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MACROZOOBENTHOS IN THE PUSTA REKA RIVER, LEFT TRIBUTARY OF THE SOUTH MORAVA RIVER

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Abstract - In the period from April 1998 to January 1999 macrozoobenthos of the Pusta Reka river was investigated. The Pusta Reka river is a principal water artery of the Pusta Reka region in southeastern Serbia. It originates from the Kurtiška, Statovačka and Dragodelska Reka rivers, joined in the village of Kruškar, and flows, 64 *km* further, into the Ju`na Morava river near Doljevac.The bottom fauna of the Pusta Reka river is composed of 20 groups of macroinvertebrates with 135 determined taxa, 73 being determined at the species and 62 at the genus level. The insect orders Ephemeroptera (25 taxa), Trichoptera (19 taxa), Diptera (19 taxa) and Coleoptera (11 taxa) are the most diverse, whereas the Isopoda and Decapoda and insects from Megaloptera and Neuroptera orders have the most uniform structure, each containing one species. In the river course near the source the Gammaridae individuals are predominant. In the upper and middle river course, in localities IV, VII, VIII, IX, X and XI, the Chironomidae larvae are prevalent whereas in localities III, V and VI those of Ephemeroptera. The Trichoptera larvae are the most numerous in the lower part of the river flow *i.e.* in the locality XI. On the basis of biocoenotic analysis, three biocoenotic complexes may be distinguished on the bottom of the Pusta Reka river: one specific of the river course near the source, the second is peculiar of the upper and middle river course, and the third specific of the lower part of the river course. It should be noted that the species *Hemiclepsis marginata, Baetis niger, Ecdyonurus aurantiacus, Helodes marginata, Blepharicera fasciata, Heptatoma pellucens, Rhyacophila pascoei*, were recorded for the first time for the fauna of Serbia.

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INTRODUCTION

As small running waters are affected by numerous abiotic factors, the communities along the river length greatly differ. Owing to their low water quantity they are very sensitive to anthropological impacts. Within the biocoenoses of small running waters, the benthofauna, given that it inhabits the bottom, as well as owing to its long life cycle and limited possibility for movement, represents a sensitive indicator of the changes in the abiotic environmental factors. The bottom fauna is also a very important link in the food chain. Thus, in salmonid waters, it constitutes the basic food for Salmonidae, particularly for their fingerling. Some representatives of macroinvertebrates support the process of mineralization, and consequently the water selfpurification.

Despite its great importance, the macrozoobenthos community was studied in a relatively small number of hill and mountain running waters in the territory of Serbia, *i.e.* in: the Katušnica river (Filipović 1954), the Lisinski Potok stream (Filipović 1965), the Crni Timok river (Filipović 1969), the Grošnička Reka river (Baračkov 1973), the Prizrenska Bistrica river (Shukriu 1979), the Blatava river (Janković 1967), the Veliki Timok river (Janković 1987), the Đetinja river (Marković 1989), the Svrljiški and Trgoviški Timok rivers (Simić 1993), the Kriveljska Reka river (Marković and Miljanović 1995), Lomnička Reka river (Konta 1997), the Banja river (Marković *et al.* 1997), the Obnica river (Marković *et al.* 1997a; Miljanović 2001), the Jablanica river (Marković *et al.* 1998; Miljanović 2001), the Veternica river (Martinović-Vitanović *et al.* 1998), the Vlasina (Paunović 2001) and the Crvena Reka river (Živić *et al.* 2001).

One of the hill-mountain running waters bottom fauna of which was not surveyed is the Pusta Reka river. The study concerning macrozoobenthos of the Pusta Reka river represents a challenge for the researchers because of its geographical position, a low anthropological impact, and the influence of the Brestovac reservoir on the structure of its zoobenthos. The aim of this study was to assess the faunistic structure and changes occurring in the macrozoobenthic communities all along the river course.

MATERIAL AND METHODS

From April 1998 to January 1999 the macrozoobenthos of the Pusta Reka river was explored on six occasions. With 569 km^2 of river basin, the Pusta Reka

river represents the main water artery of the Pusta Reka region in southeastern Serbia. It originates from joining of the Kurtiška, Statovačka and Dragodelska rivers in the village of Kruškar. From the source of the Dragodelska River in Mt. Radan up to the mouth of the Pusta Reka river into the Južna Morava river near Doljevac, it is 64 *km* long, the riverbed slope being 570 *m*. The specimens of the bottom fauna were collected in 11 localities, along a 64 *km* long river section (Fig.1). The localities were chosen according to the river's altitude, riverbed slope, place of its tributaries inflow and the source of pollution. The specimens were collected from different substrata: stone, gravel, silt and sand.

Locality I – is one of the sources of the Dragodelska Reka river (one of the contributors of the Pusta Reka river), at the altitude of 760 *m*. It is dammed, being 1.4 *m* long, 1.0 *m* wide, and its water depth varied from 0.16 (August) up to 0.3 *m* (January). Water temperature ranged from 7^{0}C (January) up to 9^{0}C (October).

Locality II – is situated 70 *m* off the source, at the altitude of 759 *m*. The riverbed is narrow, being 0.3 *m* (January) – 0.6 *m* (June), and shallow, 0.018 – 0.025 *m* (May, June). The bottom is composed of small stones covered with moss and, in part, with fallen beech leaves. The water is coldest in January (6^{0}C), and warmest in June (11^{0}C).

Locality III – is 200 *m* downstream from the place where the Kurtiška, Statovačka and Dragodelska Rivers join at the altitude of 440 *m*, in the village of Kruškar. The bottom is composed of large stones and stone blocks. The riverbed width varies from 2.8 *m* (October) to 5 *m* (April), and the depth from 0.10 (May, October) to 0.6 *m* (January). According to Huet's classification (H u e t 1961), the water velocity is moderate, being 0.33 *m/s* in June, and rather rapid in January, being 0.66 *m/s*. The lowest water temperature (0^{0}C) was measured in January, and the highest (17^{0}C) in August.

Locality IV is 16. 5 *km* distant from the locality I, and situated at the altitude of 327 *m* and 200 *m* upstream from the "Brestovac" reservoir. The bottom is composed of sand, gravel and small stones. The river is 3 *m* (June and October) up to 7.5 *m* wide (April). Its depth varies from 0.04 (May) up to 0.55 *m* (January). The water velocity ranges from 0.18 to 0.91 *m/s*. The water temperature varied from 0 (January) to 22^{0}C (June).

Locality V – is situated at the altitude of 295 *m*, about 200 *m* downstream from the "Brestovac" reservoir and 18 *km* off the source of the Dragodelska River. The bottom is composed of stones and stone blocks. The riverbed width varies from 1.8 *m* (August) to 5 *m* (May), and the depth from 0.02 (May) to 0.4 *m* (April). Across the rocky bottom water flows at the speed of 0.86 *m/s*. Water was coldest in January (3^{0}C) and warmest (11^{0}C) in July and October.

Locality VI – is situated 27 *km* off the source, at the altitude of 250 *m*. The bottom is composed of small gravel and stones. The river is 5 *m* (August) up to 10 *m* (January) wide, while the depth varied from 0.04 *m* (October) up to 0.58 *m* (January). Water velocity was from 0.32 (October) up to 1.29 *m/s*. Water temperature varied from 2 (January) to 19^{0}C (August).

Locality VII – is situated at the exit from the town of Bojnik, 28 *km* off the source, and at the altitude of 245 *m*. The bottom is stony, with few gravel along the right bank. The riverbed width varies from 4 *m* (May, June, August) up to 8 *m* (January), and the depth from 0.03 *m* (August) up to 56 *m* (January). Water speed varies from moderate (0.46 *m/s*) in August, up to very rapid (1.11 *m/s*) in January. The lowest water temperature (0^{0}C) was measured in January, and the highest (21^{0}C) in August.

Locality VIII – is situated at the altitude of 220 *m* and 45 *km* off the source. The bottom consists mainly of small gravel, though along the left bank there are many places under stones and surrounded by stones not affected by water current with accumulated sand and silt. The river width is from 2 *m* (August) up to 10 *m* (January), and the depth from 0.03 *m* (May) up to 1.2 *m* (January). The water speed varies from 0.50 (January) up to 0.98 *m/s* (October), and water temperature from 1^{0}C (January) to 19^{0}C (August).

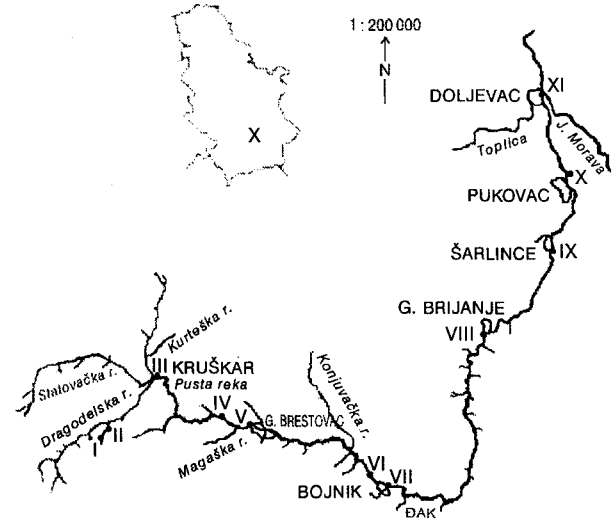

Fig. 1. Explored localities in the Pusta reka River. Insert - a picture is a map of Serbia with the position of the Pusta reka River marked with X.

Locality IX – is situated at the altitude of 205 *m* and 100 m below the bridge on the local road Donji Brestovac-Bojnik, 52 *km* off the source of the Pusta Reka river. The bottom is covered with gravel. The riverbed width varies from 7 m (May, June, August) up to 25 m (January), and the depth from 0.02 *m* (August) to 1.5 *m* (January). The water velocity varies from 0.48 up to 1.15 *m/s*. The water temperature ranged from 1^0C (January) up to 20^0C (August).

Locality X – is situated at the altitude of 198 *m* in the village of Pukovac, 56 *km* off the source of the Pusta Reka river, 300 *m* distant from the overpass of the railroad Belgrade-Niš. The bottom is mainly composed of sand, and in some places silt is accumulated. The river width varies from 5 *m* (August) up to 20 *m* (January), and the water depth from 0.06 *m* (May) to 2.4 *m* (January). The water velocity is rather slow and moderate througout year, except in October (0.68 *m/s*). Water temperature varied from 0^0C (January) up to 25^0C (August).

Locality XI – is situated 150 *m* upstream from the mouth of the Pusta Reka river into the Juzna Morava river, at the altitude of 192 *m*. The bottom is composed of gravel, with silt along the left bank. The riverbed depth is from 3 *m* (August) up to 13 *m* (January), and the depth varies from 0.05 *m* (June) to 0.75 *m* (January). The water speed varies from moderate in August to very rapid in April. The lowest water temperature (1^0C) was measured in January, and the highest (20^0C) in August.

Macrozoobenthic specimens were collected qualitatively and quantitatively, *i.e.* by thorough searching of the riverbed bottom, and with a net, spread over the area of 300 cm^2, according to the method of Surber, respectively. The specimens were fixed in 76% alcohol on the spot.

The collected organisms, which are kept in the Institute of Zoology, Faculty of Biology, University of Belgrade were determined using the following relevant literature (Žadin 1940; Wesenberg 1943; Carausu *et al.* 1955; Bogoescu 1958; Ikonomov 1959; Grandi 1960, Čekanovskaja 1962, Brinkhurst 1963, Hynes 1977, Hrabe 1979; Macan 1979; Roskošny (ed.) 1980; Kerovec 1986).

The α-diversity was estimated using the Shannon-Weaver index (Southwood 1978).

For biocoenotical analysis the statistical procedure reported by Illies (1953) was used.

RESULTS

The bottom fauna of the Pusta reka River is composed of 20 groups of macroinvertebrates (Table 1) with 135 determined taxa (73 determined at the level of species and 62 at the level of genus). The insect orders Ephemeroptera, Trichoptera, Diptera and Coleoptera, are the most diverse, while Isopoda (*Asselus aquaticus*), Decapoda (*Astacus astacus*), Megaloptera (*Sialis fuliginosa*) and Neuroptera (*Osmylus fulvicephalus*) are the most uniform orders, each with a single identified species.

The Ephemeroptera larvae are represented by 25 taxa (20 determined at the level of species and 5 at the level of genus) classified into 7 families (Table 1). The largest number of determined taxa belongs to the families Baetidae (*Baetes niger, B. tracheatus, B. vernus, B. muticus* and *B. buceratus*) and Heptagenidae (*Epeorus assimilis, Rhithrogena semicolorata, Ecdyonurus insignis* and *E. aurautiacus*).

In the macrozoobenthos of the Pusta Reka river Trichoptera larvae are represented by 19 taxa (9 determined at the level of species and 10 at the level of genus) from 6 families (Table 1). The most diverse is the Hydropsychidae family (*Hydropsyche saxonica, H. contubernalis, H. pellucidula, H. angustipennis* and *Cheumatopsyche lepida*).

Diptera (without the species from families Simulidae and Chironomidae) are represented by 19 taxa from 8 families (Table 1). The most diverse are families Tipulidae (*Tipula lateralis, T. fulvipennis, T. maxima, Dolichopeza sp.*) and Limoniidae (*Dicranota bimaculata, Limnophila sp., Ormosia sp., Hexatoma sp.* and *Pedicia* sp.).

Coleoptera are represented by 11 taxa (3 determined at the level of species and 8 at the level of genus) from 9 families (Table 1). Together with the dipterous insects, the Coleoptera represent the macrozoobenthic group found in all localities and in all samples. The most diverse is Elmidae family with three identified taxa (*Stenelmis sp., Limnius sp.* and *Helmis (Elmis) maugei*).

Among the found taxa, the species *Hemiclepsis marginata, Baetis niger, Ecdyonurus aurantiacus, Helodes marginata, Blepharicera fasciata, Heptatoma pellucens, Rhyacophila pascoei,* were recorded in the fauna of Serbia for the first time. Besides, as these species are widely spread in Europe, it is indicative that insufficient attention has been paid to the zoobenthic investigations of the rivers in Serbia.

The changes in the species diversity were also monitored in the surveyed localities (Fig. 2.). The greatest species diversity (2.6) was established in the locality III, indicating the existence of a greater number of ecological factors resulting in the development of a more diverse macrozoobenthos community. The lowest species diversity (0.5) was found in the locality X, which is a consequence of unfavorable environmental conditions for a large number of species (water quality is of the third class, Živić *et al.* 2001a).

Table 1. Qualitative composition of macrozoobethos of the Pusta Reka river

TAXONOMIC GROUPS	LOCALITIES										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Turbellaria											
Dugesiidae											
Dugesia (Planaria) gonocephala Duges		+									
Mollusca											
Unionidae											
Unio sp.						+					
U.pictorum Linneaus						+	+	+	+	+	
U.tumidus Philipsson							+		+	+	
U.crassus Philipsson								+			
Lymnaeidae											
Lymnaea peregra Müller					+	+	+	+		+	+
Ancylidae											
Ancylus fluviatilis Müller			+	+	+	+		+	+		
Physidae											
Physa fontinalis Linnaeus							+			+	+
Suceineidae											
Succinea oblonga Draparnaud						+					
Oligochaeta											
Aeolosomatidae											
Aeolosoma sp.					+			+		+	
Lumbriculidae											
Lumbriculus sp.	+	+	+	+		+	+	+	+	+	+
Trichodrilus sp.						+	+	+	+	+	+
Tubificidae											
Limnodrilus sp.								+			+
Peloscolex sp.					+		+	+	+		+
Lumbricidae											
Lumbricus sp.	+	+		+		+		+			+
Haplotaxidae											
Eiseniella tetraedra Savigny		+				+	+	+			
Haplotaxis gordioides Hartmann	+		+			+		+			
Hirudinea											
Erpobdellidae											
Erpobdella sp.											+
E.testacea Savigny				+	+		+	+	+		+
E.octoculata Linnaeus					+		+	+		+	+
Glossiphonidae											
Helobdella stagnalis Linne							+			+	
Hemiclepsis marginata Müller								+		+	
Hirudimdae											

Table 1. - Continued

TAXONOMIC GROUPS	LOCALITIES										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Hirudo medicinalis Linnaeus	+				+		+				
Haemopsis sanguisuga Linnaeus		+									
Hydracarina											
Aturidae											
Aturus scaber Kramer							+				
Hydrobatidae											
Atractides acutirostris Notas & Angelier							+				
Hydrobates calliger Piersig						+					
Lebertiidae											
Lebertia sp.											
Sperchonidae											
Sperchon clupeifer Piers				+	+	+	+		+		
Torrenticolidae											
Torrenticola amplexa Koenike			+			+					
Torrenticola brevirostris Halb						+					
Isopoda											
Asellidae											
Asellus aquaticus Linne	+	+	+		+	+	+		+	+	+
Gammaridae											
Gammarus sp.	+		+								
Gammarus pulex fossarum Koch	+		+	+	+						
G.balcanicus Schaferna	+		+								
Decapoda											
Astacus astacus Linneaus			+								
Collembola											
Isotomidae											
Isotomurus sp.								+		+	
Ephemeroptera											
Siphlonuridae											
Siphlonurus aestivalis Eaton								+			
Baetidae											
Baetis sp.			+	+	+	+	+	+	+	+	+
B. niger Linne									+		
B. vernus Curtis								+	+		
B. tracheatus Keffermüler & Machel								+			
B. muticus Linne			+		+						
B. buceratus Eaton								+	+		
Heptageniidae											

Table 1. - Continued

TAXONOMIC GROUPS	LOCALITIES										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Ecdyonurus sp.	+		+	+	+	+	+	+	+		+
E. insignis Eaton			+								
E. aurautiacus Burmeister						+					
E. forcipula Pictet								+	+		
Epeorus assimilis Eaton			+								
Rhithrogena semicolorata Curtis			+	+	+						
Ephemerellidae											
Ephemerella sp.			+	+	+		+	+	+		+
E. ignita Poda				+	+		+	+	+	+	+
Caenidae											
Caenis sp.			+	+	+		+	+	+	+	+
C. moesta Bengtsson							+				
C. macrura Stephens				+							
Leptophlebiidae											
Habrophlebia lauta Eaton			+	+		+					
H. fusca Curtis			+		+		+	+			
Paraleptophlebia cincta Retzius	+	+	+	+	+	+		+			
Ephemeridae											
Ephemera sp.			+			+		+			
E. danica Müller			+	+			+				
E. lineta Eaton						+					
E. vulgata Linne									+		
Odonata											
Calopterygidae											
Calopteryx splendens Harris							+				
Gomphidae											
Ophiogomphus serpentinus Charpentier					+	+			+	+	
Onychogomphus forcipatus Linne			+					+	+		
Gomphus simillimus Selys								+			
Cordulegasteridae											
Cordulegaster annulatus Latereille		+						+			
Plecoptera											
Perlodidae											
Perlodes sp.	+		+						+		
Perlidae											
Perla sp.			+	+							
P. burmeisteriana Claassen			+								
Nemouridae											
Nemoura sp.			+	+	+	+	+		+	+		+

Table 1. - Continued

TAXONOMIC GROUPS	LOCALITIES										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Protonemura sp.				+					+		
Taeniopterygidae											
Brachyptera sp.			+	+	+	+					
Leuctridae											
Leuctra sp.			+	+							
Heteroptera											
Hydrometridae											
Hydrometra sp.			+		+	+	+	+			+
Nepidae											
Nepa cinerea Linne						+	+	+			+
Gerridae											
Gerris sp.			+					+			
Rheumatobates sp.			+								
Notonectidae											
Notonecta sp.						+	+	+	+		
Aphelosheiridae											
Aphelosheirus aestivalis Fabricius							+	+	+		
Megaloptera											
Sialidae											
Sialis fuliginosa Pictet					+	+		+			
Neuroptera											
Osmylus fulvicephalus Scopoli			+								
Coleoptera											
Haliplidae											
Haliplus sp.											+
Helodidae											
Hydrocyphon sp.				+							
Helodes marginata					+						
Hydraenidae											
Hydraena sp.	+										+
H. gracilis Germ		+		+	+		+	+	+	+	+
Elmidae											
Stenelmis sp.		+		+	+		+	+	+	+	+
Helmis (Elmis) maugei Müller			+		+	+	+	+	+		+
Limnius sp.				+							+
Gyrinidae											
Gyrinus sp.						+	+		+		
Dytiscidae											
Platambus sp.					+	+	+	+			
Hydrophilidae											

Table 1. - Continued

TAXONOMIC GROUPS	LOCALITIES										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Laccobius sp.							+	+	+		+
Simuliidae											
Simulium sp.			+		+	+	+	+	+		+
Chironomidae											
Tanypus sp.			+		+	+	+	+	+	+	+
Ablabesmyia sp.	+			+		+		+	+		
Corynoneura sp.	+				+	+					
Diptera											
Ceratopogonidae											
Bezzia sp.				+		+	+	+	+	+	
Athericidae											
Atherix sp.				+		+	+	+	+		
Blephariceridae											
Blepharicera fasciata Westwood						+			+		
Limoniidae											
Limnophila sp.			+								
Pedicia sp.	+			+			+	+	+		
Dicranota bimaculata Schumm			+		+		+		+		+
Hexatoma sp.				+	+	+		+	+	+	
Ormosia sp.					+				+		
Empididae											
Hemerodromia sp.				+		+			+		
Hemerodromia sp.							+				
Clinocera nigra Meigen											
Tipulidae											
Tipula sp.	+	+		+	+	+	+	+	+	+	+
Tipula lateralis Meigen								+			
T.maxima Poda	+	+									
T. fulvipennis De Geer	+	+			+						
Dolichopeza sp.		+									
Tabanidae											
Hybomitra sp.				+							
Haematopota sp.				+					+		
Heptatoma pellucens Fabricius											+
Trichoptera											
Rhyacophilidae											
Rhyacophila sp.						+					
R. nubila Zetterstedt							+	+			
R. pascoei Mc Lachlan						+		+			
Glossosomatidae											

Table 1. - Continued

TAXONOMIC GROUPS	LOCALITIES										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Agapetus sp.			+	+		+					+
Glossosoma sp.						+					
Philopotamidae											
Wormaldia sp.		+	+								
Hydropsychidae											
Cheumatopsyche lepida Pictet				+							
Hydropsyche sp.				+		+	+	+		+	+	+	+
H. pellucidula Curtis			+		+	+			+		+			+	
H. angustipennis Curtis				+				+		+		+			+
H. contubernalis Mc Lachan							+				+				+
H. saxonica Mc Lachan							+								
Polycentropodidae															
Polycentropus sp.		+	+		+		+		+			+			
P. flavomaculatus Pictet				+											
Holocentropus sp.	+		+		+		+								
Cyrnus sp.			+												
Limnephilidae															
Allogamus sp.	+	+	+		+			+		+					
Anabolia nervosa Curtis			+		+		+					+			
Stenophylax sp.	+		+		+			+	+			+			

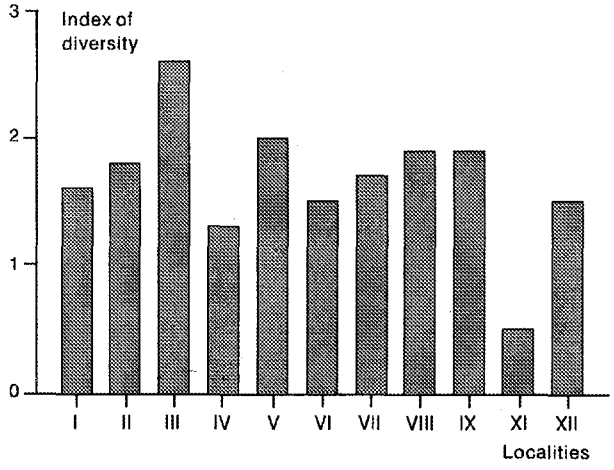

Fig. 2. Diversity index on explored localities.

On the basis of biocoenotic analysis of the macrozoobenthos in the Pusta Reka river, three biocoenotical complexes can be distinguished clearly (Fig. 3.).

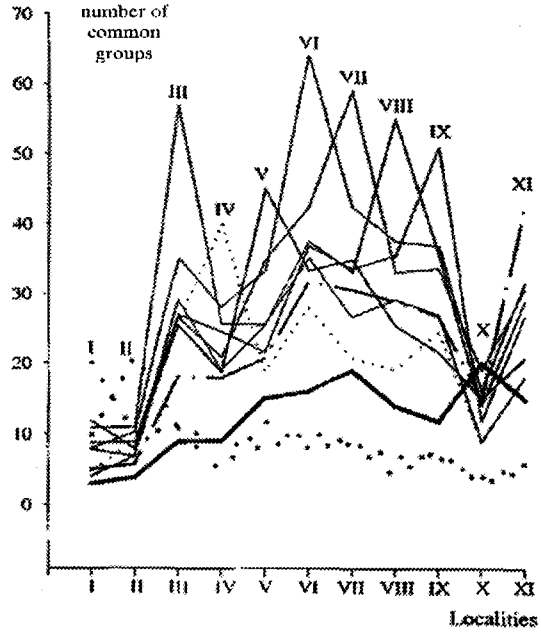

Fig. 3. Curves represent biocoenotic composition of the bottom fauna.

The macrozoobenthos of the localities I (the source) and II makes the first biocoenotic complex. Its dominant organisms (Fig. 4.) belong to Gammaridae family accounting for 67.09%, and 69.56%, respectively and subdominant ones are the larvae from the Chironomidae family (in locality I, 19.74%) and the individuals from the Coleoptera order (in locality II, 6.78%). The species *Planaria gonocephala, Gammarus balcanicus, Haemopsis saquisuga, Tipula maxima*, as well as the representatives of the genus *Dolichopeza* characterize this complex.

The species *Gammarus fossarum, Tipula fulvipennis* and the species of the genus *Wormaldia* invade the initial part of the second biocoenotic complex.

The bottom fauna of the localities III - IX represents the second biocoenotic complex, which can also be designated as the complex of the upper and middle river course.

The macroivertebrate settlements in the localities III, IV and V are inter-heterogeneous. In the locality III 59 taxa from 11 macroinvertebrate groups were recorded. The Ephemeroptera larvae are dominant, accounting for 39.87%, while the subdominant groups are Coleoptera, Chironomidae, Trichoptera and Plecoptera, constituting 14.86, 12.36, 11.00, and 10.98%, respectively (Fig. 4.). In the locality IV 39 taxa from 10 macrozoobenthic groups were recorded. The Chironomidae family is dominant (76.60%), while the Ephemeroptera (9.3%) and Coleoptera (8.34%) are subdominant orders (Fig. 4.). The locality V is inhabited by organisms of 46 taxa from 13 groups where by Ephemeroptera larvae are dominant, accounting for 46.98%, while the family Chironomidae and class Oligochaeta are subdominant (26.54%, and 9.05%, respectively).

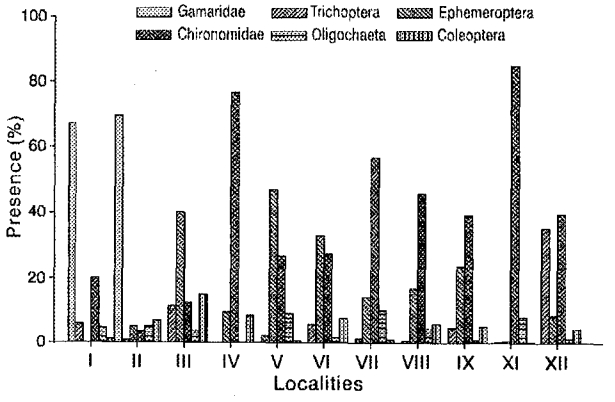

Fig. 4. Presence percentage of the dominant and subdominant groups of macrozoobenthos on explored localities.

Settlements of the localities VI, VII, VIII and IX are more similar to one another so that they can be considered as a separate sub-complex (of the middle river course). In the middle course of the Pusta Reka river, Chironomidae and Ephemeroptera are dominant (Fig. 4.). Thus, these two groups are present almost in equal number in the locality VI constituting 27.02% and 32.66%, respectively. In the locality VII, the Chironomidae larvae become predominant (56.83%), while the presence of the Ephemeroptera larvae is drastically reduced (13.82%), and the occurrence of the Oligochaeta increased (10.01%). In the localities VIII and IX the dominance of the Chironomidae larvae persists. However, their dominance is not significant, being 45.23% in the locality VIII, and 38.81% in the locality IX, since the number of the Ephemeroptera larvae gradually increases accounting for 16.72% in the locality VIII and 23.28% in the locality IX (Fig. 4.). In addition to Ephemeroptera larvae, the individuals from the Diptera order also occur as a subdominant group constituting 16.17% in the locality VIII and 16.77% in the locality IX.

In the locality X great changes occur in the structure and composition of the bottom fauna, so that it represents a separate biocoenotic complex (the third one) characteristic of the lower river course. The abiotic factors prevailing in the locality X are a sharp decrease in water velocity, an increase in water quantity, great annual fluctuations in the water temperature (1 - 25^{0}C), silty–sandy substratum and the deterioration of water quality (α - mesosaprobic zone, Ž i v i ć *et al.* 2001a). Such a complex of abiotic factors led to the reduction in the macrozoobenthic diversity, *i.e.* the appearance of a specific biocoenotic complex. Only 20 taxa from 7 groups of macroinvertebrates were recorded, with a marked dominance of the Chironomidae family (84.82%), while the organisms from the class Oligochaeta are subdominant, accounting for 8.02% (Fig. 4.).

The bottom settlement of the locality XI due to the improvement of the environmental conditions (as compared with the locality X) resulting from self purification capability of the river is more similar to the biocoenotic complex of the upper and middle river course than with that of the lower river course, into which it should fall owing to its location. Namely, the presence of the Chironomidae larvae dropped to 39.25%, and a massive appearance of the Trichoptera larvae constituting 35.05% was recorded (Fig. 4.).

DISCUSSION

The obtained results concerning the Pusta Reka river macrozoobenthos is the first attempt to determine more closely its place in the water system of Serbia, on the basis of the composition and structure of the bottom

fauna. They also contribute to the study of the fauna of the aquatic ecosystems, given that 135 taxa were found, of which 7 species are new to the fauna of Serbia.

The diversity of the community established in the Pusta Reka river is greater as compared with that of macroinvertebrates in the following hill and mountain running waters investigated so far in the territory of Serbia: the Lisinski Potok stream (Filipović 1965), the Grošnička Reka river (Baračkov 1973), the Prizrenska Bistrica river (Shukriu 1979), \etinja (Marković 1989), the Kriveljska Reka river (Marković and Miljanović, 1995), the Lomnička Reka river (Konta, 1997), the Banja Reka river (Marković et al. 1997), the Obnica river (Marković *et al.* 1997a; Miljanović 2001), the Jablanica river (Marković *et al.* 1998; Miljanović 2001), the Veternica river (Martinović-Vitanović *et al.* 1998), the Vlasina river (Paunović 2001), the Crvene Reka river (Živić *et al.* 2001). The Trgoviški and the Svrljiški Timok rivers (Simić 1993) are characterized by greater diversity with respect to the Pusta Reka river. The above mentioned facts indicate that the Pusta Reka river is characterized by a relatively high diversity, which is the consequence of a lower level of pollution (Živić *et al.* 2001a) and its specific location, being situated on the border between the zoogeographic region of the Greek (Hellenic) Balkan and those of the Dinaric Western Balkan and the Eastern Balkan (according to Illies 1978).

The diversity of macrozoobenthos in the initial course of the Pusta Reka river is considerably lower with respect to the middle and the lower river course, which is the consequence of a lower diversity in the ecological factors of the source. Our present results support the results of the investigations conducted so far (Filipović 1954, 1965, 1969; Čepić and Marinković-Gospodnetić 1978; Anderson and Anderson 1995; Marković 1998).

According to the biocoenotic analysis, three biocoenotic complexes may be distinguished in the Pusta Reka river. The first complex includes the settlements of the source and the locality II. Great similarity between these two settlements was also observed in the Lisinski Potok stream (Filipović 1954), which is the consequence of the similar ecological conditions, due to the small distance between the source and locality II in the case of the Pusta Reka river and the Lisinski Potok stream.

In contrast to the earlier investigations (Illies 1953; Filipović 1965; Konta 1997), in which the existence of clearly delimited biocoenotic complexes, of the upper (epirhytron), middle (metarhytron) and lower (hyporhytron) river courses was established, the Pusta Reka river is characterized by specific biocenotic complex, situated in the upper and the lower course (from the locality III to IX).

The absence of a clear limit between the bottom fauna of the upper and the middle course may be explained by the existence of the "Brestovac" reservoir between the locality IV and V. Namely, the locality III has all characteristics of the upper course, *i.e.* great diversity, small number of individuals (Živić *et al.* 2000) and the dominance of Ephemeroptera, Plecoptera and Trichoptera orders. In the locality IV, the reservoir causes the slowing down of water velocity, fluctuations in the water level and great water temperature oscillations, which lead to a low diversity, dominance of the Chironomidae larvae, and thus, a low diversity index (1.3). In the locality V, in contrast to the locality IV, the presence of the reservoir, causes a great and constant water velocity as well as low and relatively constant water temperature, so similarity between their benthocoenoses is low. However, the abiotic factors, prevailing in locality V, although more favorable for the development of zoobenthos than in the locality IV, are still considerably more uniform than in the locality III, which leads to a decrease in the diversity of the bottom settlements in the locality V, and contrary to expectations, to the lower similarity between locality V and III than between the locality V and VI. For this reason the biocoenotic complex of the upper river course (which is expected to be composed of the macroinvertebrate communities in the localities III, IV and V owing to the river's hydrogeographic characteristics) can't be separated from the middle river course.

The remaining part of the biocoenotic complex of the upper and the middle course (from the locality VI to XI), is characterized by a greater mutual similarity, so it could be separated as a distinct subcomplex of the middle river course. The differences between these localities are primarily caused by the vicinity of the town of Bojnik, (located between the locality VI and the VII), whose waste waters from the households and smaller factories, affect the water quality (Živić *et al.* 2001a). Thus, although these two localities are only 2 km apart, the quantitative composition of the bottom settlements is markedly different. While in the locality VI the Chironomidae family and the Ephemeroptera order are equally represented, in the locality VII the Chironomidae are clearly dominant, and the subdominant Oligochaeta and Hirudinea replace the Trichoptera. Given that after Bojnik there are no significant polluters, in the locality VIII and IX, there occurs water self purification, which is reflected in a gradual decrease of Chironomidae,

a marked decrease of Oligochaeta, complete vanishing of the Hirudinea, an increase of Ephemeroptera, the Diptera and the Trichoptera, as well as an increase of the diversity index.

On the locality X, due to the inflow of the waste waters from the village of Pukovac and the bull farm in the village of Draškovac, great changes in the composition and structure of the bottom fauna occur, forming a separate biocoenotic complex, being in lower river course – hyporhytron (F i l i p o v i ć 1954). This biocoenotic complex is characterized by a small number of species, marked dominance of the Chironomidae larvae and reappearance of the Oligochaeta as a subdominant group.

These abiotic and biotic factors do not persist in the locality XI. A decrease in water amount that resulted from the separation of one branch of the Pusta Reka river (550 m before the locality XI) and its flow into the Južna Morava river, caused an increase in the water velocity and the dissolved oxygen quantity. Besides, due to the absence of human settlements and industrial facilities water quality was improved through the selfpurification process (Ž i v i ć *et al.* 2001a). Such environmental conditions led to great changes in the bottom settlement, so that it is more similar to the biocoenotic complex of the upper and middle river course than to the lower one. The similarities are reflected in an increase of both the number of identified taxa, and the diversity, as well as in the massive appearance of the Trichoptera and Chironomidae larvae.

CONCLUSION

In the period from April 1998 to January 1999 the macrozoobenthos of the Pusta Reka river was investigated, along the river length of 64 *km*.

The river bottom was found to be inhabited by 135 determined taxa (73 determined at the species level and 62 at the genus level) from 20 groups of macroinvertebrates. The insect orders Ephemeroptera (25 taxa), Trichoptera (19 taxa), Diptera (19 taxa) and Coleoptera (11 taxa) are the most diverse, while the Isopoda and Decapoda, and insects from Megaloptera and Neuroptera orders, each with a single species found, are of the most uniform structure.

In the river course near the source, the Gammaridae individuals are dominant. In the upper and middle river course (localities IV, VII, VIII, IX, X and XI) the Chironomidae larvae are prevalent. Ephemeroptera larvae are dominant in localities III, V and VI, while the Trichoptera larvae are the most numerous in the locality XI.

The greatest diversity of species was found in the locality III (2.6) and the smallest in the locality X (0.5).

On the basis of biocoenotic analysis, three biocoenotic complexes may be distinguished on the bottom of the Pusta Reka river: one specific of the river course near the source, the second is peculiar of the upper and middle river course, and the third specific of the lower river course.

It should be noted that the species *Hemiclepsis marginata, Baetis niger, Ecdyonurus aurantiacus, Helodes marginata, Blepharicera fasciata, Heptatoma pellucens, Rhyacophila pascoei*, were recorded for the first time for the fauna of Serbia.

REFERENCE

Anderson, M. T. and *Anderson, H.N.* (1995). The insect fauna of spring habitats in semiarid rangelands in central oregon. *J. Kansas entomol. Soc.* **68** (2), suppl. 65 - 76.

Baračkov, Z. (1973). Ekološka proučavanja naselja dna Grošničke reke. *Magistarska teza*, Prirodno-matematički fakultet u Kragujevcu, 1-100.

Bogoescu, C. (1958). Fauna republicii populare Romine, Insecta, Ephemeroptera, **7** (3), Editura Academiei Republicii Populare Romine.

Brinkhurst R. U. (1963). A Guide for the Identification of British Aquatic Oligochaeta. *Scientific Publication* 22.

Carausu, S., Dobreanu, E., Manolache, C. (1955). Fauna Republicii populare Romine, Crustacea, **4** (4), Amphipoda. Editura Academiei Republicii populare Romine.

Čekanovskaja, O. V. (1962). *Maloščetkonovi červi fauni SSSR*, Akademija nauk SSSR, Moskva.

Čepić, V., Marinković - Gospodnetić, M. (1978). Zoobentos rijeke Toplice. *God. Biol. inst. Univ. u Sarajevu* **31**, 25 - 32.

Filipović, D. (1954). Ispitivanje živog sveta tekućih voda Srbije. I Prilog poznavanju naselja planinskog potoka Katušnice (Zapadna Srbija). *SANU-Inst. ekolog. biogeograf. Zbor. rad.* **5** (8), 117-133.

Filipović, D. (1965). Dinamika i ekologija ekosistema Lisinskog potoka na Kopaoniku. *Doktorska disertacija*, Biološki fakultet, Univerzitet u Beogradu, Beograd.

Filipović, D. (1969). Faunistički sastav izvorskog regiona Crnog Timoka i njegove karakteristike. *III Kongr. biol. Jug. Knji. plenar. ref. pouzet.* **104**, Ljubljana.

Grandi, M. (1960). Fauna d'Italia 3, Ephemeroopidea. Edizoni colderini Bologna.

Hrabe, S. (1979). Vodni maloštetinatci (Oligochaeta) ^esko-slovenska. *Acta Universitatis Carolinae - Biologica.*

Hynes, H. B. N. (1977). A key to the adults and nymphs of the British stoneflies (Plecoptera), with notes on their ecology and distribution. *Freshwater Biol. Associ.* **17**.

Ikonomov, P. (1959). Ephemeroptera na Makedoniija. Sistematika i faunistika, *Doktorska disertacija*, PMF na Univerzitet Tetovo, Skoplje, **274**.

Huet, M. (1961). Influence de coorant sur la distribution des poissons dans les eavy courantes. *Symposium-Castanienbaum* (Luzern.), **131**.

Illies, J. (1978). *Limnofauna Europea.* – Gustav Fischer-Verlag-Stuttgart-New York, Swets & Zeitlinger B. V.-Amsterdam, 1-473.

Illies, J. (1953). Die Besiedlung der Fulda nach dem jetztigen Stand der Untersuchungen, *Ber. D. L. F. F. V*, 1-28.

Janković, M. (1967). Limnološke karakteristike reke Baltave pre podizanje brane. *Ekologija* **2** (1-2), 33-49, Beograd.

Janković, M. (1987). Stanje faune dna Velikog Timoka u uslovima datog zagaenja. *Glas CCCXLIX, SANU*, **51**, 92-106, Beograd.

Kerovec, M. (1986). Priručnik za upoznavanje beskralješnjaka naših potoka i rijeka. *Liber* 1-127, Zagreb.

Konta, P. S. (1997). Analiza uticaja ekoloških faktora na makrozoobentos Lomničke reke. *Magistarski rad*, Biol. fak. Univ. u Beogradu, 1-99.

Macan, T. T. (1979). A key to the nymphs of the British Species of Ephemeroptera with motes on their ecology. *Freshwater Biol. Assoc.* **20**, 1 - 63.

Marković, Z. (1995). Reka Đetinja, makrozoobentos u oceni kvaliteta vode. *Ministarstvo za zaštitu životne sredine Republike Srbije i Naučnoistraživački centar Užice*, 1-131.

Marković, Z. i *Miljanović, B.* (1995). Makrozoobentos Kriveljske reke. III naučno-stručni skup o prirodnim vrednostima i zaštiti životne sredine. *Zbor. rad. "Naša ekološka istina"*, 221-225.

Marković, Z., Miljanović, B. i *Mitrović-Tutund'ić, V.* (1997). Saprobiološka ocena kvaliteta vode reke Banje na osnovu makrozoobentosa kao bioindikatora. *God. Jug. društ. za zašt. voda* 350-354, Beograd.

Marković, Z., Mitrović-Tutundžić, V. and *Miljanović, B.* (1997a). Effect of pollution on the macrozoobenthos diversity and structure in the river Obnica (Serbia, Yugoslavia). *Ekologija* **32** (2), 37-46.

Marković, Z. (1998). Izvori brdsko-planinskih područja Srbije, ekološka studija makrozoobentosa. *Biol. fak. Univ. u Beogradu*, **318**.

Marković, Z., Miljanović, B. i *Mitrović-Tutund'ić, V.* (1998). Makrozoobentos kao pokazatelj kvaliteta vode reke Jablanice. *God. Jug. društ. za zašt. voda* 369-372.

Martinović-Vitanović, V., Kalafatić, V., Jakovčev, D., Paunović, M, i *Martinović, M. J.* (1998). Reka Veternica – sastav i stuktura biocenoza, saprobiološki status i kvalitet vode. *Ecologica* **5, 3**, 22-28, Beograd.

Miljanović, B. (2001). Makrozoobentos reka Kolubare, Obnice i Jablanice. *Biblioteka ACADEMIA*, Beograd **80**.

Paunović, M. (2001). Prostorna i sezonska dinamika makrozoobentosa reke Vlasine. *Magistarski rad*, Biol. fak.. Univ. u Beogradu, 1-200.

Rozkošny, R. ed. (1980). Klič larev vodneho hmyzu. *Československa Akademie Ved.* 227 – 457, Praha.

Shukriu, A. (1979). *Ekološka uvjetnost i zonalni raspored makrozoobentosa u rijeci Prizrenska Bistrica*, 6-124, Zagreb.

Simić, V. (1993). Saprobiološka valorizacija Svrljiškog i Trgoviškog Timoka na osnovu sastava macrozoobenthosa. *Magistarski rad*, Biol. fak. Univ. u Beogradu, 1-263.

Southwood, T. R. E. (1978). *Ecological Methods.* Chapman and Hall, London, 524.

Wesenberg, L. C. (1943). *Biologie der Susswasserinsekten*, Berlin - Wien.

Žadin, V. I. (1940). *Žizni presnih vod SSSR*, Akademija nauk SSSR, Moskva.

Živić I., Marković, Z. i *Brajković, M.* (2000). Sekundarna produkcija makrozoobentosa Puste reke. *God. Jug. društ. zašt. voda* 175-180.

Živić, I., Marković, Z. i *Brajković, M.* (2001). Prilog poznavanju kvalitativnog sastava makrozoobentosa i kvaliteta vode Crvene Reke. *God. Jug. društ. zašt. voda* 175-182.

Živić, I., Marković, Z. i Brajković, M. (2001a). Saprobiološka istraživanja Puste reke korišćenjem makrozoobentosa kao bioindikatora. *Zašt. prir.* 52, 51-60.

МАКРОЗООБЕНТОС ПУСТЕ РЕКЕ ЛЕВЕ ПРИТОКЕ ЈУЖНЕ МОРАВЕ

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У периоду од Априла 1998. до Јануара 1999. године обављена су истраживања макрозообентоса Пусте реке. Пуста река је главна водна артерија пусторечког краја у југоисточној Србији. Настаје спајањем Куртишке, Статовачке и Драгоделске реке у засеоку Крушкар, а у Јужну Мораву се после 64 *km* тока улива код Дољевца.

Фауну дна Пусте реке сачињава 20 група макроинвертебрата са 135 детерминисаних таксона (73 детерминисаних на нивоу врсте и 62 на нивоу рода). Највеће разноврсности су инсекатски редови Ephemeroptera (25 таксона), Trichoptera (19), Diptera (19) и Coleoptera (11), док су најуниформнијег састава ракови (Isopoda и Decapoda) и инсекти из редова Megaloptera и Neuroptera, са по једном нађеном врстом.

У изворском региону доминирају јединке Gammaridae, у горњем и средњем току реке ларве Chironomidae (IV, VII, VIII, IX, X и XI локалитет) и Ephemeroptera (III, V и VI локалитет), док су ларве Trichoptera најбројније на XI локалитету.

На основу биоценотичке анализе у насељу дна Пусте реке могу се издвојити три биоценотичка комплекса: биоценотички комплекс који одговара изворском региону, комплекс који одговара региону горњег и средњег, и комплекс који одговара региону доњег тока реке.

Врсте *Hemiclepsis marginata, Baetis niger, Ecdyonurus aurantiacus, Helodes marginata, Blepharera fasciata, Heptatoma pellucens, Rhyacophila pascoei,* су први пут забележене за фауну Србије.