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ASSEMENT OF THE ECOLOGICAL STATUS OF THE CRNA RIVER BASED ON THE FISH FAUNA – CONTRIBUTION TO THE ESTABLISHEMENT OF THE MONITORING SYSTEM OF RIVERS IN R. MACEDONIA

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The purpose of this study is to assess the longitudinal variation of species composition and the community structure of ichthyofauna from the Crna River, as well as the assessment of the ecological status of the river based on the fish fauna. The investigation is made on 12 sampling points on the river during August, September and October 2006 including the reservoir Tikveš. Twenty nine species belonging to 9 families have been recorded. Among them 21 are autochthonous (native) species and 8 are allochthonous ones. The structure of fish community is evaluated by using structural indices of species richness – d, diversity H', homogeneity – J(e) and similarity (S). Reduction of fish diversity could be noticed along the river course. It seems that changes in the habitat condition mainly associated with human activities are the main factors which alter the structure of fish community. EFI values indicate a healthy, natural or nearly natural water ecosystem or good ecological status along the river course from the source region to the sampling point T_3. After the inflow of the River Blato, at the profile "Trojkrsti" (T_4), the ecological status deteriorates. The remaining downstream parts of the river has a moderate ecological status, except the profile below the town of Bitola, which according to the EFI has a bad ecological status. Below the "Skočivir" profile, the water quality improves toward moderate status. The use of selected parameters of the community is found to be the effective basis for further development of the system of the ecological status assessment based on the fish fauna.

Keywords: fish community structure; structural indicies; EFI; Crna River; Rpublic of Macedonia

ПРОЦЕНА НА ЕКОЛОШКИОТ СТАТУС НА ЦРНА РЕКА ВРЗ ОСНОВА НА РИБНАТА ФАУНА – ПРИДОНЕС ВО ВОСПОСТАВУВАЊЕТО НА МОНИТОРИНГ СИСТЕМ НА РЕКИТЕ ВО Р. МАКЕДОНИЈА

Целта на оваа студија беше да се изврши процена на лонгитудиналното варирање на видовиот состав и структурата на заедницата на ихтиофауната во Црна Река, како и процена на еколошкиот статус на реката врз основа на рибната фауна. Истражувањата беа извршени на 12 мерни места на реката, вклучувајќи ја и акумулацијата Тиквеш, во текот на август, септември и октомври 2006 год. Регистрирани беа 29 вида кои припаѓаат на 9 фамилии риби. Од нив 21 вид е автохтон и 8 видови се алохтони. Структурата на рибната заедница беше проценета со помош на структурни индекси на видово богатство – d, диверзитет – H', хомогенитет – J(e), и сличност – S. По течението на реката беше забележана редукција на диверзитетот на рибите. Најверојатно измените на условите во стаништата и антропогеното влијание се главните фактори коишто влијаат на структурата на рибната заедница. Вредностите EFI индицираат добар квалитет на вода, односно добар еколошки статус по течението на реката од изворот до мерното место T_3. По вливот на реката Блато кај профилот "Тројкрсти" (T_4) еколошкиот статус се влошува. Долнот тек на реката се карактеризира со прифатлива еколошка состојба, освен профилот под градот Битола, којшто според EFI има лош еколошки статус. Под профилот „Скочивир" квалитетот на водата се подобрува и се категоризира како водно тело со прифатлив статус. Примената на горенаведените параметри за анализа на структурата на рибната фауна може да послужи како основа за воспоставување иден мониторинг систем за процена на еколошкиот статус на реките.

Клучни зборови: структура на рибната фауна; структурни индекси; EFI; Црна Река; Република Македонија.

INTRODUCTION

The primary goal of freshwater biomonitoring is to determine the relative impacts of pollution on the living communities in surface waters. The use of living organisms has several advantages over traditional chemical and microbial water quality analyses. Freshwater organisms live almost continuously in the water and respond to all environmental stressors, including synergistic combinations of pollutants (acting together with a greater total effect than the sum of their individual effects). That is why the European Union's Water Framework Directive – WFD (EC, 2000), underlined the central role of biological indicators to assess the ecological status of rivers.

For aquatic ecosystems, biological indicators can be chosen from a variety of animal or plant assemblages, but fish are of a particular interest because (1) they are present in many water bodies, (2) their taxonomy, ecological requirements and life history are generally better known than for other assemblages, (3) they occupy a variety of trophic levels and habitats, and (4) they have both economic and aesthetic values, and thus help raise awareness about the necessity of conserving aquatic habitats (Oberdorff et al., 2001). Despite the European trend of fast development of biological assessment methodology for waters, biological methods, including metrics based on analyses of fish community are neglected in the Republic of Macedonia. As a candidate country for the European Union, the Republic of Macedonia is obligated to harmonize the national legislation with the European Directive (EC, 2000), which includes the harmonization of the national monitoring system of waters. Natural perturbations and recent increased anthropogenic influences (such as water abstraction, canalization, damming, introductions of exotic species, and agricultural, industrial, and municipal waste inputs) on freshwater resources have become more intense over the past 40 years, resulting in elimination and degradation of surface water resources and aquatic habitats in the R. of Macedonia. These alterations have resulted in fragmented, polluted freshwater fish habitats and communities that have led to extirpation of some native species (Kostov et al., 2010). As the streams disturbance becomes increasingly recognized, the interest to use fishes as ecological indicators to assess and evaluate the level of degradation and health of rivers in the R. of Macedonia has grown.

On the other hand in the R. of Macedonia there is still a lack of data about the fish community structure of many rivers. Most of these investigations concern the River Vardar and its major tributaries, as well as, the three natural lakes while the fish fauna of small aquatic systems has been poorly investigated (Kostov et al., 2010). Although the River Crna is one of the biggest rivers in Macedonia, its fish fauna is steel partially investigated (Kostov et al., 1998; Kostov, 2008). The Crna River is a good model system for testing the assessment methodology, since different segment types are available and the different levels of pressure are in force along the watercourse. This river is a good example of the strong human induced influences potentially affecting native fish communities, therefore in this study we focused on it. The purpose of this study was to reveal species composition and community structure of ichthyofauna from the Crna River, as well as assessment of the ecological status of the river based on the fish fauna. As the European Water Framework Directive (EC, 2000) proposes the use of abundance data, as well as presence–absence of fish species, the results of this study could be a solid basis for future bioassessment programs.

STUDY AREA

The Crna River is the biggest tributary of the Vardar River. The spring is near the village Železnec at 760 m.a.s in the area named "Crna Dupka". The river length is 222 km, while the river basin is 5.887 km^2 (Gashevski, 1979). From the spring to the village Bučin, the Crna Reka flows through the Demirhisar area and from there to the village Skočivir through the biggest Macedonian basin Pelagonija. Near Brod the river turns in the southeast direction. From the village Skočivir it goes through the canyon Skočivir (it is the longest canyon in Macedonia) and the highest area Mariovo. Through Mariovo, the Crna River has characteristics of a mountain river. It is fast, with a short river bed and high banks. At the end of the canyon the Tikveš Reservoir is built. This reservoir (35 km long, with an area of 14 km^2, and a capacity of 475 millions m^3 water) is one of the oldest reservoirs in Macedonia built in 1968. The reservoir is used for irrigation and electricity production. From the dam to the village Vozarci where the Crna River flows into the River Vardar, the Crna River has characteristics of a field river.

The biggest tributaries of the River Crna are: the Blato, the Dragor, the Jeleska Reka and the Blašica (Gaševski, 1979).

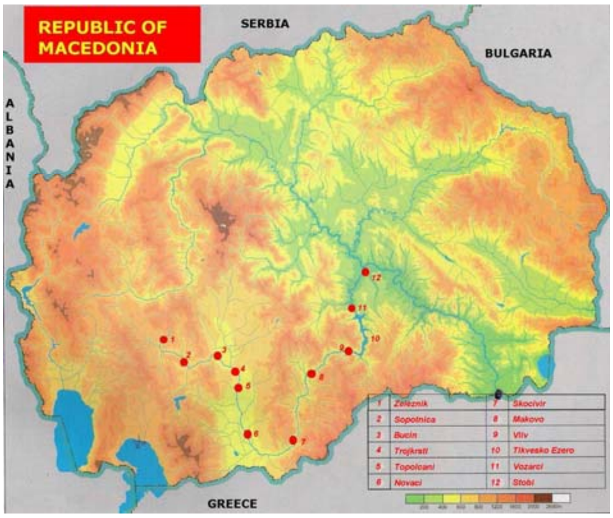


Fig. 1. Map of the investigated area

MATERIAL AND METHODS

The investigation was made on 12 sampling points on the River Crna and the reservoir Tikveš during August, September and October 2006. The sampling sites T_1–T_9 are located above the Tikveš Reservoir while T_{11}–T_{12} below the dam. The first sampling site T_1 – "Železnec" is after the part where the small rivers the Ilinska and the Cerska River go together and form the Crna River. This is the part where the Crna River has characteristics of a typical mountain river with a relative slope of 4 ‰. These characteristics are identical for the second sampling point T_2 – "Sopotnica". After the sampling site T_3 – "Bučin" until the sampling site T_7 – "Skočivir" the Crna River goes through the Pelagonia basin. At the sampling sites T_4 – "Trojkrsti", T_5 – "Topolčani", T_6 – "Novaci" the Crna River has the characteristics of a slow flowing field river. The sampling sites T_7 – "Skočivir", T8 – "Makovo" and T_9 – "Vliv" are localities where the river is fast, with a short river bed and high banks, with characteristics of a typical mountain river. The sampling site T_{10} presents the Tikveš Reservoir. The sampling point T_{11} – "Vozarci" was defined after the dam while T_{12} – "Stobi" was chosen as the last sampling point where the River Crna inflows in the River Vardar. During the investigation period for each of the following localities assessment of the geographical coordinates (GPS), the determination of substrate type composition, the temperature of the water, oxygen and pH were measured.

The fishes were caught by electro fishing (Samus 725G) according to the FAME (2002, 2004) methodology and relevant standards (EN 14011 – CEN 2003). Gill nets with a different mesh size were used for collecting material from the lake. The netting procedure was done according to the European standard protocols (EN 14757 – CEN 2005). All specimens were identified to species level by external morphological characters and the total number of individuals per species was recorded on the field protocol data sheet. After processing and measurement of the basic characteristics the fish was photographed and returned into the water at the same place where they were caught. Fish determination was made with standard keys (Vukovic, 1971; Georgiev, 1998; Kottelat, 1997; Kottelat and Freyhof, 2007), while the taxonomic classification of the fish species is based on Kottelat and Freyhof (2007).

The structure of fish community was evaluated by using structural indices of species richness – d, diversity H', homogeneity – J(e) and similarity (S).

– **Index of species richness** (*d*) according to the Margalef (1958) formula:

$$d = \frac{S-1}{\ln N}$$

where *S* is the number of species, N is the total number of specimens.

– **Index of diversity (*H'*)** according to the Schaennon – Wiener (Glowacinsky, 1975) formula:

$$H' = \sum_{i=1}^{s} pi \ln pi \qquad pi = \frac{ni}{N}$$

where *ni* is the number of specimens of *i* – species, while *N* is total the number of specimens.

– **Index of homogenity** ($J_{(e)}$) according to the Pielou (1966) formula:

$$J_{(e)} = \frac{H'}{\ln S}$$

– **Index of dominance** (*D*%) according to the Karr (1971) formula:

$$DI = \frac{Y_1 + Y_2}{Y} * 100$$

where Y_1 is density of the first dominant species, Y_2 is density of the second dominant species, while Y is the total density of community.

– **Index of similarity** (S) according to the Marczewski and Steinhaus (1959) formula:

$$S = \frac{W}{a + b - W} * 100$$

where W is the number of common species, a is the total number of species from one sampling site, b is the total number of species from the other sampling site.

The classification of the ecological status of the Crna River was done by using the European Fish Index (EFI), produced by the FAME 2002, 2004.

RESULTS

During the investigation of the fish fauna from the Crna River and the Tikves Reservoir, 5442 specimens were collected and measured (Tab. 1). Twenty nine species belonging to 9 families (Tab. 2) were recorded. Among them 21 are autochthonous (native) species and 8 are alochthones.

T a b l e 1

Fish Species Abundance in the Crna River

	fish species	total number	% contribution to the total number	
1	*Alburnoides bipunctatus* (Bloch, 1758)	*1116*	20,51	**I group**
2	*Barbus balcanicus* (Kotlik, Tsigenopoulos, Rab & Berrebi, 2002)	*986*	18,12	**10 – 25%**
3	*Ameiurus nebulosus* (Leseur, 1819)	*521*	9,57	**II group**
4	*Rutilus rutilus* (Linnaeus, 1858)	*425*	7,81	**5 – 10 %**
5	*Alburnus sp.* (thessalicus and/or macedonicus)	*399*	7,33	
6	*Lepomis gibbosus* (Linnaeus, 1758)	*359*	6,6	
7	*Gimnocephalus cernua* (Linnaeus, 1758)	*269*	4,94	**III group**
8	*Carassius gibelio* (Bloch, 1782)	*236*	4,34	**1 – 5%**
9	*Squalius vardarensis* (Karaman, 1928)	*235*	4,32	
10	*Gobio bulgaricus* (Drensky, 1926)	*154*	2,83	
11	*Rhodeus meridionalis* (Karaman, 1924)	*125*	2,3	
12	*Perca fluviatilis* (Linnaeus, 1758)	*125*	2,3	
13	*Salmo pelagonicus* (Karaman, 1938) or *S.trutta* (Linnaeus, 1758)	*105*	1,93	
14	*Barbus macedonicus* Karaman, 1928	*99*	1,82	
15	*Chondrostoma vardarense* (Karaman, 1928)	*66*	1,21	
16	*Cobitis vardarensis* (Karaman, 1928)	*33*	0,61	**IV group**
17	*Pseudorasbora parva* (Temminck & Schlegel, 1846)	*32*	0,59	**0,1 – 1%**
18	*Carassius carassius* (Linnaeus, 1758)	*29*	0,53	
19	*Scardinius erythrophthalmus* (Linnaeus, 1758)	*28*	0,51	
20	*Vimba melanops* (Heckel, 1837)	*26*	0,48	
21	*Pachychilon macedonicum* (Steindachner, 1892)	*21*	0,39	
22	*Cyprinus carpio* (Linnaeus, 1758)	*10*	0,18	
23	*Tinca tinca* (Linnaeus, 1758)	*10*	0,18	
24	*Sabanejewia balcanica* (Karaman, 1928)	*9*	0,17	
25	*Esox lucius* (Linnaeus, 1758)	*8*	0,15	
26	*Romanogobio elimeius* (Kattoulas, Stephanidis & Economidis, 1973)	*7*	0,13	
27	*Silurus glanis* (Linnaeus, 1758)	*6*	0,11	
28	*Acipenser ruthenus* (Linnaeus, 1758)	*2*	0,04	
29	*Acipenser gueldenstaedtii* (Brandt & Ratzeburg, 1833)	*1*	0,02	
		5442	**100**	

Table 2

Number of registered fish species on the sampling place, the number or caught fish specimens on the sampling place and the total fish catch duringthe investigation in the Crna River and the Reservoir Tikveš

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	Frequency %	No caught specimen
Cyprinidae														
Alburnoides bipunctatus	-	-	141	298	354	4	-	274	7	30	-	8	66,67	1116
Alburnus sp	-	-	-	112	99	3	-	-	2	179	-	4	50,00	399
Barbus macedonicus	-	-	-	-	-	-	-	37	62	-	-	-	16,67	99
Barbus balcanicus	-	1	187	-	221	12	-	146	-	-	365	54	58,33	986
Carassius carassius	-	-	1	-	22	-	-	-	2	-	-	4	33,33	29
Carassius gibelio	-	-	-	-	-	102	4	64	-	66	-	-	33,33	236
Chondrostoma vardarense	-	-	3	5	16	-	-	-	3	11	-	28	50,00	66
Cyprinus carpio	-	-	-	-	-	1	-	-	-	9	-	-	16,67	10
Romanogobio elimeius	-	-	7	-	-	-	-	-	-	-	-	-	8,33	7
Gobio bulgaricus	-	-	13	-	30	55	-	29	-	-	9	18	50,00	154
Squalius vardarensis	-	-	12	3	43	24	-	25	9	15	38	66	75,00	235
Pachychilon macedonicum	-	-	-	-	-	-	-	21	-	-	-	-	8,33	21
Pseudorasbora parva	-	-	-	-	-	1	-	-	-	9	-	22	25,00	32
Rhodeus meridionalis	-	-	7	-	76	26	-	-	7	2	-	7	50,00	125
Rutilus rutilus	-	-	-	-	-	-	-	-	4	421	-	-	16,67	425
Scardinius erythrophthalmus	-	-	-	-	-	-	-	-	6	21	1	-	25,00	28
Tinca tinca	-	-	-	-	-	5	-	-	-	5	-	-	16,67	10
Vimba melanops	-	-	-	-	-	1	-	-	-	11	-	14	25,00	26
Salmonidae														
Salmo sp.	48	50	7	-		-	-	-	-	-	-	-	25,00	105
Cobitidae														
Cobitis vardarensis	-	-	-	-	3	12	-	-	-	-	-	18	25,00	33
Sabanejewia balcanica	-	-	-	-	-	-	-	-	-	-	-	9	0,00	9
Esocidae														
Esox lucius	-	-	-	-		7	-	-	-	1	-	-	16,67	8
Siluridae														
Silurus glanis	-	-	-	-	-	-	-	-	1	5	-	-	0,00	6
Centrarhidae														
Lepomis gibbosus	-	-	-	-	-	-	-	-	38	321	-	-	16,67	359
Ictaluridae														
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	521	-	-	8,33	521
Acipenseridae														
Acipenser ruthenus	-	-	-	-	-	-	-	-	-	2	-	-	16,67	2
Acipenser gueldenstaedtii										1			8,33	1
Percidae														
Perca fluviatilis	-	-	-	-	-	-	-	-	12	113	-	-	16,67	125
Gimnocephalus cernua	-	-	-	-	-	-	-	-	-	269	-	-	8,33	269
Number of species	**1**	**2**	**9**	**4**	**9**	**13**	**1**	**7**	**12**	**20**	**4**	**252**		
No caught specimen on every profile	48	51	378	418	864	253	4	596	153	2012	413	252		**5442**

Twenty five fish species (86 % of the total number of species) belonging to seven families were registered in the river ecosystem, while 20 species (69 % of the total number of species) belonging to 7 families (*Cyprinidae, Percidae, Acienseridae, Esocidae, Siluridae, Ictaluridae* and *Centrarhidae*) inhabit the reservoir "Tikveš". The presence of *Acipenser gueldenstaedtii* and *Acipenser ruthenus* was evident in the reservoir which presents the first record in the R. Macedonia. It is not known how these species have been introduced in the Tikveš Reservoir. Analyses of the fish fauna show moderately high species similarity (55 % or 16 taxa) between the river and the reservoir ecosystems.

Cyprinidae (18 fish species) were the dominant family in both, the river and the reservoir ecosystems. *Cobitidae, Percidae* and *Acypenseridae* were represented with two, while the other families such as *Salmonidae, Centrarhidae, Siluridae, Ictuliriae* and *Esocidae* were represented with only one species.

In general, *Alburnoides bipuncatatus* and *Barbus balcanicus* present dominant species contributed with 20,5% and 18,1% in the fish commnity. *Ameiurus nebulosus*, *Alburnus sp.*, *Rutilus rutilis* and *Lepomis gibbosus* (group II) were also found in considerable numbers.

Even *S. vardarense* has lower contribution (4,32%) to the fish community; it was the most frequent species (75% or 9 sampling sites), followed by the dominant *Alburnoides bipuncaatus* and *Barbus balcanicus* registered on the T_8 and T_7 sampling sites, respectively.

The results showed that the structure of fish community changed along the longitudinal gradient (Tab. 2). Namely, the sampling T_1 and T_2 belong to the salmonid region and it is characterized with a lower number of species (*Salmo sp.* and *Barbus balcanicus*) and lower community density. Additionally, the lowest values of species richness, diversity and homogeneity, accompanied with the highest values of the dominance (100%) were measured at the same part of the river (Figs. 2–3). Longitudinally, from the salmonid region till the mouth of the Crna River to the reservoir (T_3-T_9) species richness and diversity increased, with the exception at the T_4 (*H'* – 0,68; *d* – 0,5) and especially at T_7, where the indices dropped to zero. At the sampling site "Skočivir" (T_7) only one species, the introduced *C. gibelio* was recorded (Tab. 2 and Fig. 3), which caused the highest degree of dominance (100%) and the lowest homogeneity (0%).

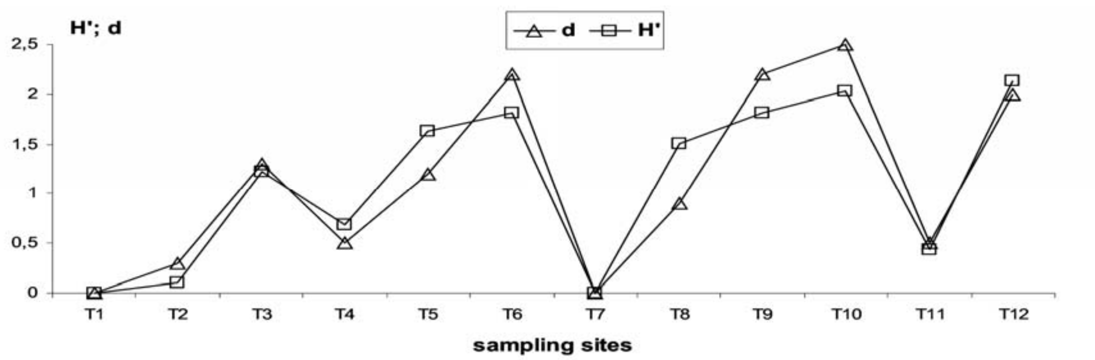
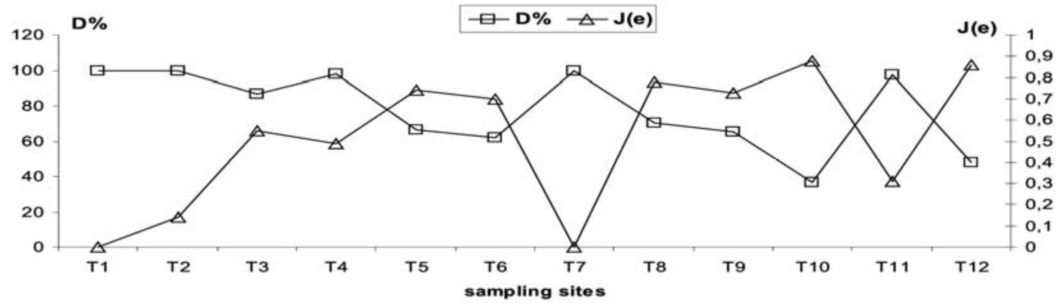


Fig. 2. Longitudinal changes (T1–T12) of richness (d) and diversity (H') indices across the Crna River.



Fig, 3. Longitudinal changes (T_1–T_{12}) of dominance (*D*) and homogeneity ($J_{(e)}$) indices across theCrna River

Concerning the Tikveš Reservoir (sampling point T_{10}) the most dominant species was *Ameiuruss nebulosus* (521 specimens). *Rutilus rutilus*, *Gimnocephalus cernua*, *Lepomis gibbosus* and *Alburnus sp*. were also found in higher number. Species richness, diversity and homogeneity at this sampling point showed high values (H' – 2,03; d – 2,5; $J_{(e)}$ – 0,88), while the dominance significantly decreased (Figs. 2–3).

Below the dam, at the sampling point T_{11}, only 4 species were caught. *Barbus balcanicus* was the most abundant species (365 specimens). Species richness, diversity and homogeneity (H' – 0,43; d – 0,5; $J_{(e)}$ – 0,31) were low again, while the dominance significantly increased (97,57%). The last sampling point T_{12} was characterized with high species richness, diversity and homogeneity (H' – 2,14; d – 2; $J_{(e)}$ – 0,86), while the dominance (47,61%) was low again.

Similarity indices may be better indicators of the fish community change than diversity indices since the former reflect changes in the relative abundance of species in common and large temporal changes in a community structure may occur without changing the value of its diversity index. In that context the index of similarity (S) has been shown as an extremely useful tool for determining the similarity of species composition of ichtyofauna along the riverbed and the Tikveš Lake. The Table 3 presented similarity between the fish community in all investigated sites (T_1–T_{12}). It could be noticed high species similarity (50 %) the between first sampling sites (T1–T2). Lower similarity between T_3 and T_4, as well as, higher similarity between T_3 and T_5 were recorded. Further, the highest similarity between T_5 and T_6 with T_{12} was evident. Analyses of the fish community, between T_9 (the mouth of the Crna River in the Reservoir) and T_{10} (the Reservoir) show similarity of 45.5%.

T a b l e 3

Similarity (%) of fish community along the Crna River

T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	
100	50	11,1	0	0	0	0	0	0	0	0	0	T_1
	100	22,2	0	10	0	0	12,5	0	0	20	7,7	T_2
		100	30	63,6	29,4	0	33,3	31,3	16	30	16,7	T_3
			100	44,4	21,4	0	22,2	33,3	20	14,3	23,1	T_4
				100	46,7	0	33,3	31,3	20,8	30	75	T_5
					100	7,7	33,3	19	32	21,4	56,3	T_6
						100	14,3	0	5	0	0	T_7
							100	18,8	12,5	37,5	26,7	T_8
								100	45,5	6,7	33,3	T_9
									100	4,3	28	T_{10}
										100	23,1	T_{11}
											100	T_{12}

In the Table 4 the biological assessment of the status of the Crna River based on the EFI index is presented. The EFI values indicaterly a healthy, natural or by near natural water ecosystem and a good ecological status along the river course the from source region to the sampling point T_3. After the inflow of the River Blato, at the profile "Trojkrsti" (T_4), the ecological status deteriorates. The remaining downstream parts of the river have a moderate ecological status, except the profile below the town of Bitola, which according to the EFI had a has ecological status. Below the "Skočivir" profile, the water quality improves toward moderate status.

Table 4

Categorization of the water quality across the Crna River based on the EFI index

Locality	Latitude	Longitude	Altitude	EFI	Ecological status
T_1	41°18′42	21°05′28	760	0.63	Good
T_2	41°17′09	21°09′33	700	0.64	Good
T_3	41°15′29	21°12′10	650	0.60	Good
T_4	41°12′32	21°25′54	620	0.41	Moderate
T_5	41°12′53	21°25′38	580	0.39	Moderate
T_6	41°02′24	21°26′23	550	0.28	Moderate
T_7	41°58′17	21°39′20	520	0.09	Bad
T_8	41°12′23	21°40′05	490	0.43	Moderate
T_9	41°05′52	21°52′48	450	0.34	Moderate
T_{10}	41°05′42	21°05′28	760	0.63	Good
T_{11}	41°25′02	21°53′47	105	0.31	Moderate
T_{12}	41°33′02	21°58′13	95	0.44	Moderate

DISCUSSION

Fish community structure in streams may differ on the longitudinal gradient according to various biological aspects such as species diversity, stress tolerance, habitat preferences, feeding behaviors and the origin of species (Balon et al., 1986, Holcík, 1989, Penczak and Mann, 1990; Belliard et. al., 1997). Usually, upstream sections are less degraded with relatively less changed physical, chemical and biological conditions of habitats. In most of the cases, from upstream to downstream, not only species composition of the community changes, but also their numbers increase (Fausch et al., 1984; Beecher et al. 1988, Morin and Naiman, 1990; Zakaria-Ismail, 1994). According to Schlosser (1982) the number of species in lower reaches is related to the increased habitat diversity.

The results of the current study show that habitat complexity of the Crna River is not the main factor influencing the taxonomic composition and abundance of fish community. Opposite of T_1 and T_2, where low diversity presents a natural phenomenon (salmonid region), the significant reduction of species richness registered along the river course (T_4, T_7 and T_{11}), indicate that the other factors affect the fish community. It is well known that human modifications of the stream channel may alter any of the fish-habitat relationships and thus may have substantial effects on the fish fauna (Swales, 1988). Variations in the fish fauna across the river bed (longitudinal direction) become more remarkable in streams facing the problem with direct discharge from untreated industrial and municipal effluents (Huet, 1959; Angermeier and Karr, 1983; Balon and Stewart, 1983; Przybylski, 1993).

In the case of the Crna River it seems that changes in the habitat condition mainly associated with human activities are the main factors which alter the structure of the fish community. Thus, at the sampling points “Trojkrsti” (T_4) which is near the inflow of the River Blato, the scarce fish community (four species) with high abundance of tolerant *Alburnoides bipunctatus* and *Alburnus sp.* was evident. Probably, the waste waters from the town Prilep discharged in this part of the river caused community changes. Lower similarity between T_3 and T_4 as well as lower EFI values show moderate water quality of the sector.

Concerning the “Skočivir” (T_7), the presence of only few specimens of the tolerant Prusssian carp (*Carassius gibelio*) has been noticed (Tab. 2). The analyses of structural indices clearly show that the fish community is strongly degraded. Extremely low similarity between fish communities from T_7 and the other sampling points (Tab. 3) and the lowest EFI values (Tab. 4), indicate an increased level of the ecosystem stress and bad a ecological status. It is obvious that the inflow of the “fifth canal”, which brings all sewage waters from the town Bitola and the waste waters from industry, has an extremely negative influence on the fish biota. According to the National Hydrometeorological Service (UHMR http://www.meteo.gov.mk) these sampling points are characterized with extremely high values of COD (chemical oxigen demand) and toxic ammonia which indicate presence of huge contents of organic matter deposit on the bottom as well as anaerobic condition.

Comparing to the "Skočivir", recovery of the fish fauna at the sampling points T_8–T_9 (upstream of the dam) has been detected. The river flows through the Skočivir canyon showing impressive self-purification ability. The increased values of the diversity, richness and homogeneity, confirm this statement and indicated improved environmental conditions. The EFI values point out a moderate level of distortion from the natural, undisturbed condition or moderate ecological status.

Regarding the sampling point T_{10} – the Reservoir Tikveš, a high diversity (20 species) of ichthyofauna has been recorded. Moderately high species similarity between thr reservoir and the upstream sector (T_{11}) indicates that the river itself presents the main colonizing source. Compared to the results of the previous investigation (Kostov et al., 1989), the findings of the current study indicate a dramatic change of the fish fauna in the Tikveš Reservoir. A significant population increase of some new introduced fish species (North American catfish species *Ameurus nebulosus* and non-native European species *Gimnocephalus cernua*) has been observed. Usually, the eutrophication favoured „trash" fish (Marković and Veljović, 2005) in the reservoirs and their dominance indicate a higher trophic state. Although, *Rutilus rutilus* is in considerable numbers, compared with the previous investigation its populations show a decreasing trend. At the same time, decline in the number of the other commercially valued species such as *Cyprinus carpio, Tinca tinca* and *Vimba malanops* has been observed. The same situation noticed in Medguvršje Reservoir, the Marković and Veljović (2005) explain with deterioration of the environmental conditions in the reservoir. It couldn't be avoided the fact that, the excessive catch during the spawn and other periods had additional negative effects on the population of commercial fishes.

Below the dam, at the sampling point T_{11}, species richness, diversity and homogeneity were low again. In comparation with upstream sections and the dam itself, low species similarity was noticed. A similar condition was detected in the Bregalnica River (Kostov et al., 2010) where the fish community bellow the dam Kalimanci was also caracterised with a low diversity. Probably the fragmentation of the stream habitat affect the river fish communities. Unstable conditions (dry and flow periods) below the dam strongly change the fish community, with high dominance of only one species (*Barbus balcanicus*).

The last sampling point T_{12} was characterized with high species richness, diversity and homogeneity, as well as, lower dominance. The high similarity of the fish fauna between the T_{12} with T_5–T_6 pointed out that stable environmental conditions were established again. It should be stressed that the high species richness at this sampling point could be due to the River Vardar itself, and fish migration probably occurred in two directions. Similar situation was registered in the mouth of other rivers in the R. Macedonia (Kostov et al., 2010).

Apart from the lower similarity between T_{11} and T_{12}, the values of the EFI showed moderate ecological status at the both sampling stations indicating that the dam influence is the only stress factor at this part of the river ecosystem. However, further comprehensive investigations should be continued in order to fully understand the dynamic nature of the reservoir and its influence on the river ecosystem.

As the fish fauna presents a relevant biological quality element according to the Water Framework Directive (EU, 2000) a regular monitoring of the Crna River watershed should be established. In order to prevent further water quality deterioration, water quality of the tributaries Dragor and Blato should be improved and to establish treatment of the waste waters from the "fifth canal". In addition, certain measures of protection and conservation of the Crna River watershed should be undertaken.

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