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Original scientific paper

ICHTHYOFAUNA OF LOWER PART OF THE VRBANJA RIVER (THE REPUBLIC OF SRPSKA, B&H)

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Summary

The diversity of freshwater ichthyofauna of Bosnia and Herzegovina (B&H) covers about 117 fish species/subspecies and makes up about 20% of European freshwater ichthyofauna. The Vrbanja River Basin is located in the central part of B&H and is one of the indigenous basins in the Republic of Srpska. The Vrbanja River is one of the largest right tributaries of the Vrbas River, with the lower part of the stream stretching for about 28 km. Ichthyological research of the lower part of the Vrbanja River was conducted during 2013, at three locations, and the sampling was performed with an electric fishing device ELT 62 II GI, 3 kW. The qualitative and quantitative compositions of ichthyofauna as well as some diversity indices (Simpson index, Shannon-Weaver index, Dominance index and Sørensen similarity index) were determined. The lower stream of the Vrbanja River is inhabited by 10 fish species belonging to three families (Cyprinidae, Cobitidae and Percidae). Family Cyprinidae is typified by the largest species diversity. The species dominant in terms of number of individuals and biomass were *Barbus balcanicus* and *Squalius cephalus,* which differ greatly from the ichthyofauna that inhabited the same area in the mid-20th century. This composition of ichthyofauna of the lower part of the Vrbanja River is related to the environmental factors and impact of certain human activities.

Key words: ichthyofauna, diversity, cyprinids, Vrbanja River

INTRODUCTION

The diversity of freshwater fish in Bosnia and Herzegovina is estimated at 117 (sub) species from 26 families (Sofradžija, 2009), and ichthyofauna in BiH represents about 20% of European freshwater ichthyofauna (Kottelat and Freyhof, 2007). The Vrbanja River Basin is located in the central part of BiH and is one of the indigenous basins in the Republic of Srpska (99.68% of the basin is located in the territory of the Republic of Srpska). The Vrbanja River is one of the largest right tributaries of the Vrbas River. It springs on the slopes of the Vlašić

Mountain at 1580 m altitude, and flows into the Vrbas River at 147 m altitude, in Banja Luka. The catchment area covers 791.33 km^2, and the length of the main stream is about 96 km (Dokić, 2009). The Vrbanja River system has a total of 396 permanent and 2174 occasional tributaries, which clearly indicates the complexity of the given river system. The lower part of the Vrbanja River stretches from the settlement of Pobrđe to the river mouth of the Vrbanja to the Vrbas River, with the length of about 28 km (Rajčević and Crnogorac, 2011).

The oldest available data on the research of the ichthyofauna of the lower part of the Vrbanja River date back to about 50 years ago, and the research was conducted for sport fishing and scientific research purposes. The aim of this paper was to provide new data on the ichthyofauna of this part of the Vrbanja River, to consider possible changes in diversity and to relate them to changes in habitat quality in the context of present anthropogenic activities.

MATERIALS AND METHODS

Ichthyofauna field research of the lower part of the Vrbanja River was conducted in the autumn of 2013. Sampling was performed at three locations: the first location (L1) Zeleni Vir - 10 km away from the river mouth, the second location (L2) Most in the settlement of Vrbanja - 5 km away from the river mouth and the third location (L3) at the river mouth of the Vrbanja River into the Vrbas River (Figure 1).

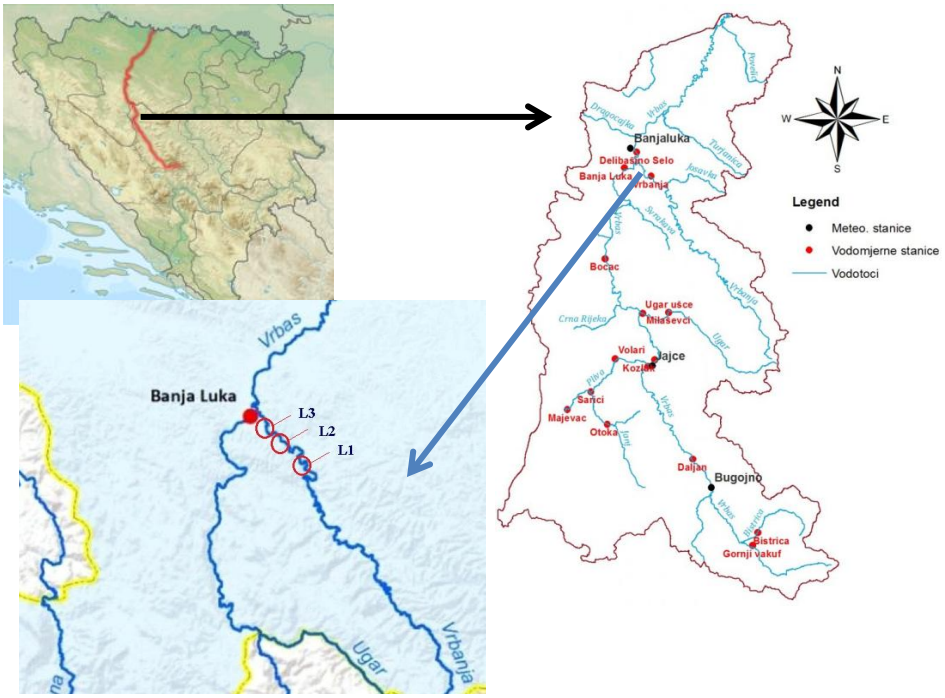

Figure 1. Position of investigated locations on the Vrbanja River
(File 2018; 2020; Topalović *et al.*, 2018; modified)

Ichthyofauna were sampled with an electric generator for fish sampling (ELT 62 II GI, 3 kW), with the permission of the Ministry of Agriculture, Forestry and Water Management of the Republic of Srpska (Decision No. 12-03.2-10175/13). After the sampling, the fish species (Kottelat and Freyhof, 2007, Sofradžija, 2009, Ćaleta *et al.*, 2019) and the qualitative and

quantitative composition of ichthyofauna were determined. Also, in order to analyze the qualitative and quantitative structure of fish communities in the studied area and assess their diversity, certain diversity indices (Simpson's diversity index and Shannon-Weaver diversity index), dominance indices and the Sørensen similarity index were calculated. The Simpson diversity index (D) was calculated according to the formula: $1\text{-}D = 1\text{-}\Sigma\ p_i^2$, where p_i = the number of individuals of the *i*-th species in the total community size (Simpson, 1949). The Shannon-Weaver diversity index (H) was calculated according to the formula: $H = -\ \Sigma\ p_i \ln p_i$, where p_i = the number of individuals of the *i*-th species in the total community size (Shannon and Weaver, 1949). The dominance index (D) was calculated by using the following formula: $D = n_a / n \times 100\%$, where n_a is the number of individuals of some species and *n* is the total number of individuals in the sample (Durbešić, 1988). The values of the dominance index were distributed in five categories (Šorić, 1996): eudominant >20%, dominant 10-20%, subdominant 4-10%, recedent 1-3% and subrecedent species <1%. In order to compare the similarity of fish community composition between the studied locations, the Sørensen similarity index was used according to the formula: $Is = 2c / a + b \times 100$, where c = number of common species, a = total number of species present in the first sample and b = total number of species present in the second sample (Sørensen, 1948).

RESULTS AND DISCUSSION

Qualitative and quantitative composition of ichthyofauna

The field research of the fish community conducted at three locations at the lower part of the Vrbanja River in 2013 resulted in the identification of 10 fish species from 3 families. Representatives of the family Cyprinidae were most numerous with a total of eight species, while the families Cobitidae and Percidae were represented with one species each[4]. Eight species of fish (exclusively members of the family Cyprinidae) were found at the location L1 (Zeleni vir) and L2 (bridge), while nine species of fish from the families Cyprinidae, Cobitidae and Percidae were registered at the location L3 (river mouth) (Table 1).

[4] According to recent literature data (Ćaleta *et al*., 2019; Schönhuth *et al*., 2018), *Rhodeus sericeus* belongs to the family Acheilognathidae, *Gobio obtusirostris* to the family Gobionidae, while the *Alburnoides bipunctatus*, *Alburnus alburnus*, *Chondrostoma nasus* and *Squalius cephalus* to the family Leuciscidae. In this paper, data on the taxonomic status of the ichthyofauna of the lower part of the Vrbanja River are given according to Kottelat and Freyhof (2007).

Table 1. Qualitative and quantitative composition of ichthyofauna from lower part of the Vrbanja River

		L1 – Zeleni Vir				L2 – bridge				L3 – river mouth			
Latin name	**Family**	**No ind.**	**%**	**Mass (g)**	**%**	**No ind.**	**%**	**Mass (g)**	**%**	**No ind.**	**%**	**Mass (g)**	**%**
Cobitis elongatoides	Cobitidae									27	24.77	216	5.19
Rhodeus sericeus	Cyprinidae	5	3.36	6	0.17	3	1.01	3	0.05	1	0.92	7	0.17
Barbus balcanicus	Cyprinidae	44	29.53	964	26.73	41	13.85	442	6.81	42	38.53	885	21.27
Barbus barbus	Cyprinidae	3	2.01	224	6.21	3	1.01	165	2.54	6	5.50	73	1.75
Gobio obtusirostris	Cyprinidae	9	6.04	73	2.02	4	1.35	13	0.20	9	8.26	135	3.25
Alburnoides bipunctatus	Cyprinidae	19	12.75	113	3.13	103	34.80	737	11.35	4	3.67	21	0.50
Alburnus alburnus	Cyprinidae	36	24.16	221	6.13	83	28.04	710	10.94	3	2.75	10	0.24
Chondrostoma nasus	Cyprinidae	6	4.03	1220	33.82	19	6.42	2121	32.67				
Squalius cephalus	Cyprinidae	27	18.12	786	21.79	40	13.51	2301	35.44	16	14.68	2795	67.19
Perca fluviatilis	Percidae									1	0.92	18	0.43
TOTAL		149	100	3607	100	296	100	6492	100	109	100	4160	100

Diversity indices

When determining the diversity indices (Simpson Diversity Index and Shannon-Weaver diversity Index), the highest values were found for the location L1 (Zeleni vir) (Table 2).

Table 2. Indices of diversity at investigated locations from lower part of the Vrbanja River

Locations	No.Species	Simpson Diversity Index(D)	Shannon-Weaver diversity Index (H)
L1 (Zeleni Vir)	8	0.80	1.76
L2 (bridge)	8	0.76	1.59
L3 (river mouth)	9	0.76	1.67

Given that the values of the Shannon-Weaver diversity index in nature usually range from 1.5 to 3.5, the situation regarding the richness of fish species in the lower part of the Vrbanja River is at a relatively acceptable level. As for the Simpson index, it varies from 0 to 1 and the higher its value, the greater the diversity of the sample. Bearing in mind this diversity index, the diversity of the ichthyofauna of the lower part of the Vrbanja River is at an agreeable level.

Dominance index

After determining the dominance index at the Zeleni vir location, it was established that there were eudominant species (*Barbus balcanicus* and *Alburnus alburnus)*, recedent species (*Barbus barbus*), and no subrecendent species. At the second location (bridge), the eudominant species were *Alburnoides bipunctatus* and *Alburnus alburnus*, there were no subrecedent species, and the recedent species were *Barbus barbus*, *Gobio obtusirostris* and *Rhodeus sericeus*. The third location (river mouth) is characterized by two eudominant species (*Barbus balcanicus* and *Cobitis elongatoides*), while the subrecedent species were *Perca fluviatilis* and *Rhodeus sericeus* (Table 3).

Table 3. Dominance index of investigated locations of lower part of the Vrbanja River

Species	L1 (Zeleni vir) (%)	L2 (bridge) (%)	L3 (river mouth) (%)
Cobitis elongatoides			24.77
Rhodeus sericeus	3.36	1.01	0.92
Barbus balcanicus	29.53	13.84	38.53
Barbus barbus	2.01	1.01	5.50
Gobio obtusirostris	6.04	1.35	8.26
Alburnoides bipunctatus	12.75	34.70	3.67
Alburnus alburnus	24.16	28.40	2.75
Chondrostoma nasus	4.03	6.42	
Squalius cephalus	18.12	13.51	14.68
Perca fluviatilis			0.92

Sørensen similarity Index

Comparing the ichthyocenoses of the investigated locations of the lower part of the Vrbanja River, a high share of common species was found, with the Sørensen similarity index ranging from 82.40 to 100%. The degree of similarity between locations 1 and 2 was 100%, while the degree of similarity between locations 1 and 3, and 2 and 3 was 82.40%.

The oldest available data on the qualitative and quantitative composition of the ichthyofauna of the Vrbanja River date back from 1968. On that occasion, dealing primarily with the analysis of feeding of the fish from the Vrbanja River, Šenk and Mahmutović (1968) also provided data on the composition of fish in the lower part of the river (from Kotor Varoš to the river mouth of the Vrbanja and Vrbas) where the most numerous species were *Squalius cephalus*, *Barbus barbus* and *Rutilus pigus*.

Based on the data from the Fisheries Management Basis from 1975 for the lower part of the Vrbanja River (Vrbanja from the border of the Municipality of Čelinac to the river mouth with the Vrbas) (Biološki Institut Univerziteta Sarajevo, 1975) the presence of 16 fish species from three families was recorded. The family Cyprinidae had most representatives (13 species), two species were represented by the family Salmonidae, while the family Percidae was represented by one species. *Chondrostoma nasus* and *Squalius cephalus* also dominated with the number of individuals and biomass.

Analyzing the data from the Fisheries Management Basis for 1985 (Biološki Institut Univerziteta Sarajevo, 1985), it was determined that the lower part of the Vrbanja River in the municipality of Banja Luka was inhabited by 14 species of fish, where 12 of them were from the family Cyprinidae and two from the Salmonidae family. On that occasion, the same species (*Chondrostoma nasus* and *Squalius cephalus*) were most numerous in number and mass.

During the research of the ichthyofauna of the lower part of the Vrbanja River (from the border of the municipality of Čelinac to the river mouth of the Vrbas) conducted in the period from 1994 to 1996 (Radević, 2000), the presence of 16 species of fish from three families (Salmonidae, Cyprinidae and Cottidae) was found. The most numerous species were *Chondrostoma nasus*, *Squalius cephalus* and *Rutilus pigus*, and they also dominated with biomass.

According to the results of ichthyological research at two locations of the lower part of the Vrbanja River (Česma and Zeleni Vir) conducted in 2010 (Golub *et al*., 2012), Vrbanja was, as in earlier research, mainly a cyprinid river. On that occasion, nine species of fish from two families (Cyprinidae and Cobitidae) were identified. Observing the individual presence, the most numerous species were *Squalius cephalus* and *Alburnoides bipunctatus*, while *Squalius cephalus* and *Chondrostoma nasus* were dominant by biomass (Table 4).

Table 4. Qualitative and quantitative composition of fish of the lower part of Vrbanja River (since 1975 to 2013)

		1975		1985		1994 -1996		2010		2013	
Species	**Family**[5]	**No ind. (%)**	**Mass (%)**	**No ind. (%)**	**Mass (%)**	**No ind. (%)**	**Mass (%)**	**No ind. (%)**	**Mass (%)**	**No ind. (%)**	**Mass (%)**
Cobitis elongatoides	Cobitidae							2.14	2.24	4.87	1.51
Rhodeus sericeus	Cyprinidae							7.86	2.42	2.42	0.11
Barbus balcanicus	Cyprinidae	+		6.90	1.99	7.61	7.52	2.14	6.73	22.92	16.07
Barbus barbus	Cyprinidae	11.39	11.98	13.89	15.99	10.87	9.68			2.17	3.24
Cyprinus carpio	Cyprinidae	3.81	4.01	0.88	1.01	2.17	2.29				
Gobio obtusirostris	Cyprinidae	+		+		2.17	1.78	11.43	6.64	3.97	1.55
Romanogobio kesslerii	Cyprinidae							1.43	0.35		
Abramis brama	Cyprinidae	4.29	3.01	1.32	1.01	4.35	4,20				
Alburnoides bipunctatus	Cyprinidae	+		+		2.17	1.66	31.43	16.22	22.75	6.11
Alburnus alburnus	Cyprinidae	+		+		1.09	0.89			22.02	6.60
Chondrostoma nasus	Cyprinidae	29.97	28.01	31.27	30.00	15.22	14.65	3.57	28.04	4.51	23.43
Leuciscus idus	Cyprinidae	3.22	3.01	2.07	1.99	5.43	4.74				
Phoxinus phoxinus	Cyprinidae	+				1.09	1.02	0.71	0.26		
Rutilus virgo	Cyprinidae	19.01	15.98	16.67	15.99	11.96	12.99				
Squalius cephalus	Cyprinidae	23.54	21.99	25.02	24.01	13.04	13.04	39.29	37.10	14.99	41.25
Vimba vimba	Cyprinidae	2.86	2.00	0.94	1.01	5.43	5.22				
Hucho hucho	Salmonidae	0.95	2.00	0.34	1.99	6.52	9,30				
Thymallus thymallus	Salmonidae	0.95	1.00	0.70	1.01	8.70	9.73				
Cottus gobio	Cottidae					2.17	1.27				
Perca fluviatilis	Percidae									0.18	0.13
Zingel sp.	Percidae	+									
Other species	6										

[5] According to recent literature data (Ćaleta *et al*., 2019; Schönhuth *et al*., 2018), *Rhodeus sericeus* belongs to the family Acheilognathidae, *Gobio obtusirostris* and *Romanogobio kesslerii* to the family Gobionidae, while the *Abramis brama*, *Alburnoides bipunctatus*, *Alburnus alburnus*, *Chondrostoma nasus*, *Leuciscus idus*, *Phoxinus phoxinus*, *Rutilus virgo*, *Squalius cephalus* and *Vimba vimba* belongs to the family Leuciscidae. In this paper, data on the taxonomic status of the ichthyofauna of the lower part of the Vrbanja River are given according to Kottelat and Freyhof (2007).

It was found that the qualitative composition of the fish community had been changed over the years showing a declining trend in the number of species. The research from 1968 (Šenk and Mahmutović) mentioned only three fish species, selected for the analysis of nutrition, so it was concluded that there were certainly more species found, but that they were not the subject of interest of the given research. During the research from 1975 (Biološki Institut Univerziteta Sarajevo, 1975), 16 fish species were recorded, and in 1985 (Biološki Institut Univerziteta Sarajevo, 1985) 14 species. From 1994 to 1996 (Radević, 2000), 17 species of fish were identified, and in 2010 (Golub *et al.*, 2012) that number was evidently lower, when only 9 identified species. During our research, which was conducted in 2013, 10 species of fish were found (Figure 2).

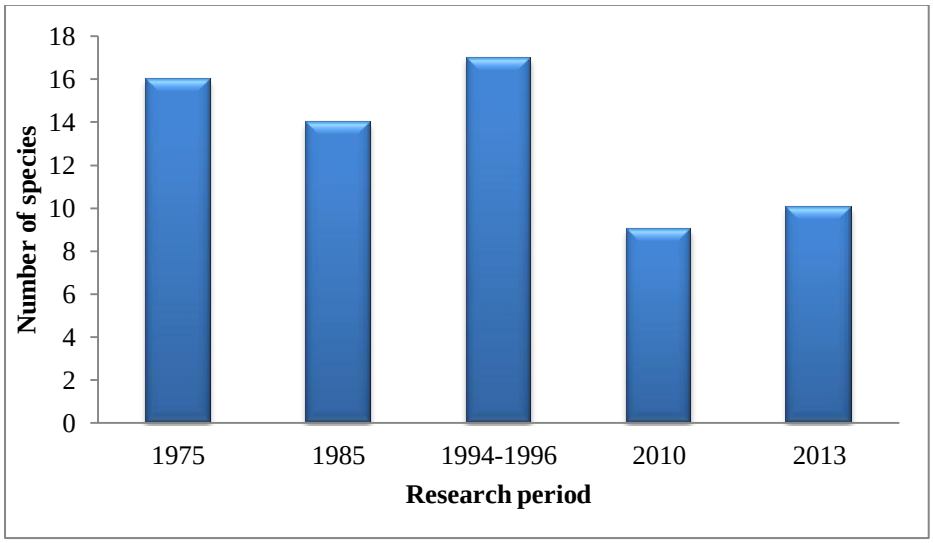

Figure 2. Number of fish species in the lower part of the Vrbanja River in the period from 1975 to 2013.

It is noticeable that during 2010 and 2013, no salmonid fish species were found (in previous research, this part of the Vrbanja River was inhabited by *Hucho hucho* and *Thymallus thymallus*). Cyprinid species, like *Barbus barbus*, *Cyprinus carpio*, *Abramis brama*, *Leuciscus idus*, *Rutilus virgo* and *Vimba vimba* were not recorded. *Cottus gobio* (Cobitidae) and *Zingel* sp. (Percidae) were also not identified.

Salmonid fish species are considered to be the most endangered ichthyological group today. Cyprinids of the mesosaprobic zone appear in their place, and the reason for this negative phenomenon is the changed environmental conditions such as increased water temperature and concentration of organic matter, decreased oxygen concentration, etc. (Grginčević and Pujin, 1998; Radević, 2000). On the other hand, it is known that these salmonid species, as well as most cyprinid species that have not been found in recent research, are a very desirable catch for fishermen, so the pressure on them is very pronounced, especially considering poaching and usage of prohibited fishing gear.

Rhodeus sericeus and *Cobitis elongatoides* appear as species that were found for the first time in 2010, and then in 2013, while *Perca fluviatilis* was caught in 2013 for the first time. Their presence indicates water of β and β-α mesosaprobic status, i.e. water that is

moderately to severely polluted (Grginčević and Pujin, 1998), which coincides with the reasons for the absence of salmonid species.

Considering the quantitative representation of individual fish species during the analyzed period, considerable variations were found, especially in terms of individual presence. Species such *Barbus barbus* and *Rutilus virgo*, which were characterized by significant numerical and mass presence during 1975 and 1985, were not caught at all (*Rutilus virgo*) or their numerical and mass presence was very small (*Barbus barbus*) in recent research (2010 and 2013). On the other hand, *Barbus balcanicus*, *Alburnoides bipunctatus* and *Alburnus alburnus*, which had a noticeable share either in terms of number of individuals or mass during recent research (2010 and 2013), were registered either only as recorded (*Alburnoides bipunctatus* and *Alburnus alburnus*) or their participation in the total sample was very small (*Barbus balcanicus*) during 1975 and 1985.

Analyzing species such as *Chondrostoma nasus* and *Squalius cephalus* whose presence was noted during the entire observed period, from 1975 to 2013, the following was observed. During 1975 and 1985, *Chondrostoma nasus* was presented both numerically and by mass with about 30%, while recent research shows that its numerical presence has decreased, but not by mass, which indicates that the sample is dominated by larger and older individuals. When it comes to *Squalius cephalus*, during 1975 and 1985, the numerical and mass presence of this species in the total sample ranged from 21% to 25%, during the period 1994-1996. These values decreased to about 13%, while in 2010 they rise to about 40%. In 2013, it was evident that the numerical representation decreased (to about 15% in relation to the total sample), while the mass increased to about 40% (the sample is dominated by larger or older fishes).

Difficulties observed when comparing data on both qualitative and quantitative composition of fish in the lower part of the Vrbanja River are related to several factors, among which is the lack of data on the methods used in various studies. For the years of 1975 and 1985 and the period 1994-1996 there is no data at all on the type of fishing gear, the length of the part of the watercourse on which the sampling was performed, the period of the year in which the sampling was performed, etc. On the other hand, the purposes of the research were also different; ichthyological research conducted in 1975 and 1985 aimed to analyze the abundance and mass of primarily those fish species that were attractive to sport and commercial fishermen, while other species were only mentioned as present, without data on abundance, and in some cases lists of species were not even complete.

Analyzing the degree of anthropogenic impact on the Vrbanja River, which results in changes in the qualitative and quantitative composition of fish, several problems were observed.

Bearing in mind the activities that lead to a degradation of habitat quality, we should point out that the construction of 18 small hydropower plants is planned on the Vrbanja River (15 with powerhouse outside the dam type: Divič, Kruševo, Stopan, Koritine, Jurići, Orahovo, Obodnik, Vrbanjci, Kotor Varoš I, Šibovi, Gradina, Rudine, Vrbanja I, Vrbanja II, Vrbanja III, and three with powerhouse inside the dam type: Šiprage, Grabovica and Čelinac I), two of which have already been realized (Kruševo brdo and Divič). In this regard, by cutting the Vrbanja watercourse, the water regime will be significantly changed (Tošić *et al.*, 2010). The

existing power plants already operate at minimum capacity, and due to the lack of water they do not operate for several months a year.

Regarding the monitoring of water quality in the Republic of Srpska since 2007, in accordance with the Water Framework Directive, surface water monitoring has been carried out through national and international surveillance as well as operational monitoring. The Vrbanja River, with one location (the rivermouth of the Vrbanja and Vrbas), is part of this monitoring system. The results of water analysis indicate that most of the examined parameters meet the criteria of class II water quality, while deviations, in most cases, were observed in terms of concentrations of suspended solids, total phosphorus, oxygen saturation and total alkalinity in relation to which the water quality ranged from III to IV classes (Cvijić, 2016). In this regard, it is clear that the problem of the arrival of pollutants exists, probably with untreated communal and agricultural wastewaters.

Also, one of the main pressures on the diversity of ichthyofauna is the excessive and illegal fishing with the use of illegal device gears. According to the data collected from the local population, the fish protection service was widely present and due to the constant controls and harsh penalties this problem is now decreasing.

CONCLUSION

Ichthyofauna research of the lower part of the Vrbanja River registered the presence of 10 fish species from 3 families. Representatives of the family Cyprinidae with 8 species had a dominant place, while the families Percidae and Cobitidae were represented with one species each. The species that dominated with both the number of individuals and the biomass were *Barbus balcanicus* (22.92% of individual and 16.07% of mass participation) and *Squalius cephalus* (22.74% of individual and 41.25% of mass participation).

The values of the Shannon-Weaver diversity index in relation to the investigated locations ranged from 1.59 to 1.76, while the values of the Simpson index varied from 0.76 to 0.80 (also depending on the location), on the basis of which it can be concluded that the condition in terms of species richness is at a relatively satisfactory level. The Sørensen similarity index ranged from 82.40% to 100.00%, which indicated a great similarity between the examined locations in relation to the observed species.

Observing the changes in the composition and number of fish species in the lower part of the Vrbanja River in the period from 1975 to 2013, it was found that the diversity of ichthyofauna had a declining trend. The absence of all salmonid fish species was observed, as well as a certain number of cyprinid species, on the basis of which it can be concluded that living conditions had changed.

Analyzing the number of individuals of the identified fish species, we may suggest that by 2010 the most dominant species were *Chondrostoma nasus*, *Squalius cephalus*, *Barbus barbus* and *Rutilus virgo*, in 2010 there were *Squalius cephalus*, *Alburnoides bipunctatus* and *Gobio obtusirostris*, and in 2013 the most numerous were *Alburnoides bipunctatus*, *Alburnus alburnus*, *Barbus balcanicus* and *Squalius cephalus*. The mass part of certain species during different periods of research showed a more uniform state, ie *Squalius cephalus* and *Chondrostoma nasus* were constantly the most represented ones.

All these changes are related to the impaired living conditions, where water pollution, together with the disturbed water regime due to the impact of small hydropower plants, stand out as essential.

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