TÜBİTAK

Turkish Journal of Zoology

http://journals.tubitak.gov.tr/zoology/

Research Article

Turk J Zool
(2015) 39: 210-224

doi:10.3906/zoo-1307-35

Macroinvertebrate communities along the Velika Morava River

Vanja MARKOVIĆ[1,*], Jelena TOMOVIĆ[1], Ana ATANACKOVIĆ[1], Margareta KRAČUN[1], Marija ILIĆ[1], Vera NIKOLIĆ[2], Momir PAUNOVIĆ[1]

[1]Institute for Biological Research "Siniša Stanković", University of Belgrade, Belgrade, Serbia

[2]Department of Zoology, Faculty of Biology, University of Belgrade, Belgrade, Serbia

Received: 26.07.2013 • **Accepted:** 26.05.2014 • **Published Online:** 27.02.2015 • **Printed:** 27.03.2015

Abstract: This paper presents the results of a faunistic study of the macrozoobenthos of the Velika Morava River. The investigation was conducted during the summer and autumn months in 2010. A total of 84 macroinvertebrate taxa have been identified, with Insecta (Ephemeroptera) as the most diverse and Oligochaeta as the most abundant groups. A tubificid worm, *Limnodrilus hoffmeisteri*, was the most important species with regard to relative abundance and frequency of occurrence. Two rare and endangered species, *Theodoxus transversalis* and *Unio crassus*, were recorded, as well as 5 alien species. Locality VM4 (Markovac Bridge) is of particular interest as the northernmost locality, as well as having the most abundant population of *T. transversalis* found. Despite being in the lower stretch of the river, this site is particularly taxa-rich, presumably due to conspicuous microhabitat diversity. Water temperature and pH value were determined to be the most important factors of the 32 environmental variables tested. Multivariate analyses revealed separation of summer samples compared to autumn. The Mann–Whitney test showed significant differences in fauna only in the case of ecoregions, confirming their current delineation and the transitional character of this river.

Key words: Macroinvertebrates, diversity, benthos community, multivariate statistics, large river, Serbia

1. Introduction

Since ancient times, human societies have been bound to large rivers, and as civilizations have developed the impact on the rivers has become more obvious. Unfortunately, that impact has turned out to be predominantly negative; thus, we are now faced with an urgent need to conserve and restore riverine ecosystems.

Rivers in the largest and most densely populated European river basin, the Danube Basin, are particularly affected by a variety of anthropogenic influences, from damming, impoundments, and other hydromorphological alterations (e.g., gravel and sand extraction), to various types of pollutions (organic, toxic, thermal, biological) (Final Danube River Basin Management Plan (2009), International Commission for the Protection of the Danube River (ICPDR)). The Velika Morava River, a tributary of the Danube in Serbia, is an example of the abovementioned: it flows through a densely populated area (Pomoravlje), and it is under heavy anthropogenic influences (Marković et al., 2011; Kolarević et al., 2012). Besides being (along with the Zapadna and Južna Morava tributaries) one of the largest rivers on the Balkan Peninsula, this river is important as a connection between the Pannonian and Balkan ecoregions (Paunović, 2007; Paunović et al., 2012b).

However, the aquatic life of the Velika Morava has hardly been explored, especially regarding its macroinvertebrate fauna. According to available data, the river has been studied only as part of broader research in which the wider area was examined (Simić, 1996; Paunović, 2007; Paunović et al., 2010), as part of several specialized investigations of specific taxa such as Chironomidae (Janković, 1979), *Branchiura sowerbyi* (Paunović et al., 2005), *Corbicula fluminea* (Paunović et al., 2007a), and *Sinanodonta woodiana* (Paunović et al., 2006), and in water quality assessment (Marković et al., 2011).

The Velika Morava is an important part of the southern invasive corridor (Rhine–Main–Danube; Panov et al., 2009), and this migration route provides a potential link with the Aegean basin. The following nonindigenous species have been discovered in the Velika Morava River: the aquatic worm *Branchiura sowerbyi* (Paunović et al., 2005); the clams *Sinanodonta woodiana* (Paunović et al., 2006) and *Corbicula fluminea* (Paunović et al., 2007a); and the amphipods *Corophium curvispinum* (Borza et. al., 2010) and *Dikerogammarus villosus*.

The aim of this paper is to provide more detailed information on the fauna of the macroinvertebrates of the Velika Morava River. The data are important not only to

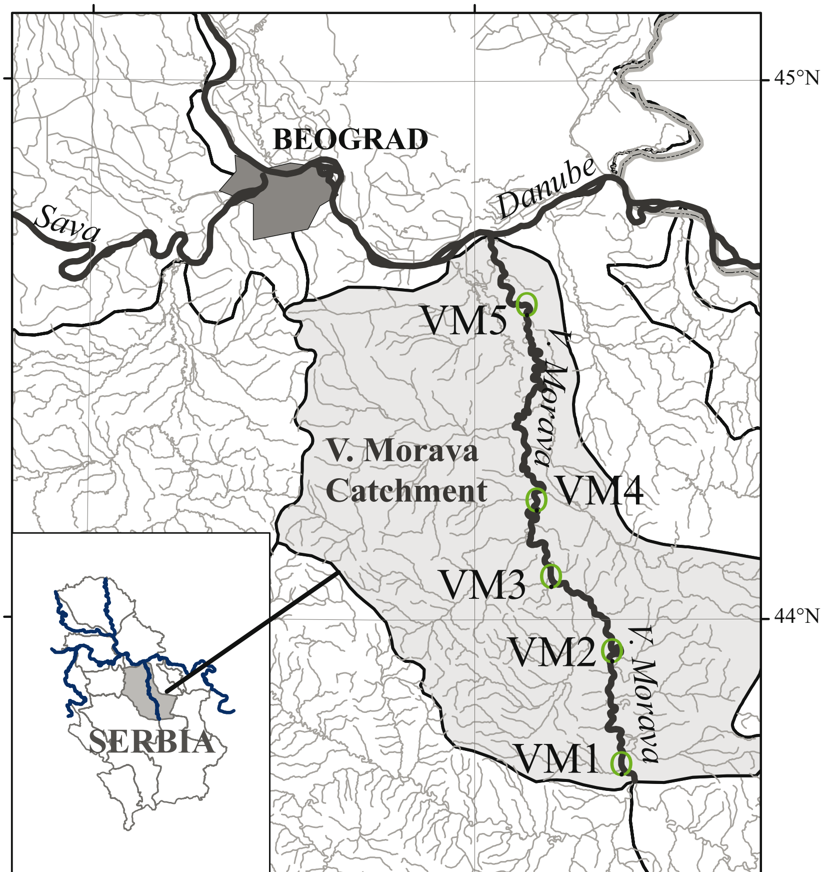
* Correspondence: vanjam@ibiss.bg.ac.rs

identify the status of biodiversity, but also as a platform for better water management practices. The Velika Morava Basin is the biggest watershed in Serbia that is under the influence of different types and intensities of stressors.

2. Materials and methods

2.1. Study area and sampling sites

The Velika Morava River (Figure 1), one of the major tributaries of the Danube in Serbia, is 175 km long and has a catchment area of 38,000 km^2. Over 95% of the basin is located in the territory of the Republic of Serbia, contributing to about 40% of its territory. The river is formed from the Zapadna and the Južna Morava rivers at their confluence near the settlement of Stalać. The mouth of the Velika Morava, where it flows into the Danube, is near the city of Smederevo. Near its confluence, the mean annual flow is 245 m^3/s, according to the gauge station Ljubičevo (Annual Water Quality Report (2001–2010), Hydrometeorological Service of Serbia). The water regime is unimodal, characterized by prominent seasonal fluctuations: in the spring, the river can be almost torrential, with a mean flow at the mouth of 560 m^3/s, while the rest of the year is typically described as a “low water” period, particularly in the autumn when the mean



Sampling site	Ecoregion	Latitude, N	Longitude, E	Altitude (m)	River length (km)	River bed width (m)
VM1	ER5_Ser	43 43.022	21 23.053	130	169.83	120
VM2	ER5_Ser	43 56.921	21 21.873	115	135.2	110
VM3	ER5_Ser	44 05.099	21 11.377	102	108.81	95
VM4	ER5_Ser	44 13.485	21 09.215	95	82.27	85
VM5	ER_11	44 35.182	21 7.748	72	21.52	135

20°E 21°E

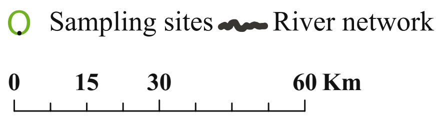


Figure 1. Sampling sites on the Velika Morava River.

flow does not exceed 100 m^3/s (Mihailović and Radić, 2006). The riverbed is 80–200-m wide and up to 10-m deep, although the average depth usually does not exceed 2 m. Silicates are the dominant geological substrate in the entire catchment area.

According to the main geographical features (geomorphology and hydromorphology), the river can be divided into 2 main parts. The lower part stretches from the confluence with the Danube to the mouth of the Resava River (near Svilajnac) and is 85 km long. This is a typical lowland watercourse (with an altitude below 100 m a.s.l.), with 0.35‰ declination, and sand and mud/silt as the dominant fractions of the riverbed. According to Paunović (2007), this part of the Velika Morava River belongs to Ecoregion 11 (ER_11; Illies, 1978). The upper part stretches from the mouth of the Resava to the town of Stalać, and is about 90 km long. The average altitude is above 100 m a.s.l. (up to 135 m), declination is 0.44‰, and the riverbed is predominantly composed of sand and gravel. This part belongs to Ecoregion 5 (ER5_Ser; Paunović, 2007; Paunović et al., 2012b).

The sampling sites were located at every 30 km on average. They were chosen to evenly cover the investigated stretch of the river with representative habitat types and exposure to different kinds of pressures (up- and downstream of cities, communal and industrial waste waters, hydromorphological alterations, agricultural areas). The main features of the sampling sites are provided in Figure 1.

The sampling site VM1 is located upstream from the small town of Varvarin, and about 15 km downstream of the city of Kruševac (with a population of 135,000 in the metropolitan area; the town is a moderately large industrial center, with metal, chemical, and beverage industries). Sampling was performed on the right bank, at a stretch of 100 m that includes a low waterside largely surrounded by open meadows, a smaller section shaded by *Populus* sp. trees, and a part composed of gravel reefs. The dominant component of the substrate is gravel, followed by fine sediment (mud/silt and detritus) and rocks.

The sampling site VM2 is located downstream of the town of Ćuprija (with a population of 21,000), and 10 km downstream of the town of Paraćin (25,000 residents; major industries include sugar, textiles, and food processing). Sampling was performed along a 100-m stretch on the left river bank that is slightly elevated, composed of clay, and in large part shady (mostly *Populus* sp. trees). Fine sediment (mud/silt and detritus) prevails in the riverbed, along with sand.

The sampling site VM3 is near the village of Bagrdan in the Bagrdan Gorge, 10 km downstream of the city of Jagodina (with a population of 40,000), which is an industrial center with a brewery and slaughterhouse. Sampling was performed on the left clay riverbank, which is shady and slightly elevated. The riverbed substrate consists of a combination of fine mud/silt and clay, and a smaller portion of gravel. This locality is exposed to hydromorphological pressure because of the 25-m long and 5–6-m wide gravel and rock fill at medium water level that extends to the river channel, which is used for angling. This impedes the flow, creating lentic conditions; as it narrows, the flow rate increases.

The sampling site VM4 is below the Markovac-Svilajnac Bridge, about 500 m downstream of the Morava thermal power plant and 10 km downstream from the confluence of the Lepenica and Velika Morava. The Lepenica River is one of the largest tributaries of the Velika Morava. It brings waste waters from the nearby regional center, the city of Kragujevac, with a population of over 180,000 in the metropolitan area. Upstream from the site are a few kilometers of a green belt with meanders known as the Morava Swamps. The riverbed substrate is heterogeneous, composed of rock and gravel, as well as sand and fine sediment of mud/silt and detritus in parts. The site is under intense hydromorphological pressure because of the bridge, which creates artificial rapids (along with the presence of stony barriers in the river) in the lower part, as well as a channel that brings thermal water from the Morava thermal power plant, which lies upstream.

The sampling site VM5 is located at the bridge near the Ljubičevo stable, in a predominantly agricultural area in the vicinity of the city of Požarevac (population of 45,000). Sampling was performed on a stretch of the right riverbank that is elevated, mostly composed of clay, and contains sections of large stones and concrete and gravel/sandy reefs downstream. The dominant component of substrate is fine sediment, mostly composed of mud/silt, while a smaller part contains large stones.

2.2. Sampling and sample processing

The study is based on the benthic material that was sampled at 5 localities in July, August, October, and November 2010. Semiquantitative sampling was performed with a hand net (625 cm^2, 0.5-mm mesh size). A multihabitat sampling procedure (Hering et al., 2004) was applied. A total of 20 samples were preserved in 4% formaldehyde. The preserved material was sorted and identified in the laboratory. Identification was carried out to species level for the majority of taxa; representatives of Chironomidae (Insecta: Diptera), Nematoda, and water mites (Arachnida: Acari: Hydrachnidia) were recorded only as present in the community. Identification was performed using the appropriate taxonomic keys (Botnariuc, 1953; Bertrand, 1954; Lozek, 1956; Mann, 1964; Macan, 1970; Brinkhurst and Jameieson, 1971; Wallace et al., 1990; Edington and Hildrew, 1995; Nilsson, 1996, 1997; Waringer and Graf, 1997; Glöer, 2002; Timm, 2009).

2.3. Data analyses

The following common diversity indices were used to estimate the structures of the communities: taxa richness, relative abundance, the frequency of occurrence or constancy (F; Tischler, 1948), the Shannon–Wiener diversity index or Shannon entropy (SWI; Shannon, 1949), Simpson's diversity (1 - Dominance) or the Gini–Simpson index (SDI; Simpson, 1949; Jost, 2006), the Pielou evenness index or species evenness (PE; Pielou, 1984), the Sørensen index or Sørensen's similarity coefficient (Cs; Sørensen, 1948) as the simplest measure of β-diversity.

The frequency of occurrence or constancy revealed the dispersion of taxa and species in the investigated communities. It was obtained from the formula:

$F = n / N \times 100$,

where n is the number of samples containing a given taxon, and N is the total number of samples. Constant taxa are defined as having F >50%; taxa with F <25% are referred to as accidental taxa; taxa with F >75% are referred to as euconstant taxa.

Calculations of indices were performed using ASTERICS software (version 3.0; www.aqem.de), except for frequency of occurrence and the Sørensen index, which were calculated manually. Further calculations with indices (SWI before all the others) were performed using Statistica software (version 6.0; StatSoft, Inc, www.statsoft.com).

Community functional analyses (longitudinal distribution–zonation, microhabitat preferences, and distribution of functional feeding groups/feeding types) were performed in order to evaluate the relationships between macroinvertebrate assemblages and environment. These parameters were also obtained with ASTERICS software (version 3.0; www.aqem.de).

Mann–Whitney's (Mann and Whitney, 1947) nonparametric tests were used (Statistica, version 6.0) to assess the statistical significance of the differences in the analyzed datasets (month, season, locality, and ecoregion). The diversity indices served as parameters for testing.

To visualize macroinvertebrate benthic communities, multivariate classification and ordination methods were applied.

Hierarchical classification of ecological data offers the possibility to perceive interrelations between studied groups and objects—in our case, the sampling sites and the months when sampling was performed. For this purpose, the divisive polythetic Noy-Meir method was chosen (Noy-Meir, 1973). Relative abundance served as input data. Generalized Euclidean distance was applied.

Ordination of the 20 × 82 samples in a taxa data matrix was performed by detrended correspondence analysis (DCA; Hill and Gauch, 1980). The taxa Nematoda and Hydrachnidia were excluded since they were not identified to a satisfactory level (at least to family level), and, as such, they were of minor importance for our analysis. The down-weighting of rare species procedure (Karadžić, 2013) using the weighted averages (WA; Karadžić, 2013) algorithm was performed in order to reduce the influence of rare taxa and the considerable number of zeroes in the community data matrix, which is a common issue to be resolved in ecostatistical surveys. An ordination biplot was constructed that consisted of points representing species and taxa, and squares representing samples. This plot reveals their multidimensional relations in 2-dimensional space.

Canonical correspondence analysis (CCA; ter Braak 1986; Karadžić, 2013) was carried out in order to reveal the affinities of each taxon/sample for the selected environmental variables, and to determine the spatial distribution of the macroinvertebrate community. The available environmental dataset, consisting of 32 environmental variables (mostly related to water chemistry), was retrieved from 4 measuring stations/sampling sites (Annual Water Quality Report (2010), Hydrometeorological Service of Serbia), and covered a total of 14 samples. Because of the large number of environmental variables, especially in regards to the number of samples (32 vs. 14), problems due to overfitting and noisy environmental variables could arise (McCune, 1997). Consequently, forward analysis (FA; ter Braak and Verdonschot, 1995; Karadžić, 2013) was performed to extract factors with the greatest influence, i.e. those that correlated most with a given community (the "best variables"). For the purpose of our study, 6 of the "best" factors were chosen (Table).

The weighted averaging (WA) model/algorithm, with down-weighting of rare species and weighted average (WA) scores, was run on 14 × 75 samples-by-taxa, and 14 × 6 samples-by-factors data matrices, and gave rise to an ordination triplot. Such a triplot contains points and squares that correspond to different taxa and samples, respectively, as well as arrows (vectors) that correspond to environmental variables. The lengths and directions of these arrows that run from the center of the triplot indicate the strength (significance) and influence of a particular variable on the community. The angles between the arrows indicate correlations between the environmental variables. Thus, an angle of 90° denotes no correlation (ca: 0), an angle of 180° indicates negative correlation (ca: −1; an opposite effect), while a full match is represented by an angle of 0° and indicates perfect correlation (ca: 1; ter Braak, 1990). It should be pointed out that the first CCA axis corresponds to the first synthetic gradient, the second axis to the second gradient, and so on (ter Braak and Verdonschot, 1995). As is the case with ordinary CA, the first few axes are sufficient to describe a dataset and to cover most of the community variability.

Table. The forward selected environmental variables used in CCA. Samples are coded as localities (VM1, VM3, VM4 and VM5) and months (July as 7, August as 8, October as 10 and November as 11).

	Sample	Water temperature (°C)	pH	Orthophosphate mg/L	Organic nitrogen mg/L	Ammonium mg/L	TOC mg/L
1	VM1_7	22.5	8.4	0.074	1.87	0.06	2.8
2	VM3_7	24.8	8.4	0.039	1.85	0	3.5
3	VM4_7	24.3	8.5	0.095	0	4.52	3.2
4	VM5_7	25.8	8.4	0.029	0.5	0.71	2.4
5	VM1_8	23.5	8.4	0.015	1.71	0.02	7.2
6	VM3_8	24.2	8.4	0.077	0.18	0.44	9.5
7	VM4_8	23.6	8.5	0.112	0.12	0.95	10.4
8	VM5_8	25.2	8.4	0.045	0.32	0.95	6.8
9	VM1_10	10	8	0.117	2.2	0.02	4
10	VM3_10	10.2	8	0.197	1.21	0.09	4.7
11	VM5_10	12.3	8	0.159	0.9	0.02	4.4
12	VM1_11	9	8	0.094	2.21	0.14	4.9
13	VM4_11	10.4	7.7	0.166	1.39	0.1	5.2
14	VM5_11	12.2	7.9	0.149	1.6	0.13	4.9

All multivariate analyses were performed by FLORA software (version 6.0; Karadžić et al., 1998; Karadžić, 2013).

3. Results

During our investigations, we identified a total of 84 macroinvertebrate taxa (Appendix).

Insects (Insecta) were found to be the principal component of the community with respect to taxa richness, with 42 identified taxa. Aquatic worms (oligochaetes; Oligochaeta) and mollusks (Mollusca) were also important, with 15 identified species each. The diversity of other registered groups of taxa was significantly lower. Leeches (Hirudinea) were represented by 5, Isopoda and Amphipoda (Crustacea) by 4, and Nematoda, Turbellaria, and Hydrachnidia by only 1 taxon each. Among insects, the most diverse group was mayflies (Ephemeroptera), represented by 16 species. Caddisflies (Trichoptera) and true flies (Diptera) were represented by 8 species each; dragonflies and damselflies (Odonata) were represented by 5 species. It should be mentioned that, unlike in other insect groups, almost all Trichoptera diversity accounted for 1 genus only—*Hydropsyche* (Hydropsychidae). Among oligochaetes, tubificids (Tubificidae) with 7 and naidids (Naididae) with 5 recorded taxa were the most diverse families. Of the mollusks, snails (gastropods; Gastropoda) were represented by 11 and bivalves (Bivalvia) by 4 taxa. Bearing in mind that some groups, most notably chironomids (Chironomidae; Diptera), were not identified to species level, we can assume that overall taxonomic richness is higher.

The number of identified taxa per sample varied from just 5 (VM5_7) and 6 taxa (VM5_8), up to 26 (VM1_7 and VM1) and 29 (VM1_8, VM3_7, VM4_10, and VM4_11). The greatest overall diversity (taxa richness) was recorded at the sampling site VM1 (56 taxa). As our examination progressed downstream, decreasing diversity was observed (Figure 2). The lowest diversity was observed at the sampling site VM5 (17 taxa). When expressed relative to the time scale, the diversity is apparently more balanced: the greatest diversity was observed in October, when 54 different taxa were identified, and the lowest was detected in November (46 taxa).

It is important to note that 5 alien taxa were found: the aquatic worm *Branchiura sowerbyi*, amphipods *Corophium curvispinum* and *Dikerogammarus villosus*, and bivalves *Corbicula fluminea* and *Sinanodonta woodiana*.

In terms of relative abundance, aquatic worms (Oligochaeta) were observed to be the principal component of the community in most of the samples. This is illustrated by *Limnodrilus hoffmeisteri*, which was identified in 34% of the total number of processed

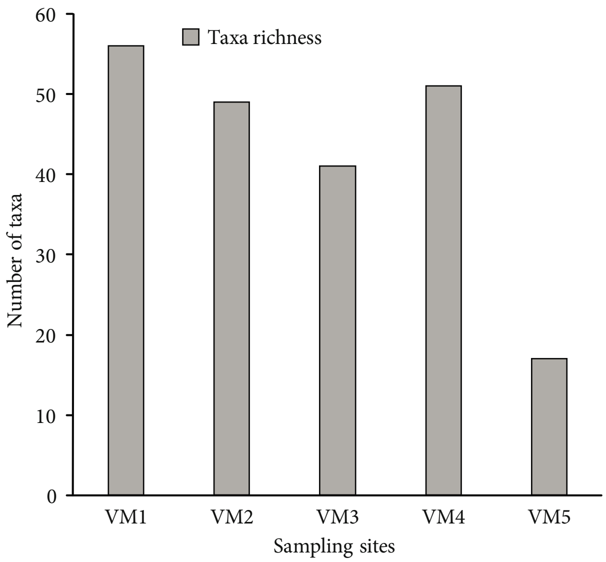


Figure 2. Overall taxa richness at the sampling sites.

specimens; with 55% of all specimens from sampling site VM3, it was by far the most abundant species. Relative abundances of the main groups by sampling sites and different months are presented in Figure 3. The relative abundance of Oligochaeta was highest at sampling sites VM3 and VM5 (81.9% and 60.5%, respectively). Although it was not so apparent in terms of the month of sampling, Oligochaeta were found to be the dominant group (from 31.5% of the total community abundance in July to 55% in October). Chironomidae (Diptera) were also abundant in the processed samples (22.6% overall and 70.6% in sample VM2_10), especially at sampling sites VM2 and VM1 (46% and 29%, respectively). Snails and bivalves were the principal components of the community at sampling site VM4 (29%), as well as the most abundant groups after the oligochaetes and chironomids, during the autumn months. In general, of the bivalves, the most abundant/dominant species was *Corbicula fluminea*, which occupied 7% of the overall macroinvertebrate community and 31% in the sample VM4_11. In July, mayflies and caddisflies, which contributed to 33% of the community members, were the most abundant. This was most noticeable in the sample VM1_7 (66%). Of these organisms, the most abundant taxa were *Hydropsyche* sp. and *Baetis* sp. Amphipods, which contributed to 8.4% of the overall abundance, were important members of the community in terms of relative abundance, especially at sampling site VM5 (27%), while by month amphipods were the most abundant in July (18%). *Corophium curvispinum* was the most abundant species of crustacean. This was most clearly demonstrated in sample VM5_11 (67%).

Considering the frequencies of occurrence/constancy, the most frequent/euconstant taxa were chironomids (F = 0.95) and the tubificid worm *L. hoffmeisteri* (F = 0.9). Constant taxa were *Limnodrilus claparedianus* (F = 0.65), *Gammarus* sp. (F = 0.65), *Branchiura sowerbyi* (F = 0.6), *C. fluminea* (F = 0.6), *Holandriana holandrii* (F = 0.55), and *Hydropsyche contubernalis* (F = 0.55). With regard to the sampling sites, euconstant taxa, aside from the chironomids, were the following: *H. holandrii*, *Theodoxus danubialis*, *C. fluminea*, and *Gammarus* sp. (at sampling site VM1); *L. hoffmeisteri* (VM2); *L. claparedianus*, *L. hoffmeisteri*, *Lithoglyphus naticoides*, and *Gomphus vulgatissimus* (VM3); and *Hydropsyche incognita* and *H. contubernalis* (VM4); and at sampling site VM5, the most common species was *L. hoffmeisteri.* Examination of the seasonal aspect of distribution of euconstant taxa showed that, apart from the chironomids, *L. hoffmeisteri*, *H. contubernalis*, and *Hydropsyche* sp. were euconstant in the summer months, while in autumn samples *L. hoffmeisteri*, *B. sowerbyi*, and *C. fluminea* were euconstant.

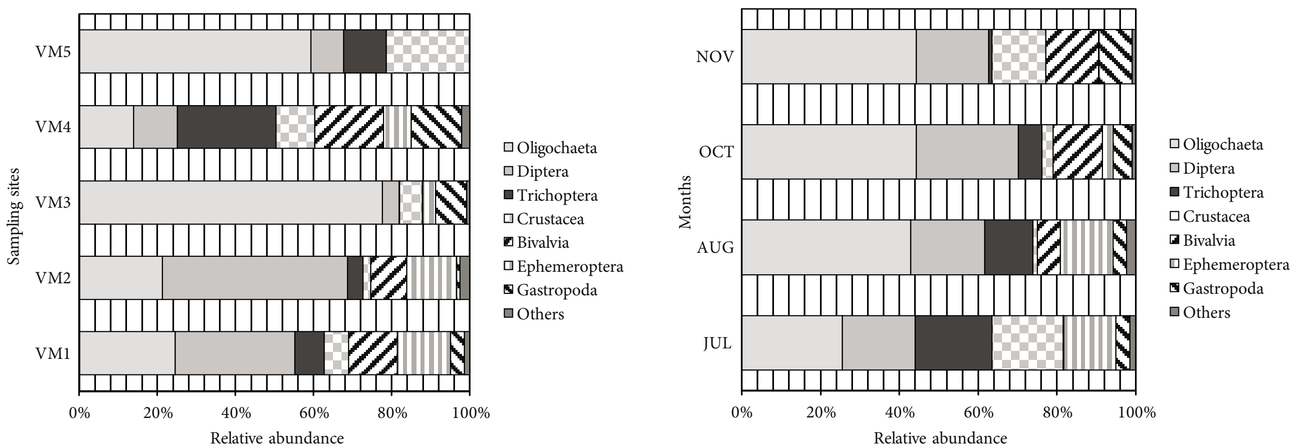


Figure 3. Relative abundance of the main taxonomic groups regarding sampling sites (a) and months (b).

The calculated values of the α-diversity indices ranged from 0.942 to 2.817 (VM5_8/ VM4_10) in the case of the Shannon–Wiener index, and from 0.4790 to 0.917 (VM2_10/ VM4_10) in the case of Simpson's diversity. The greatest diversity was present at the sampling site VM4 (SWI: 2.35; SDI: 0.86), while the lowest was at the site VM3 (SWI: 1.49; SDI: 0.65). On a monthly scale, the greatest diversity was observed in July (SWI: 2.013; SDI: 0.81), and the lowest in November (SWI: 1.55; SDI: 0.67). The overall mean values of the calculated indices during the investigated period were 1.75 for the Shannon–Wiener index and 0.72 for Simpson's diversity. The mean values of the Shannon–Wiener indices for the sampling sites and months are shown in Figure 4. The mean values of Shannon–Wiener indices with regard to the season and ecological region are given in Figure 5. The Mann–Whitney test revealed a statistically significant difference (P = 0.05) only with regard to the ecological regions.

The values of evenness varied from 0.422 to 0.917 (VM2_10/VM5_7). The case of sample VM5_7 is interesting. It exhibited the lowest number of recorded taxa (only 5) with the highest equitability. When we examined the spatial and temporal aspects, the evenness ranged from 0.527 (VM3) to 0.745 (VM4), i.e. from 0.549 (in November) to 0.745 (in July). The mean value for the river in the investigated period was 0.624.

Sørensen's β-diversity/similarity indicates that the sites VM1 and VM4 (0.7523) were the most similar, while the lowest similarity was recorded between sites VM1 and VM5 (0.3158). On the temporal scale, July and August were the most similar (Cs: 0.7451), while the greatest distance/dissimilarity was between July and November

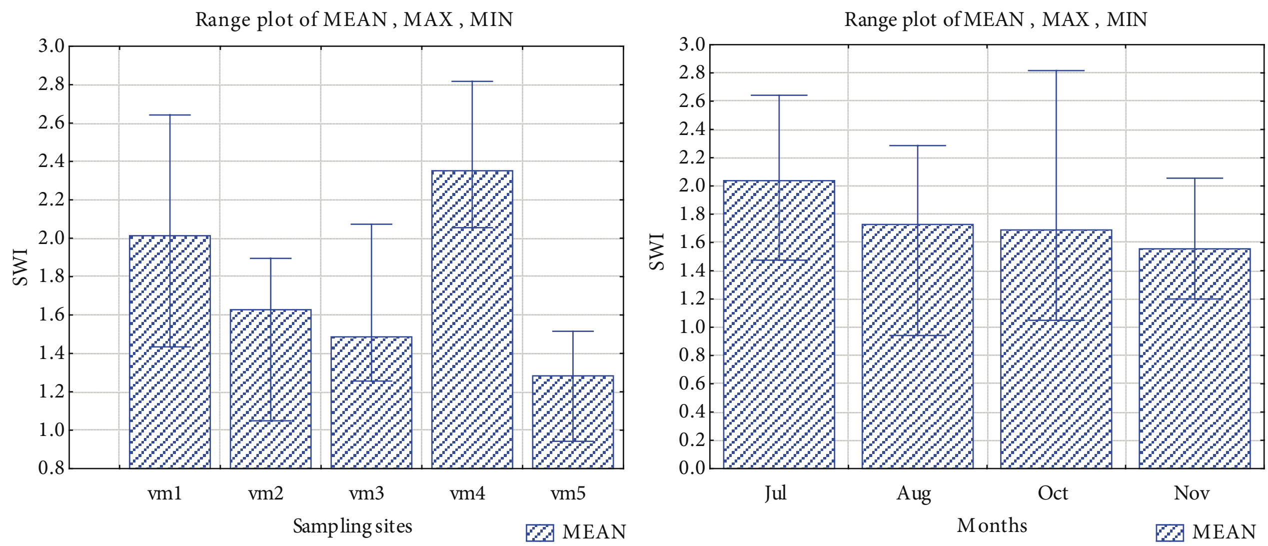


Figure 4. The Shannon–Wiener index: spatial (a) and monthly (b) aspects (mean, maximal, and minimal values).

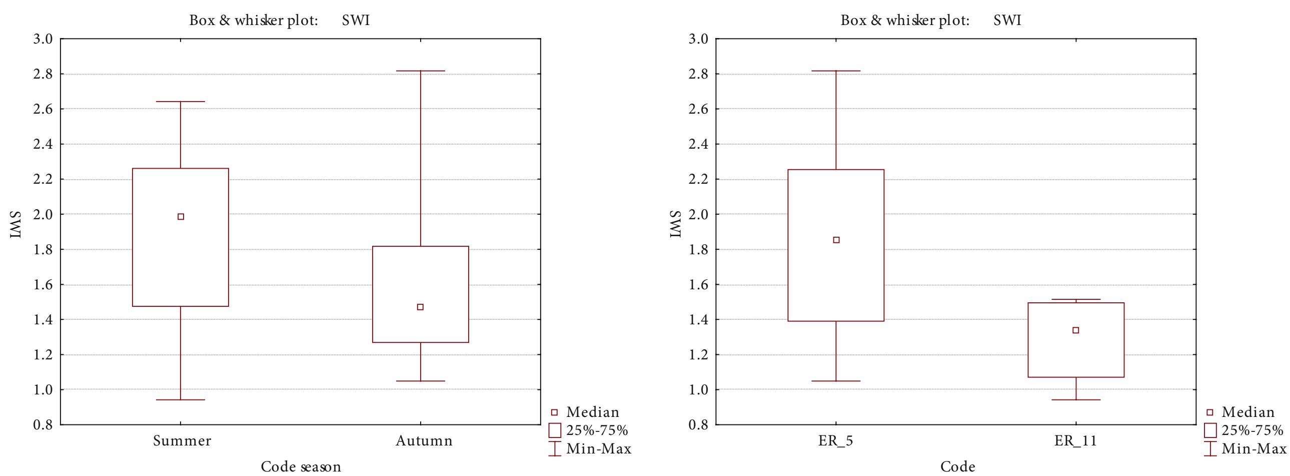


Figure 5. The Shannon–Wiener index: ecoregions (a) and seasonal (b) aspect (median, min, max).

(Cs: 0.4742). In general, the similarity varied more on the locational (0.3158–0.7523) than on the temporal planes (0.4742–0.7451).

In the case of spatial zonation, epipotamal, littoral, and metapotamal taxa were found to be the most common community members (16%, 15%, and 13%, respectively). Epipotamal taxa were dominant at VM1 and VM4; a significant portion of hyporhithral elements (13.3%) was also recorded at the same sites. At VM2, epipotamal and littoral taxa were equally represented. Littoral and metapotamal taxa were the most common at VM3 and VM5; at VM3, profundal and hypopotamal elements were also important. Examination of the temporal aspect revealed that in July the epipotamal and hyporhithral were the most common community members (13.6% and 12.3%, respectively). Other types, except the least represented epirhithral and hypopotamal types, were equally and moderately represented. During other months, epipotamal, metapotamal, and littoral taxa predominated, with increasing contributions from profundal and hypopotamal types in November.

With regard to the microhabitat preference in the macrozoobenthos community of the Velika Morava, pelophilous forms were dominant (35% of the total number of taxa). Lithophilous and psammophilous taxa (17% each) were also important. The share of pelophilous taxa was the highest at VM3 (50%) and VM5 (38%). Pelophilous taxa were dominant at all of the localities, except at VM4 where the lithophilous taxa were dominant (23%). On the temporal scale, pelophilous taxa were also dominant; however, in July a significant presence of lithophilous taxa was noted.

With regard to the type of diet, gatherers/collectors were the dominant component of the community at all of the localities, in particular at VM3 (88%). At sampling site VM4, grazers/scrapers as well as passive filter feeders (16% and 14%, respectively) were significant components. Active filter feeders were important at VM5 (18.6%). The gatherers/collectors were also the dominant component on the monthly scale. In July, a significant share of grazers/scrapers, passive filter feeders, and shredder forms were recorded.

Cluster analysis (Noy-Meir method) revealed the closest similarity between sampling sites VM1 and VM2, as well as the existence of 2 main clusters (Figure 6a). With regard to the temporal dynamics, the closest similarity was observed between August and October, whereas July was set apart from the main cluster (Figure 6b).

Detrended correspondence analysis (Figure 7) did not reveal a clear distinction, but rather overlap of most samples and taxa along the DCA axes. However, along the first DCA axis, 2 groups of samples and corresponding taxa could be distinguished. The left group was more dispersed, consisting mostly of the summer samples, and mostly of mayfly and caddisfly taxa. The right group was more compact, consisting of the autumn samples, with greater shares of tubificid and mollusk taxa, as well as the majority of VM3 and VM5 samples.

Performed CCA (Figure 8) revealed a similar faunistic structure. The result of CCA shows that the community

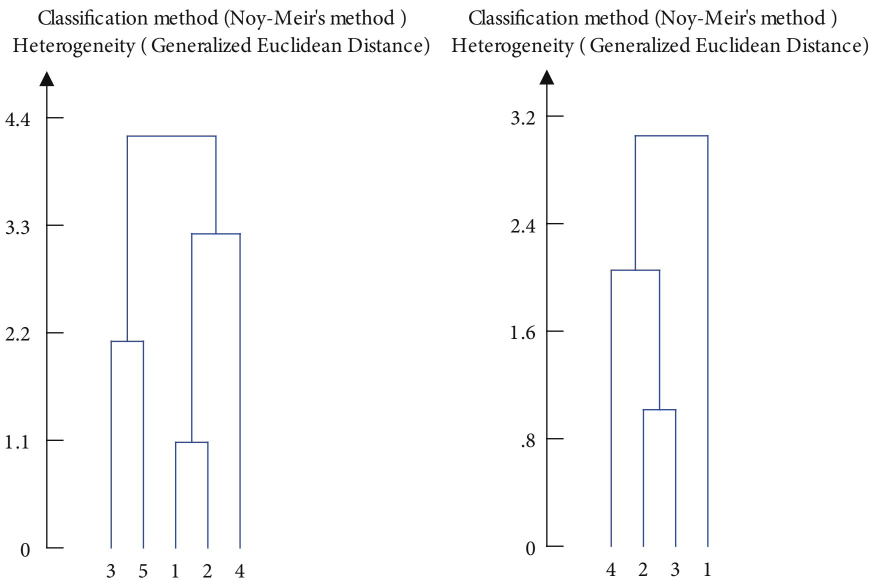


Figure 6. Hierarchical classification of the sampling sites (a) and months (b) according to the relative abundance of macroinvertebrate taxa, using Noy-Meir clustering from generalized Euclidean distances. The sampling sites are coded as follows: 1 – VM1, 2 –VM2, 3 – VM3, 4 – VM4, and 5 – VM5. The months are coded as follows: 1 – July, 2 – August, 3 – October, and 4 – November.

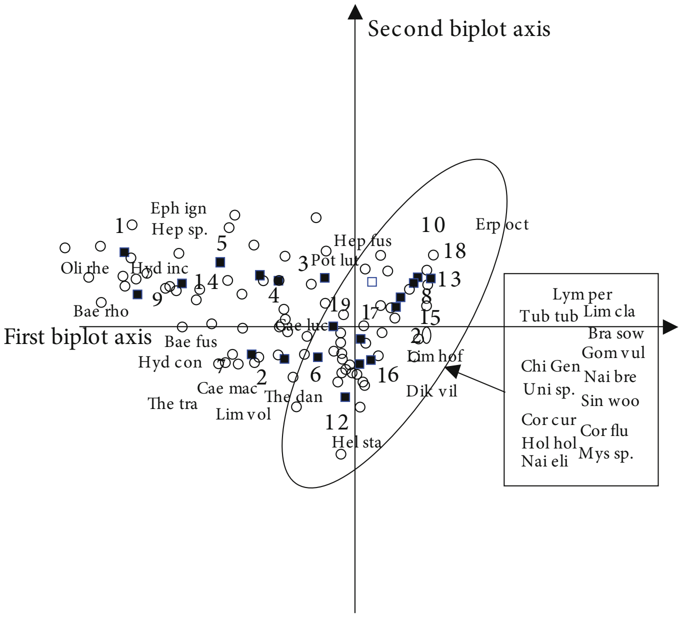


Figure 7. DCA biplot based on the matrix of 82 taxa and 20 samples displaying 36% of total variance (first DCA axis, 22.3%; second DCA axis, 13.6%). Down-weighting of rare species and the WA method were performed. Ellipse shows the autumn/VM3/VM5 group of samples/taxa. The names of the taxa and species are abbreviated as follows: Bae rho – *Baetis rhodani*, Pot lut – *Potamanthus luteus*, Hep fu – *Kageronia fuscogrisea*, Hep sp. – *Heptagenia* sp., Eph ig – *Ephemerella ignita*, Hyd sp – *Hydropsyche* sp.. etc. (full list of abbreviations is provided in the Appendix). The samples are coded as follows: 1- VM1_7, 2-VM2_7, 3-VM3_7, 4-VM4_7, 5-VM5_7, 6-VM1_8, 7-VM2_8, etc.

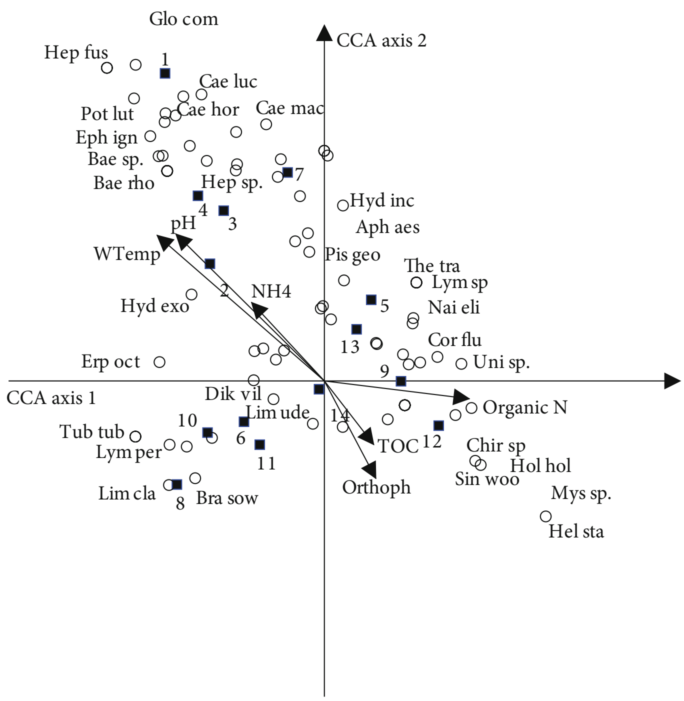


Figure 8. CCA triplot (75 taxa, 14 samples, and 6 environmental factors) displaying 56% variance (first CCA axis, 31.4%; second CCA axis, 24.1%) in the WA (weighted averages) of taxa and species with respect to the environmental variables. Down-weighting of rare species was performed, and the WA algorithm was applied. The names of the taxa and species are abbreviated as follows: Hep fus – *Kageronia fuscogrisea*, Hep sp. – *Heptagenia* sp., Pot lut – *Potamanthus luteus*, Eph ign – *Ephemerella ignita*, Bae rho – *Baetis rhodani*, Hyd sp – *Hydropsyche* sp., etc. (full list of abbreviations is provided in the Appendix). The environmental factors are coded as follows: pH (pH), WTemp (water temperature), NH4 (ammonium ion), Organic N (organic nitrogen), TOC (total organic carbon), and Orthoph (orthophosphate). The samples are coded as in the Table (for example, 1- VM1_7, 2 – VM3_7, etc.).

correlates the most with organic nitrogen (ca: 0.9), which defines the first CCA axis. Along this axis, on the left side, a positive correlation was displayed by the samples that were collected in autumn (and localities VM3 and VM5); these were mostly oligochaete and mollusk taxa. A negative correlation is presented on the right side and is exhibited by the samples that were collected in summer (and at sites VM1 and VM4); these are mayfly and caddisfly taxa. The summer group is associated with increased water temperature, pH, and ammonia concentration in contrast to the autumn group. The orthophosphate gradient along the second CCA axis (ca: 0.65) reveals similar separation of summer and autumn samples, with clearer positioning of tubificids in the autumn group. As lengths of the vectors correspond to their respective intensities, it is evident that the pH and water temperature have the strongest influence on the overall community.

4. Discussion

The recorded taxonomic richness, evidenced by the 84 registered taxa, is relatively high, especially when compared to similar watercourses and recent investigations with similar taxonomic resolution that were undertaken in the region. Thus, 62 taxa were recorded in the Serbian stretch of the Sava River (Paunović et al., 2008), while 80 taxa were recorded in the stretch between Zagreb and Belgrade (Paunović et al., 2012a). In the Serbian stretch of the Danube, in one instance 74 (Paunović et al., 2007b) and in another 68 taxa (Tubić et al, 2013) were recorded. The lowest macroinvertebrate diversity, with 18 taxa only, was found in the Serbian stretch of the Tisza (Paunović et al., 2010). In the Ibar River, 57 taxa were reported (Tubić et al., 2012), while in the Lim River, 66 taxa were found (Marković et al., 2012). In the most recent investigations of the Zapadna Morava River, 71 taxa were recorded (Novaković, 2013). Thus, regarding this parameter, the Velika Morava River is most similar to the Južna Morava River (83 taxa; Novaković, 2012).

In regard to overall diversity, recorded dominance of insect taxa differs to a certain extent from the observed and generally expected patterns for large lowland rivers (potamon-type) in the region, where oligochaetes and mollusks were found to be the principal components of communities (Paunović, 2007; Paunović et al., 2007b, 2008, 2010; Tubić et al., 2013). Among insects, diversity of the Ephemeroptera and Trichoptera was in range with that recorded in the Zapadna and Južna Morava Rivers, while diversity of Diptera was higher than in these rivers (Novaković, 2012, 2013). A further similarity with the Zapadna and Južna Morava rivers is the absence of stoneflies (Plecoptera), which in the upper part could be related to more intense anthropogenic pressures, since in some similar water courses (large rivers in ER_5), such as the Lim and the Ibar rivers, stoneflies were recorded (Marković et al., 2012; Tubić et al., 2012). Regarding diversity of Hydropsychidae as the most numerous members of caddisflies, a few things should be pointed out. An absence of *Hydropsyche bulgaromanorum* Malicky, 1977, a characteristic species of the lower parts of large European rivers (Czachorowski and Serafin, 2004), should be noted. As it was found in the Danube (Paunović et al., 2007b) and in the Sava (Paunović et al., 2012a) rivers, it could be expected to be found at least in the lower part of the Velika Morava River. Comparing diversity of this particular group, the similarity with the Južna Morava River is noticeable (Živić et al., 2003; Novaković, 2012).

Finally, our findings of *Hydropsyche incognita* (metarhithral taxa according to AQEM database; www.aqem.de) and *H. pellucidula* (hyporhithral–eupotamal taxa; AQEM), could indicate that their adaptability is broader than has been reported in the literature so far (Bálint and Ujvárosi, 2009).

In regards to the relative abundance of taxa, where oligochaetes, chironomids, and mollusks were found to be dominant, the Velika Morava River is a typical large lowland river. Sampling sites VM3 (Bagrdan) and especially VM5 (Ljubičevo), located in the lower stretch of the river, are examples of poor macroinvertebrate communities characteristic for such rivers (Paunović, 2007; Paunović et al., 2008, 2010). Performed cluster analysis confirmed their similarity. Communities at these sites were predominantly composed of collector/gatherer taxa, exhibiting high abundances (tubificids, *Limnodrilus* species, in particular *L. hoffmeisteri*). Knowing that *Limnodrilus* species are among the most common oligochaetes in polluted waters (Wolfram et al., 2010), this situation is in accordance with the results of water quality assessments (Marković et al., 2011; Kolarević et al., 2012).

Thus, considering overall diversity/taxa richness and relative abundance of taxa, the transitional character of this river is obvious, as the upper, more diverse stretch belongs to Ecoregion 5 (as a large Balkan river), and the lower part belongs to Ecoregion 11 (as a large lowland/Pannonian river). The Sørensen similarities and analyses of the diversity index (SWI; Mann–Whitney tests) confirm this transitional character and the current revision and delineation of Ecoregions 5 and 11 (Paunović; 2007; Paunović et al., 2012b).

Ordination analyses DCA and CCA revealed similar faunistic structures with overlapping of samples/taxa. However, it also indicates segregation of autumn samples and samples from localities VM3 and VM5 (defined by a greater share of oligochaetes and mollusks). The performed CCA clarifies noted segregation by linking it with environmental variables, in this case with decreases of water temperature, pH, and ammonia, and increases in organic nitrogen, orthophosphate, and total organic carbon concentrations. On first inspection, this result contradicts common sense and faunistic and taxonomic knowledge. It suggests that mayflies and caddisflies prefer warm water, while mollusks predominate in autumn. However, if we take into consideration that the majority of caddisfly taxa belong to the group Hydropsychida (genus *Hydropsyche*), which prevails on stone substrate in rivers and sites with increased organic contamination (Pliūraitė and Kesminas, 2004), this result is not so unexpected. The population dynamics of the Ephemeroptera group, with more juveniles present in summer, could explain the observed predominance of mayflies in the samples that were collected in summer. This conclusion is supported by the registered higher share of unidentified species. (a sp. taxa in *Baetis*, *Caenis*, *Heptagenia*, *Ephemerella* genera) in the samples collected in summer (ca. 30%), compared to the samples that were collected in autumn (ca. 10%).

We also would like to point out the presence of several relatively rare species (at least in Serbia), such as the dragonfly *Ophiogomphus cecilia* and the aquatic worm *Propappus volki* (Atanacković et al., 2011).

The finding of the rare neritid snail *Theodoxus transversalis* at localities VM2, VM3, and an especially dense population at VM4 is of special interest. Apart from our finding, *T. transversalis* has been reported from the Južna Morava and Nišava rivers (Simić et al., 2006; Novaković, 2012). Thus, we could assume that this river system represents one of its few remaining refugia, as the International Union for Conservation of Nature (IUCN) marked this taxon as endangered, with less than 20 subpopulations remaining and with a severe declining trend with regard to population number as well as population size (Solymos and Feher, 2011). According to the same source, as a stenobiont and fluvial taxon preferring hard substrate and well-oxygenated water, *T. transversalis* is especially vulnerable to habitat decline and to the spreading of competitive alien taxa (particularly *T. fluviatilis*). Therefore, it is imperative to continue regular monitoring of water/habitat quality as well as the spreading of invasive taxa. Moreover, the locality VM4, with its recorded abundant population of this endangered snail, should be preserved, as it could serve as a potential model for the species' restoration. This site, as the northernmost population of *T. transversalis* in the Velika Morava–Južna Morava–Nišava river system, is situated in the lower river stretch, and as such it is more exposed to all mentioned risks/pressures. However, the VM4 locality is characterized by high taxa richness, in the range of certain mountain streams, such as that reported in the Pčinja River (Simić and Simić, 2003) and the Temska and Visočica rivers (Živić et al, 2005), even with an abundant populations of some invasive taxa (bivalves *C. fluminea* and *S. woodiana*). Knowing that diverse microhabitats assume an important role in establishing diversity and structure of macroinvertebrate communities (Cogerino et al., 1995; Costa and Melo, 2008), conspicuous variety of microhabitats (mud, sand, gravel, and rock, as well as relatively preserved riparian vegetation) could be an explanation for the observed taxa richness at this site.

Abundant populations of another IUCN endangered species, *U. crassus* (Van Damme, 2011), at localities VM1, VM4, and especially VM2 were reported and discussed by Tomović et al. (2012).

Five alien taxa were established as important members of the community, confirming previous reports (Zorić et al., 2010, 2013). In light of the observed abundance and common presence of clams *C. fluminea* and *S. woodiana* at localities VM4 and particularly VM1, the term xenocommunities could be used, according to Arbačiauskas et al. (2008). Although these abundant populations have been previously reported (*S. woodiana*: Tomović et al., 2012; *C. fluminea*: Zorić et al., 2013), it should be underlined once more, particularly regarding *C. fluminea* as a recent invader (Vranković et al., 2010).

To conclude, the macroinvertebrate fauna of the Velika Morava River is diverse, despite intensive anthropogenic influence. Locality VM4, despite being in the lower river stretch, is characterized by particularly high taxa richness, presumably due to high microhabitat diversity. The dominance of insect taxa in regards to diversity, and oligochaetes in regards to relative abundance, along with the other tested parameters (Sørensen similarities, SWI), indicate the transitional character of this river. This confirms the current ecoregion delineation, with the lower part (locality VM5) belonging to Ecoregion 11 and the upper part to Ecoregion 5. The performed multivariate analyses (CLA, DCA, and CCA) revealed separation of summer (July) from autumn samples. In addition, grouping of localities VM3 (ER_5) and VM5 (ER_11) was noted. The water temperature and the pH value were found to be the most important factors of the 32 environmental variables analyzed. Of special importance are abundant populations of rare and endangered taxa, neritid snail *T. transversalis* and unionid mussel *U. crassus*, as well as populations of alien taxa in expansion, above all *C. fluminea* and *S. woodiana*. Further investigations should continue as part of the regular monitoring of large Serbian rivers, aimed at estimating anthropogenic influences and improving ecological status when possible.

Future research is expected to improve our knowledge of invasive and alien species (the dynamics of their spread, their ecology, etc.), and contribute toward endangered species conservation and restoration efforts. Finally, more comprehensive research is needed in order to better estimate the influence and importance of environmental variables for macroinvertebrate communities and freshwater ecosystems as a whole.

Acknowledgments
This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Projects TR 37009 and OI 173025. The authors would like to thank Dr Zoran Gačić and Dr Goran Poznanović for their help during preparation of the manuscript, and 2 anonymous referees for their valuable comments.

Appendix

Appendix – The list of identified taxa, with abbreviations.

Phylum NEMATODA
Phylum PLATYHELMINTHES
Class TURBELLARIA
Dugesia lugubris (Schmidt, 1861); abbr. -Dug lu
Phylum ANNELIDA
Class CLITELLATA
Subclass OLIGOCHAETA
Family Naididae
Nais sp.; abbr. – Nai sp.
Nais behningi Michaelsen, 1923; abbr. – Nai beh
Nais bretscheri Michaelsen, 1899; abbr. –Nai bre
Nais elinguis Müller, 1773; abbr. –Nai eli
Stylaria lacustris (Linnaeus, 1767); abbr. – Sty lac
Family Tubificidae
Branchiura sowerbyi Beddard, 1892; abbr. – Bra sow
Limnodrilus claparedianus Ratzel 1869; abbr. – Lim cla
Limnodrilus hoffmeisteri Claparede, 1862; abbr. – Lim hof
Limnodrilus udekemianus Claparede, 1862; abbr. – Lim ude
Potamothrix hammoniensis (Michaelsen, 1901); abbr. – Pot ham
Psammoryctides albicola (Michaelsen, 1901); abbr. – Psa alb
Tubifex tubifex (Muller 1774); abbr. –Tub tub
Family Propappidae
Propappus volki Michaelsen, 1916; abbr. – Pro vol
Family Lumbriculidae
Rhynchelmis limosella Hoffmeister, 1843; abbr. – Rhy lim
Stylodrilus heringianus Claparede, 1862; abbr. – Sty her
Subclass HIRUDINEA
Family Erpobdellidae
Erpobdella octoculata (Linnaeus, 1758); abbr. – Erp oct
Erpobdella lineata (Müller, 1774); abbr. – Erp lin
Family Glossiphoniidae
Glossiphonia complanata (Linnaeus, 1758); abbr. – Glo com
Helobdella stagnalis (Linnaeus, 1758); abbr. – Hel sta
Family Piscicolidae
Piscicola geometra (Linnaeus, 1758); abbr. – Pis geo
Phylum MOLLUSCA
Class GASTROPODA
Family Lymnaeidae
Radix sp; abbr. – Lym sp.
Radix auricularia (Linneaeus, 1758); abbr. – Lym aur
Family Bithyniidae
Bithynia tentaculata (Linnaeus, 1758); abbr. – Bit ten
Family Melanopsidae
Holandriana (Amphimelania) holandrii (C. Pfeiffer 1828); abbr. – Hol hol
Family Neritidae
Theodoxus transversalis (C. Pfeiffer, 1828); abbr. – The tra
Theodoxus danubialis (C. Pfeiffer, 1828); abbr. – The dan
Family Viviparidae
Viviparus sp.; abbr. – Viv sp.
Viviparus acerosus (Bourguignat, 1862); abbr. – Viv ace
Family Lithoglyphidae
Lithoglyphus naticoides (C. Pfeiffer 1828); abbr. – Lyt nat
Family Physidae
Physa acuta Draparnaud, 1805; abbr. – Phy acu
Physa fontinalis (Linnaeus, 1758); abbr. – Phy fon
Class BIVALVIA
Family Unionidae
Sinanodonta woodiana (Lea, 1834); abbr. – Sin woo
Unio crassus; abbr. – Uni sp.
Family Corbiculidae
Corbicula fluminea Müller, 1774; abbr. – Cor flu
Corbicula sp. juv.
Phylum ARTHROPODA
Subphylum CRUSTACEA
Order ISOPODA
Asellus aquaticus (Linnaeus, 1758); abbr. – Ase aqu
Order AMPHIPODA
Corophium curvispinum (Sars, 1895); abbr. – Cor cur
Gammarus sp.; abbr. – Gam sp.
Dikerogammarus villosus (Sowinsky, 1894); abbr. – Dik vil
Subphylum HEXAPODA
Class INSECTA
Order Odonata
Gomphus vulgatissimus (Linaeus, 1758); abbr. – Gom vul
Calopteryx splendens (Harris, 1782); abbr. – Cal spl
Platycnemis pennipes (Pallas, 1771); abbr. – Pla pen
Ophiogomphus cecilia (Fourcroy, 1785); abbr. – Oph cec
Onychogomphus forcipatus (Linnaeus, 1758); abbr. – Ony for
Order Ephemeroptera
Baetis rhodani (Pictet, 1843); abbr. – Bae rho
Baetis fuscatus (Linnaeus, 1761); abbr. – Bae fus
Baetis scambus Eaton, 1870; abbr. – Bae sca
Baetis sp.; abbr. – Bae sp.
Caenis sp.; abbr. – Cae sp.
Caenis horaria (Linnaeus, 1758); abbr. – Cae hor
Caenis luctuosa (Burmeister, 1839); abbr. – Cae luc
Caenis macrura Stephens, 1835; abbr. – Cae mac
Ephemerella ignita (Poda, 1761); abbr. – Eph ign
Ephemerella sp.; abbr. – Eph sp.
Heptagenia coerulans Rostock, 1878; abbr. – Hep coe
Kageronia fuscogrisea (Retzius, 1783); abbr. – Kag fus

Heptagenia sulphurea (Muller, 1776) ; abbr. – Hep sul
Heptagenia sp.; abbr. – Hep sp.
Oligonuriella rhenana (Imhoff, 1852); abbr. – Oli rhe
Potamanthus luteus (Linnaeus, 1767); abbr. – Pot lut
Order Hemiptera
Aphelocheirus aestivalis (Fabricius, 1794); abbr. – Aph aes
Order Trichoptera
Hydropsyche sp.; abbr. – Hyd sp.
Hydropsyche angustipennis (Curtis, 1834); abbr. – Hyd ang
Hydropsyche contubernalis McLachlan, 1865; abbr. – Hyd con
Hydropsyche incognita Pitsch, 1993; abbr. – Hyd inc
Hydropsyche pellucidula (Curtis, 1834); abbr. – Hyd pel
Hydropsyche exocellata Dufour, 1841; abbr. – Hyd exo
Mystacides sp.; abbr. – Mys sp.
Leptocerus sp.; abbr. – Le sp.
Order Diptera
Eloeophila sp.; abbr. – Elo sp.
Hexatoma sp.; abbr. – Hex sp.
Tipulidae; abbr. – Tip
Simulidae Gen. sp.; abbr. – Sim Gen
Ceratopogonidae; abbr. – Cer
Chironomidae; abbr. – Chi
Empididae; abbr. – Emp
Limoniidae Gen.sp.; abbr. – Lim Gen
Order Coleoptera
Family Elmidae
Elmis sp.; abbr. – Elm sp.
Limnius volckmari (Panzer, 1793); abbr. – Lim vol
Potamophilus acuminatus (Fabricius, 1792); abbr. – Pot acu
Class ARACHNIDA
Hydrachnidia

References

Arbačiauskas K, Semenchenko V, Grabowski M, Leuven RSEW, Paunović M, Son MO, Csányi B, Gumuliauskaitė S, Konopacka A, Nehring S et al. (2008). Assessment of biocontamination of benthic macroinvertebrate communities in European inland waterways. Aquatic Invasions 3: 211–230.

Atanacković A, Jakovčev-Todorović D, Simić V, Tubić B, Vasiljević B, Gačić Z, Paunović M (2011). Oligochaeta community of the main Serbian waterways. Water Research and Management 1: 47–54.

Bálint M, Ujvárosi L (2009). Distribution patterns of *Hydropsyche incognita* (Pitsch, 1993) and *H. pellucidula* (Curtis, 1834) in Transylvania (Romania), with special reference to their ecological requirements (Trichoptera: Hydropsychidae). Bulletin de la Société des Naturalists Luxembourgeois 110: 167–172.

Bertrand H (1954). Les insectes aquatiques d'Europe. Vol. I and II. Paris: P. Lechevalier.

Borza P, Csanyi B, Paunović M (2010). Corophiids (Amphipoda, Corophioidea) of the River Danube: the results of a longitudinal survey. Crustaceana 83: 839–849.

Botnariuc N (1953). Fauna Republici Populare Romane 4. Bucharest: Editura Academiei Republicii Populare Romane.

Brinkhurst RO, Jameieson BGM (1971). Aquatic Oligochaeta of the World. Edinburgh: Oliver and Boyd.

Czachorowski S, Serafin E (2004). The distribution and ecology of *Hydropsyche bulgaromanorum* and *Hydropsyche contubernalis* (Trichoptera: Hydropsychidae) in Poland and Belarus. Lauterbornia 50: 85–98.

Cogerino L, Cellot B, Bournaud M (1995). Microhabitat diversity and associated macroinvertebrates in aquatic banks of a large European river. Hydrobiologia 304: 103–115.

Costa SS, Melo AS (2008). Beta diversity in stream macroinvertebrate assemblages: among-site and among-microhabitat components. Hydrobiologia 598: 131–138.

Edington JM, Hildrew AG (1995). A revised key to the caseless caddis larvae of the British Isles with notes on their ecology. Scientific Publication No. 53. Ambleside, UK: Freshwater Biological Association.

Glöer P (2002). Susswassergastropoden Nord- und Mitteleuropas. Hockenheim: ConchBooks.

Hering D, Verdonschot PFM, Moog O, Sandin L (2004). Overview and application of the AQEM assessment system. Hydrobiologia: 516: 1–20.

Hill MO, Gauch JrHG (1980). Detrended correspondence analysis: an improved ordination technique. Vegetatio 42: 47–58.

Illies J (1978). Limnofauna Europaea, 2nd ed. Stuttgart, Germany: G. Fischer.

Janković MJ (1979). Communities of Chironomid larvae in the Velika Morava River. Hydrobiologia 64: 167–173.

Jost L (2006). Entropy and diversity. Oikos 113: 363–375.

Karadzić B, Saso-Jovanović V, Jovanović Z, Popović R (1998). "Flora": a database and software for floristic and vegetation analyzes. Progress in Botanical Research: 69–72.

Karadžić B (2013). FLORA: a software package for statistical analysis of ecological data. Water Research and Management 3: 45–54.

Kolarević S, Knežević-Vukčević J, Paunović M, Vasiljević B, Kračun M, Gačić Z, Vuković-Gačić B (2012). Seasonal variations of microbiological parameters of water quality of the Velika Morava River, Serbia. Arch Biol Sci 64: 1017–1027.

Lozek V (1956). Klic Ceskoslovenskych Mekkyšu. Bratislava: Vyda Vatelstvo Slovenskej Akademie Vied, sekcia biologickych a lekarskych vied (in Slovak).

Macan TT (1970). A Key to the Nymphs of the British Species of Ephemeroptera, with Notes to their Ecology. Scientific Publication No. 20. Ambleside, UK: Freshwater Biological Association.

Mann HB, Whitney DR (1947). On a test of whether one of two random variables is stochastically larger than the other. Annals of Mathematical Statistics 18: 50–60.

Mann KH (1964). A Key to the British Freshwater Leeches with Notes on Their Ecology. 2nd ed. Ambleside, UK: Freshwater Biological Association.

Marković V, Atanacković A, Tubić B, Vasiljević B, Simić V, Tomović J, Paunović M (2011). Indicative status assessment of the Velika Morava River based on aquatic macroinvertebrates. Water Research and Management 1: 47–53.

Marković V, Vasiljević B, Atanacković A, Tomović J, Zorić K, Tubić B, Paunović M (2012). Status Assessment of the Lim River based on Macroinvertebrate Communities. In: BALWOIS Conference 2012. Ohrid, Republic of Macedonia. Online at: http://www.balwois.com.

McCune B (1997). Influence of noisy environmental data on canonical correspondence analysis. Ecology 78: 2617–2623.

Mihailović V, Radić ZM (2006). Structure of Daily Hydrologic Series in Serbia and Northern Mediterranean. In: BALWOIS Conference 2006. Ohrid, FYR Macedonia. Online at: http://www.balwois.com.

Nilsson A (1996). Aquatic Insects of North Europe: A Taxonomic Handbook. Vol. 1: Ephemeroptera, Plecoptera, Heteroptera, Megaloptera, Neuroptera, Coleoptera, Trichoptera and Lepidoptera. Stenstrup, Denmark: Apollo Books.

Nilsson A (1997). Aquatic Insects of North Europe: A Taxonomic Handbook. Vol. 2: Odonata – Diptera. Stenstrup, Denmark: Apollo Books.

Novaković B (2012). Indicative ecological status assessment of the Južna Morava River based on aquatic macroinvertebrates. Water Research and Management 2: 45–50.

Novaković B (2013). Indicative ecological status assessment of the Zapadna Morava River based on aquatic macroinvertebrate community. Water Research and Management 3: 37–43.

Noy-Meir I (1973). Divisive polythetic classification of vegetation data by optimized division on ordination components. The Journal of Ecology 753–760.

Panov VE, Alexandrov B, Arbačiauskas K, Binimelis R, Copp GH, Grabowski M, Leuven R, Nehring S, Paunović M, Semenchenko V (2009). Assessing the risks of aquatic species invasions via European inland waterways: from concepts to environmental indicators. Integrated Environmental Assessment and Management 5: 110–126.

Paunović M, Miljanović B, Simić V, Cakić P, Djikanović V, Jakovcev-Todorović D, Stojanović B, Veljković A (2005). Distribution of non-indigenous tubificid worm *Branchiura sowerbyi* (Beddard, 1892) in Serbia. Biotechnology and Biotechnological Equipment 19: 91–97.

Paunović M, Csányi B, Simić V, Stojanović B, Cakić P (2006). Distribution of *Anodonta* (*Sinanodonta*) *woodiana* (Rea, 1834) in inland waters of Serbia. Aquatic Invasions 1: 154–160.

Paunović M (2007). Composition of macro-invertebrate communities as indicator of running waters types in Serbia. PhD thesis, Faculty of Biology, University of Belgrade, Belgrade, Serbia.

Paunović M, Csányi B, Knežević S, Simić V, Nenadić D, Jakovčev-Todorović D, Stojanović B, Cakić P (2007a). Distribution of Asian clams *Corbicula fluminea* (Müller, 1774) and *C. fluminalis* (Müller, 1774) in Serbia. Aquatic Invasions 2: 105–112.

Paunovic MM, Jakovcev-Todorovic DG, Simic VM, Stojanovic BD, Cakic PD (2007b). Macroinvertebrates along the Serbian section of the Danube River (stream km 1429–925). Biologia 62: 214–221.

Paunović MM, Borković SS, Pavlović SZ, Saičić ZS, and Cakić PD (2008). Results of the 2006 Sava survey: aquatic macroinvertebrates. Arch Biol Sci 60: 265–271.

Paunović M, Csányi B, Simić V, Đikanović V, Petrović A, Miljanović B, Atanacković A (2010). Community structure of the aquatic macroinvertebrates of the Danube River and its main tributaries in Serbia. In: Paunović M, Simonović P, Simić V, Simić S, editors. Danube in Serbia – Joint Danube Survey 2. Belgrade: Ministry of Agriculture, Forestry and Water Management – Directorate for Water, University of Kragujevac, Faculty of Science, Institute for Biology and Ecology, University of Belgrade, Institute for Biological Research "Siniša Stanković", pp. 183–206.

Paunović M, Tomović J, Kovačević S, Zorić K, Žganec K, Simić V, Atanackovic A, Markovic V, Kracun M, Hudina S et al. (2012a). Macroinvertebrates of the Natural Substrate of the Sava River–Preliminary Results. Water Research and Management 2: 33–39.

Paunović M, Tubić B, Kračun M, Marković V, Simić V, Zorić K, Atanacković A (2012b). Ecoregions delineation for the territory of Serbia. Water Research and Management 2: 65–74.

Pielou EC (1984). The Interpretation of Ecological Data: a Primer on Classification and Ordination. New York: Wiley Interscience.

Pliūraitė V, Kesminas V (2004). Species composition of macroinvertebrates in medium-sized Lithuanian rivers. Acta Zoologica Lituanica 14: 10–25.

Shannon CE (1949). Communication theory of secrecy systems. Bell System Technical Journal 28: 656–715.

Simić V (1996). Possibilities of ecological monitoring of river systems in Serbia based on macrozoobenthos communities. PhD, Faculty of Biology, University of Belgrade, Belgrade, Serbia.

Simić VM, Simić SB (2003). Macroalgae and macrozoobenthos of the Pčinja River. Arch Biol Sci 55: 121–131.

Simić V, Simić S, Petrović A, Paunović M, Šorić V. Dimitrijević V (2006). Biodiversity in aquatic ecosystems in Serbia, ex situ conservation (BAES ex situ; http://baes.pmf.kg.ac.rs).

Simpson EH (1949). Measurement of diversity. Nature 163: 688.

Solymos P, Feher Z (2011). *Theodoxus transversalis*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2.

Sørensen T (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Biol skr 5: 1–34.

Ter Braak CJF (1986). Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology 67: 1167–1179.

Ter Braak CJF (1990). Interpreting canonical correlation analysis through biplots of structural correlations and weights. Psychometrika 55: 519–531.

Ter Braak CJF, Verdonschot PF (1995). Canonical correspondence analysis and related multivariate methods in aquatic ecology. Aquatic Sciences 57: 255–289.

Timm T (2009). A guide to the freshwater Oligochaeta and Polychaeta of Northern and Central Europe. Lauterbornia 66: 1–235.

Tischler W (1948). Biozönotische Untersuchungen an Wallhecken. Zool Jb Syst 77: 283–400.

Tomović J, Zorić K, Kračun M, Marković V, Vasiljević B, Simić V, Paunović M (2012). Freshwater mussels of the Velika Morava River. Water Research and Management 2: 51–55.

Tubić B, Zorić K, Vasiljević B, Tomović J, Atanacković A, Marković V, Paunović M (2012). Saprobiological analyze of the Ibar River based on aquatic macroinvertebrates. BALWOIS Conference 2012. Ohrid, Republic of Macedonia. Online at: http://www.balwois.com.

Tubić BP, Simić VM, Zorić KS, Gačić ZM, Atanacković AD, Csányi BJ, Paunović, MM (2013). Stream section types of the Danube River in Serbia according to the distribution of macroinvertebrates. Biologia 68: 294–302.

Van Damme D (2011). *Unio crassus*. In: IUCN 2013. In IUCN Red List of Threatened Species. Version 2013.2.

Vranković J, Zorić K, Đikanović V, Simić V, Paunović M (2010). Rasprostranjenost alohtonih vrsta školjki roda Corbicula sa nalazima na novim lokalitetima u Srbiji. „Zaštita voda 2010", Zbornik radova, pp. 59–62, Divcibare (article in Serbian with an abstract in English).

Wallace ID, Wallace B, Philipson GN (1990). A key to the case-bearing caddis larvae of Britain and Ireland. Scientific Publication No. 51. Ambleside, UK: Freshwater Biological Association.

Waringer J, Graf W (1997). Atlas der österreichischen Köcherfliegenlarven: unter Einschluss der angrenzenden Gebiete. Wien: Facultas-Univ.-Verlag.

Wolfram G, Orendt C, Höss S, Großschartner M, Adamek Z, Jurajda P, Traunspurger W, De Deckere E, van Liefferinge C (2010). The macroinvertebrate and nematode community from soft sediments in impounded sections of the river Elbe near Pardubice, Czech Republic. Lauterbornia 69: 87–105.

Zorić K, Vranković J, Cakić P, Tomović J,Vasiljević B, Simić V, Paunović M (2010). Chapter 15 Introduced species of aquatic macroinvertebrates. In: Paunović M, Simonović P, Simić V, and Simić S, editors. Danube in Serbia – Joint Danube survey 2. Belgrade: Ministry of Agriculture, Forestry and Water Management – Directorate for Water, University of Kragujevac, Faculty of Science, Institute for Biology and Ecology, University of Belgrade, Institute for Biological Research Siniša Stankovic", pp. 267–280.

Zorić K, Marković V, Vasiljević B, Tomović J, Atanacković A, Ilić M, Kračun M, Paunović M (2013). Alien macroinvertebrate species of the Velika Morava River. „EcoIst '13", Conference Proceedings, Bor, pp. 43–47.

Živić I, Marković Z, Brajković M (2003). The diversity of Trichoptera larvae in the Južna Morava River basın. Arch Bioi Sci Belgrade 55: 33–34.

Živić I, Marković Z, Ilić J (2005). Composition, structure and seasonal dynamics of macrozoobenthos in the Temska and Visočica rivers (Serbia). Arch Biol Sci 57: 107–118.