of the Stream Banja, clustered with the tributaries of the upper section of the Kolubara River. The similarity matrix of the Jaccard's indices of fish fauna from particular localities in 1993 and UPGMA dendrogram generated from it (Figure 2b) delimited three clusters that comprised fish fauna in upper reaches of tributaries that form the Kolubara River and direct tributaries of its downstream section, lower reaches of tributaries that form the Kolubara River and the spring of the River Gradac, respectively.

The difference between fish communities at localities in 1977/88 samples, as well as the intercorrelation between them, were also significant ($\chi^2 = 1175.03$, df = 105, $p < 0.001$). All pairwise comparisons for fish community structure between localities were significant ($p < 0.05$), and few pairs (e.g., K1 and O1, as well as G2 and K2) appeared similar on using the more strict criteria ($p < 0.01$). χ^2 distances between fish communities of particular localities clustered by UPGMA (Fig. 3a) revealed that fish community from the Brook Pocibrava (P) was the most distinct and that fish community of the spring section of the Gradac River (G1) was very different from all other fish communities in rivers tied to the Kolubara River. The similarity matrix of the Jaccard's indices of fish fauna from particular localities in 1977/78 and 1988 and UPGMA dendrogram generated from it (Figure 3b) delimited essentially two clusters comprising the fish fauna of the lower reach of Kolubara River (K2) and fish communities from all other localities, respectively.

Table 1: Shannon's information index (H), evenness index of homogeneity of distribution (J) and saprobic index (S_i) from the upper reach of the River Kolubara and its tributaries on particular localities (see "Materials and Methods") in years 1977 & 1978 (* - 1988 for P) and 1993.

	H		J		S_i	
Locality	1977	1993	1977	1993	1977	1993
B	/	0.58	/	0.69	/	1.10
P*	0.72	0.64	0.79	0.82	1.39	1.96
O1	0.16	0.27	0.33	0.57	1.45	1.97
O2	/	0.73	/	0.94	/	1.60
J1	0.31	0.53	0.44	0.75	1.24	1.45
J2	0.46	0.71	0.54	0.84	1.14	1.55
G1	0.40	0.43	0.83	0.90	0.58	0.58
G2	0.70	0.79	0.73	0.83	1.01	1.21
K1	0.48	0.66	0.56	0.78	1.60	1.52
K2	0.51	0.67	0.53	0.70	1.37	2.00

Comparison of fish community composition between same localities in 1977/88 and in 1993 samples suggested that certain communities remained similar, e.g. those at the localities G1 (χ^2 = 18.27, df = 5, p > 0.05) and G2 (χ^2 = 19.47, df = 9, p > 0.05). For some localities, however, the significant change occurred, resulting in very different fish community composition, e.g. P (χ^2 = 41.65, df = 9, p < 0.001), J1 (χ^2 = 50.88, df = 6, p < 0.001), J2 (χ^2 =31.46, df = 7, p < 0.001), K1 (χ^2 = 83.33, df = 7, p < 0.001) and K2 (χ^2 = 85.82, df = 11, p < 0.001).



a) b)

Figure 2: Relationship between particular localities (for abbreviations see 'Material and Methods') in 1993 according to χ^2 values (a) and Jaccard's similarity indices (b), clustered by UPGMA.

Discussion

The saprobic status in 1993 was generally worse than in the 1977/88, inferring from the change in composition of fish fauna. Thus, G1, J1 and K1, retained their previous saprobic status, in G2 it slightly deteriorated, in K1 it slightly improved, while in all other localities it deteriorated remarkably. The biggest information (H) and evenness (J) indices were calculated for locality G2, both in 1993 and 1977 samples (Table 2), as well as for locality P in 1977, regardless the greatest number of fish species (which were less homogeneous in abundance) was detected in K2 locality in 1993. The biggest deterioration of the saprobic status was on localities P, O1, J2 and K2 (Table 2). The possible causes of those deteriorations probably were the eutrophication of the upstream reservoir at locality P, intensive influx of organic pollutants from the nearby slaughterhouse

upstream of the locality O1, intensive pollution by wastewaters from the suburban communal sewage (J2) and intensive organic pollution from the surrounding agricultural area and wastewaters from local sewage nearby the locality K2 (Figure 1). The rise in diversity and evenness of distribution of fish communities that followed deterioration of saprobic status at majority of localities suggests the change in habitat features in favor to more numerous fish species occurring in communities from the downstream sections. Comparing the 1977/78 and 1993 samples, the saprobic status slightly improved at the mere origin of the Kolubara River, which implies the pollution in the J2 locality was not that strong in 1993 and remarkably diluted after passing the confluence with Obnica River, which obviously managed to cleanse itself on flowing from the upper, very polluted stretch (O1).

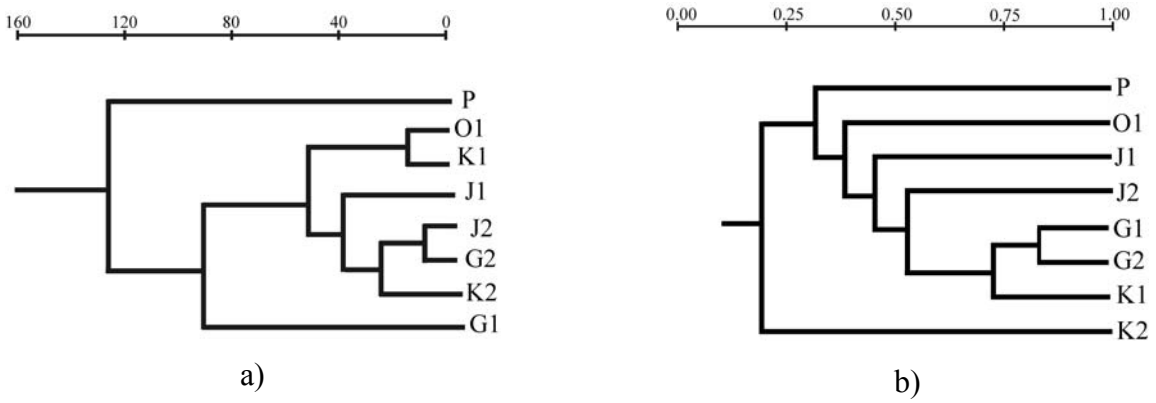


Figure 3: Relationship between particular localities (for abbreviations see 'Material and Methods') in 1977/88 according to χ^2 values (a) and Jaccard's similarity indices, clustered by UPGMA.

Only two localities, both on the Gradac river (G1 & G2), revealed slight, insignificant change of fish community since 1978, which suggests the stability of these aquatic habitats, especially of G1, which revealed a good, i.e. xenosaprobic status (Table 2). The UPGMA clustering of the particular localities using Jaccard's similarity indices mainly corroborated that. The only prominent difference was the distinctness of the fish community of G1 locality (i.e. the spring of the River Gradac in which the brown trout *Salmo trutta* was recorded in 1993) in relation to those from other localities representing upper reaches.

All localities representing upper reaches of the rivers were distinguishable from localities at their lower reaches. *Phoxinus phoxinus*, *Gobio gobio*, and *Leuciscus cephalus* were more abundant in the cluster representing upper reaches, than in localities representing lower reaches, being there also present. On the contrary, *Barbus balcanicus*, *Alburnoides bipunctatus* and *Sabanejewia aurata* were almost exclusively the inhabitants of localities in the cluster representing the lower reaches. Only brook barbel occurred in localities of the upper reaches, as well, but in a lower abundance.

The results obtained from 1993 sample confirmed that some fish species are good indicators of saprobity. E.g., the *Salmo trutta* were recorded only at locality G1 (S_i = 1.00 – 1.14). However, certain other fish species were also recommended as good indicators for the evaluation of saprobic status, e.g., *Sabanejewia aurata* found in 1993 sampling at localities O2, J2, G2, K1 and K2 (S_i = 1.59 – 1.72) and the *Gobio albipinnatus* found in 1993 sampling at locality B (S_i = 1.73).

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Appendix. Data on catch of fish in the upper reach of the River Kolubara and its tributaries in years 1977 (1988 for the Brook Pocibrava), according to literature and the original data on catch from 1993 (localities' abbreviations are explained in the 'Material and Methods').

Species	**Locality**	**B**		**P**		**O1**		**O2**		**J1**		**J2**		**G1**		**G2**		**K1**		**K2**	
	Year	77	93	88	93	77	93	77	93	77	93	77	93	77	93	77	93	77	93	77	93
Salmo trutta														10	7	3					
Onkorhynchus mykiss				1																	
Phoxinus phoxinus			18	81	6		1				14			1	6	1					
Gobio gobio			4	4	4		2		7	2	5		2				1		24		46
Gobio albipinnatus			1																		
Barbus balcanicus			1	14	7	40			15	28	46	7	9	8		12	15	15	43		4
Barbus barbus													1							7	
Leuciscus cephalus			1	25	16	33	12			5	40		8	1		3	8	24	3		5
Leuciscus leuciscus																			6		2
Chondrostoma nasus			1																	1	4
Rhodeus sericeus				23	24				5								2		1		5
Alburnoides bipunctatus				1					21	8		14	8	1		9	9	1	11		9
Cyprinus carpio				4																	
Carassius gibelio													1								
Rutilus rutilus																		3			
Pseudorasbora parva				7																	
Barbatula barbatula			7	8	1				15		2						11				
Sabanejewia aurata									9				2				4		10		6
Cobitis taenia										1											1
Cottus gobio												13		45	17	8	25	2		1	