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DIVERSITY OF FISH FAUNA OF THE ZETA RIVER (MONTENEGRO) AND ABSENCE OF TROUT SPECIES CAUSED BY INADEQUATE MANAGEMENT

SUMMARY

A comprehensive study of fish diversity, relative and absolute biomass of registered species in Zeta River, Montenegro was accomplished. The data were collected during 2019 from three major ecological sectors of the river. A total of 14 fish species were recorded. The highest relative and absolute biomass were recorded on the Lower Zeta – Bjelopavlići – the lower part of the watercourse.

Data presented in this paper shows a dramatic decline in both, the abundance and biomass of trout species from this river. Although in the 2019th river Zeta watercourse in Bjelopavlići Valley was proclaimed as a Park of Nature, we haven't detected any benefits for the fish species, especially for the salmonid ones and their abundance continued with decreasing trend. Most probably the bad practice of poaching with forbidden tools just continued no matter on newly proclaimed protection status. It is shown that proclaiming some area or river in the protected area of any level doesn't benefit to biodiversity if it is not followed with precise management plans and strict implementation.

Keywords: Ichthyofauna, CPUE, NPUE, absolute biomass, management

INTRODUCTION

The freshwater fish fauna of Montenegro currently consists of 89 species (Marić, 2019). The ichthyofauna of the inland waters of Montenegro can be divided into two groups: the Danube (Black Sea) and the Adriatic Sea. The Zeta, the Morača and the Bojana Rivers together with the Skadar Lake form the main part of the Adriatic River Basin, flowing into the Adriatic Sea. The River Zeta is the largest tributary of the Morača. In terms of biodiversity, the Zeta river is one of the most important rivers in the Adriatic basin of Montenegro. The autochthonous ichthyofauna of the River Zeta is represented by 20 species. Two of them, i.e., *Salmo zetensis* (soft-muzzled trout) and *Barbatula zetensis* (Zeta

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stone loach), are endemic to Montenegro (Marić, 2019). Cyprinid fish that form half of the autochthonous fauna dominate in the lower part of the river, while the upper part is populated by *Salmo zetensis, S. marmoratus, S. farioides*, and some cyprinids (Marić, 2018).

In terms of both biodiversity and fishery, Lake Skadar is the richest and most important area in Montenegro. The largest number of published research papers from the area of Montenegro is precisely related to the area of Lake Skadar and its fish resources (Drecun and Ristić, 1964; Ivanović *et al*., 1983; Janković, 1975; Ivanović, 1973; Milošević *et al*., 2011; Milošević and Marić, 2012; Milošević and Mrdak, 2016; Mrdak *et al*, 2017; Mrdak *et al*., 2017 b; Marić, 2018). Until now very few researches were conducted on fish biodiversity status of the Zeta River. Data on fish diversity were most often presented in the form of a list of species as well as the fishing potential of certain areas of the River Zeta (Drecun, 1951; 1981). The subject of more detailed research was only the endemic soft-mouthed trout. Results of genetic investigation on twelve microsatellite loci as well as lack of hybridization with the putative brown trout unequivocally confirm that the soft-muzzled trout from the Zeta River is a species distinct from the putative brown (*Salmo cf. farioides*) and marble (*Salmo marmoratus*) trout that live in sympatry with it (Mrdak *et al.,* 2012).

The Zeta River is categorized as a river of national importance. It has been declared a Park of Nature in 2019, by the decision of the Government of Montenegro, at the initiative of the Municipality of Danilovgrad. Thus, Zeta became an area of special importance for Montenegro, having in mind the significance of its biodiversity.

The whole lower part which runs through the Bjelopavlići Valley is under protection as a Park of Nature, while the upper part of Nikšić Valley is not protected and it was under significant human impact due to building of the hydro system for the need of the "Perućica" hydro energy plant. Bearing in mind the above as well as the fact that until now there has been no systematic research on fisheries resources of the Zeta River, this study was designed to provide answers to the following questions:

1. Which species are most abundant in the study area?
2. What's the situation in terms of relative and absolute biomass three study parts of the river?
3. What are the main reasons for fish biodiversity depletion in the Zeta River with recommendations?

MATERIAL AND METHODS

Study area

The total length of the Zeta River is about 85 km with a drainage basin area of 1,597 km^2. The river originates in Gornje Polje from the rivers Sušica and Rastovac. From the springs of Perućica and Oboštica, the watercourse of Lower Zeta is formed, which flows into the river Morača. Until its conflow with Morača

river, the lower Zeta receives several tributaries, the most important of which is Sušica with a length of 15 km. (Radojičić, 2005).

Sampling

Research on the Zeta River was conducted during the 2019. Investigating area was divided into three parts:

1. Upper Zeta-Nikšić valley (localities: Brezovik, Duklov most);

2. Lower Zeta-Bjelopavlići – the upper part of the watercourse (localities: Glava Zete, Ostrvo, Tunjevo);

3. Lower Zeta – Bjelopavlići – the lower part of the watercourse (localities: Danilovgrad, Pričelje, Vranjske njive).

Fish were sampled by electrofishing and commercial or standard benthic MMG nets (European standard EN 14757 - European Committee for Standardization 2015). A standard electrofishing gear (SUSAN-735MP) was employed according to technical instructions. All species were determined to species level. Individual MMG were 30 m long and 1.5 m high, resulting in a net surface area of 45 m^2. Each net consisted of twelve 1.5×2.5 m panels of different mesh sizes in the following sequence: 43 mm, 19.5 mm, 6.25 mm, 10 mm, 55 mm, 8 mm, 12.5 mm, 24 mm, 15.5 mm, 5 mm, 35 mm and 29 mm (knot to knot). Each fish caught was identified to a species level. Total length (TL, to the nearest mm) and total weight (TW, to the nearest g) of each specimen were measured separately. Catch per unit of effort (CPUE) and number per unit of effort (NPUE) were calculated for all sampled species as a relative measure of species biomass and species abundance, respectively.

CPUE and NPUE were calculated for individual species as follows:

− CPUE (g/m2) = biomass of total catch (in grams) divided by surface of electrofishing transect or with total net surface.

− NPUE (individuals/m2) = total number of individuals per MMG (all panels) divided by surface of electrofishing transect or with total net surface.

For calculating absolute biomass, the mean value of total biomass of all transects in the appropriate river sector was extrapolated on one hectare surface (electrofishing sampling). In case of net sampling, we calculate that catch in one net is equal to the total biomass of the surface of a square with the diagonal length of that net. The mean value of calculated biomass of each such square from appropriate river sector was extrapolated on one hectare surface.

RESULTS AND DISCUSSION

This paper provides the main information and identifies the knowledge gaps about the fish resources in the Zeta River which is an important identifying factor in planning the next steps towards conservation of fish fauna and sustainable fishing in the country.

1.Upper Zeta – Nikšić valley

a)Fish assemblage

Three species have been registered in the area of upper Zeta – Nikšić valley (Table 1). During the survey period, the highest relative abundance was recorded for *Phoxinus phoxinus* (Table 2).

Table 1. Registered species, No-number of individuals; %-percentage in the sample by locality

UPPER ZETA – NIKŠIĆKO POLJE			
Locality	**Species**	**No**	**%**
Brezovik	*Salmo labrax*	7	5 %
	Phoxinus phoxinus	121	86.5 %
	Squalius cephalus	12	8.5 %
Duklov most	*Salmo labrax*	5	2.5 %
	Phoxinus phoxinus	174	82 %
	Squalius cephalus	33	15.5 %

Table 2. Relative abundance (NPUE – in number of ind/m^2) of registered species by localities, ∑ - total NPUE by locality, mean- mean value of relative abundance for part Upper Zeta – Nikšić Valley

NPUE	***S. labrax***	***P. phoxinus***	***S. cephalus***	∑
Brezovik	0.032	0.645	0.064	**0.741**
Duklov most	0.027	0.928	0.176	**1.131**
Mean	**0.029**	**0.787**	**0.120**	**0.936**

b)Biomass

During the survey period, the highest CPUE and absolute biomass were recorded for Squalius cephalus (Table 3 and 4).

Table 3. Relative biomass (CPUE – gr/m^2) of registered species by localities, ∑ - total CPUE by locality, mean-mean value of relative abundance for part Upper Zeta – Nikšić Valley

CPUE	***S. labrax***	***P. phoxinus***	***S. cephalus***	∑
Brezovik	2.539	1.523	5.557	**9.619**
Duklov most	0.597	2.363	16.629	**19.589**
Mean	**1.568**	**1.943**	**11.093**	**14.604**

Table 4. Absolute biomass (kg/ha) of registered species by localities, ∑ - total biomass by locality, mean-mean value of absolute biomass for part Upper Zeta – Nikšić Valley

Biomass (kg/ha)	***S. labrax***	***P. phoxinus***	***S. cephalus***	∑
Brezovik	20.731	9.517	54.492	**84.740**
Duklov most	4.661	14.613	166.309	**185.584**
Mean	**12.696**	**12.065**	**110.401**	**135.162**

2.Lower Zeta-Bjelopavlići – upper part of the watercourse

a)Fish assemblage

Four species have been registered in the area of lower Zeta – Bjelopavlići, upper part of watercourse (Table 5). During the survey period, the highest relative abundance was recorded for Barbus rebeli and Salmo farioides (Table 6).

Table 5. Registered species, No-number of individuals; %-percentage in the sample by locality

LOWER ZETA BJELOPAVLIĆI – UPPER PART OF WATERCOURSE			
Locality	**Species**	**No**	**%**
Glava Zete	*Salmo farioides*	19	*100 %*
Ostrvo	*Salmo farioides*	9	*45 %*
	Barbus rebeli	8	*40 %*
	Salmo marmoratus	3	*15 %*
Tunjevo	*Salmo farioides*	7	*9 %*
	Barbus rebeli	16	*20 %*
	Telestes montengrinus	57	*71 %*

Table 6. Relative abundance (NPUE – in number of ind/m^2) and of registered species by localities, ∑ - total NPUE by locality, mean-mean value of relative abundance for part Lower Zeta Bjelopavlići – upper part of the watercourse

NPUE	***S. farioides***	***B. rebeli***	***S. marmoratus***	***T. montenigrinus***	∑
Glava Zete	0.096				**0.096**
Ostrvo	0.048	0.043	0.016		**0.107**
Tunjevo	0.037	0.085		0.304	**0.427**
Mean	**0.060**	**0.064**	**0.016**	**0.304**	**0.210**

b)Biomass

During the survey period, the highest CPUE and absolute biomass was recorded for *S. farioides* (Table 7 and 8).

Table 7. Relative biomass (CPUE – gr/m^2) of registered species by localities, ∑ - total CPUE by locality, mean- mean value of relative abundance for part Lower Zeta – Bjelopavlići, the upper part of the watercourse

CPUE	***S. farioides***	***B. rebeli***	***S. marmoratus***	***T. montenigrinus***	∑
Glava Zete	14.355				**14.355**
Ostrvo	5.379	2.883	4.600		**12.862**
Tunjevo	2.847	4.557		7.488	**14.892**
Mean	**7.527**	**3.720**	**4.600**	**7.488**	**14.036**

Table 8. Absolute biomass (kg/ha) of registered species by localities, ∑ - total biomass by locality, mean- mean value of absolute biomass for part Lower Zeta – Bjelopavlići, the upper part of the watercourse.

Biomass (kg/ha)	*S. farioides*	*B. rebeli*	*S. marmoratus*	*T. montenigrinus*	∑
Glava Zete	191.400	0	0	0	**191.400**
Ostrvo	69.240	30.178	51.450	0	**150.868**
Tunjevo	37.540	50.289	0	98.867	**186.696**
Mean	**99.393**	**26.822**	**17.150**	**32.956**	**176.321**

3.Lower Zeta – Bjelopavlići – the lower part of the watercourse

a)Fish assemblage

13 species have been registered in the area of lower Zeta – Bjelopavlići, the lower part of the watercourse (Table 9).

Table 9. Registered species, No-number of individuals; %-percentage in the sample by locality

LOWER ZETA BJELOPAVLIĆI – LOWER PART OF THE WATERCOURSE			
Locality	**Species**	**No**	**%**
Danilovgrad	*Salmo farioides*	4	2 %
	Barbus rebeli	6	2.5 %
	Telestes montenegrinus	26	11 %
	Phoxinus sp.	115	51 %
	Anguilla anguilla	3	1.5 %
	Alburnus scoranza	42	18 %
	Salmo marmoratus	2	1 %
	Rutilus prespensis	26	11 %
	Squalius platyceps	6	2.5 %
Pričelje	*Barbus rebeli*	5	1 %
	Squalius platyceps	7	2 %
	Phoxinus sp.	187	48 %
	Anguilla anguilla	4	1 %
	Alburnus scoranza	61	16 %
	Chondrostoma ohridanum	4	1 %
	Cobitis ohridana	19	5 %
	Rutilus prespensis	50	13 %
	Telestes montengrinus	49	13 %
Vranjske njive	*Salmo farioides*	5	1.5 %
	Barbus rebeli	10	3 %
	Telestes montengrinus	22	6 %
	Phoxinus sp.	314	88 %
	Anguilla anguilla	1	0.5 %
	Squalius platyceps	2	0.5 %
	Salmo marmoratus	1	0.5 %

During the survey period, the highest relative abundance was recorded for *P. phoxinus* (Table 10).

Table 10. Relative abundance (NPUE – in number of ind/m^2) and of registered species by localities, ∑ - total NPUE by locality, mean-mean value of relative abundance for part Lower Zeta Bjelopavlići – the lower part of the watercourse.

NPUE	*S. farioides*	*B. rebeli*	*S. platyceps*	*P. phoxinus*	*A. anguilla*	*A. scoranza*	*C. ohridanum*	*S. marmoratus*	*C. ohridana*	*R. prespensis*	*T. montenigrinus*	∑
Danilovgrad	0.027	0.040	0.173	2.859	0.027	0.280		0.013		0.087	0.333	**3.839**
Pričelje		0.033	0.313	1.249	0.027	0.387	0.020		0.127	0.333	0.472	**2.961**
Vranjske njive	0.033	0.067	0.093	2.093	0.007			0.007			0.153	**2.453**
Mean	**0.030**	**0.047**	**0.193**	**2.067**	**0.020**	**0.333**	**0.020**	**0.010**	**0.127**	**0.210**	**0.853**	**3.91**

b)Biomass

During the survey period the highest CPUE was recorded for A. scoranza and *T .montenigrinus* (Table 11).

Table 11. Relative biomass (CPUE – gr/m^2) of registered species by localities, ∑- total CPUE by locality, mean-mean value of relative abundance for part Lower Zeta – Bjelopavlići, the lower part of the watercourse.

CPUE	*S. farioides*	*B. rebeli*	*S. platyceps*	*P. phoxinus*	*A. anguilla*	*A. scoranza*	*C. ohridanum*	*S. marmoratus*	*C. ohridana*	*R. prespensis*	*T. montenigrinus*	∑
Danilovgrad	3.853	1.895	7.620	1.362	6.420	7.107		5.214		2.867	7.343	**43.681**
Pričelje		1.437	8.687	4.030	6.420	9.407	3.543		0.796	9.533	10.550	**54.403**
Vranjske njive	4.510	3.417	1.787	4.093	1.677			2.513			3.093	**21.091**
Mean	**4.182**	**2.250**	**6.031**	**3.162**	**4.839**	**8.257**	**3.543**	**3.864**	**0.796**	**6.200**	**6.996**	**39.725**

The highest apsolute biomass was recorded for *T. montenegrinus*, *A. scoranza* and *S. platyceps*. (Table 12).

Table 12. Absolute biomass (kg/ha) of registered species by localities, ∑ - total biomass by locality, mean- mean value of absolute biomass for part Lower Zeta – Bjelopavlići, the lower part of the watercourse.

Biomass (kg/ha)	*S. farioides*	*B. rebeli*	*S. platyceps*	*P. phoxinus*	*A.anguilla*	*A. scoranza*	*C. ohridanum*	*S. marmoratus*	*C. ohridana*	*R. prespensis*	*T. montenigrinus*	∑
Danilovgrad	37.427	15.411	77.960	17.720	53.600	71.113	0	43.467	0	58.833	73.433	**448.964**
Pričelje	0	13.200	104.967	30.479	59.380	99.127	35.113	0	7.687	94.833	88.693	**533.479**
Vranjske njive	44.107	28.133	30.673	42.848	16.787	0	0	20.956	0	0	39.187	**222.690**
Mean	**27.178**	**18.915**	**71.200**	**30.349**	**43.256**	**56.747**	**11.704**	**21.474**	**2.562**	**51.222**	**67.104**	**401.711**

Data presented in this paper are the first one related to the entire Zeta River regarding the fishes resources in terms of absolute and relative biomass. Therefore, it is clear that there are no previous ones that could be used for comparison or determining any trend of the species abundance or biomass. During this investigation, 14 fish species were registered, out of a total of 20 that are reported in the literature (Marić, 2018). In terms of the composition of the fish fauna, the upper course of the Zeta River through the Nikšić Valley, as well as the upper course of the same river after the sinkhole and reappearance in the Bjelopavlići Valley, have a similar salmonid character (Table 1 and Table 5). In the upper part along the Bjelopavlići Valley, the fauna is somewhat richer and

consists of 4 species, two of which belong to trout species, *Salmo farioides*-brown trout and *Salmo marmoratus* – marble trout (Table 1 and Table 5). In both parts, in terms of abundance, cyprinid species are dominant (Table 2 and Table 6), while in terms of biomass the situation is different, in upper parts of Zeta river in the Bjelopavlić Valley brown trout is dominant (Table 4 and Table 8).

As for the lower course of the Zeta river through the Bjelopavlići Valley, this river sector showed the highest diversity of detected fish species, 13 of theme (Table 9). As it was expected, in this sector cyprinid species were dominant pointing to the cyprinid character (Table 9). Regarding their abundance and biomass, the same group of species showed their dominance where the most dominant were *S. platiceps, T. montenigrinus, R. prespensis* and *A. scoranza* in both abundance and biomass (Table 10 and Table 12).

From the data presented in this paper it is obvious that we are facing dramatically low abundance and biomass of salmonid species (personal experience). What is of highest concern is that we haven't detected soft muzzle trout (*Salmo obtusirostris*) in lower Zeta which was in 2012 lastly reported for Zeta River (Mrdak *et al*., 2012). The absence of this species in our samples implies the further decline of its population in Zeta River. This data imply that illegal fishing, using of forbidden tools as well as no adequate management and absence of the ranger service or fish guards motivate poachers to continue or even to become more frequent on this river. According to IUCN Red List, the soft muzzled trout *S. obtusirostris* is considered Endangered B2ab(v) throughout its dispersal area (IUCN 2021), while in the national legislation of Montenegro, this is the only protected fish species. During 1990's, their population sizes dramatically decreased in the whole dispersal area and in a few reports on monitoring of protected animal species in Montenegro it was reported that this species is the most probably extinct there (National Agency for Nature Protection of Montenegro, 2003, 2004 and 2005). However, one population at the locality of the village of Tunjevo with an ultimately small number of specimens was recorded (Sušnik *et al*. 2007; Mrdak *et al*. 2012).

Neither comprehensive monitoring of fish stocks nor the estimation of maximum sustainable yield on water bodies in Montenegro has ever been performed in the past. Only recently, through the CSBL projects (Conservation and Sustainable Use of Biodiversity at Lakes Prespa, Ohrid and Shkodra/Skadar) in period 2013 to 2018, has the monitoring of fish populations been established on Skadar Lake but, unfortunately, that process did not continue beyond the end of this project (Mrdak *et al*., 2017 b). For that reasons the presented result provide first and important data about diversity and biomass of fish fauna of the important Zeta River which is part of Lake Skadar water catchment area. The data confirms that Zeta River is an important fishery area in Montenegro. Taking in mind that Zeta watercourse in Bjelopavlići valley being proclaimed as Park of Nature the results of this paper should represent the basis for establishing long-term monitoring of fish fauna.

The management and sustainable use of the fish resources poses manifold challenges to competent authorities. First of all, vulnerable species such as trout species are protected under national and EU nature conservation legislation and require special conservation efforts. Second fishes are one of four indicators that determine the ecological status of water bodies according to the EU Water Framework Directive. That means that fish fauna (and other biota) under nearly undisturbed conditions, has to be maintained or restored, and that specific measures are to be taken to fulfill this requirement. The following are recommended for preparation management plan, implementation, and conservation of fish biodiversity in the Zeta River:

1. Banning or controlling destructive fishing gears
2. Identification of the fish breeding and nursery grounds and their protection as fishing no go zones
3. Overall public awareness should be expanded through training programs to restore the habitat of these valuable fish species from close extinction
4. Banning of fishing marble trout and soft-mouth trout, control of restaurants and banning of possession and sale of marble trout and soft-mouthed trout.
5. Establishment of breeding center for indigenous trout species.

CONCLUSION

Taking in mind the river Zeta watercourse in Bjelopavlići Valley was proclaimed as a Park of Nature, the present investigation generate first, very important and comprehensive data set. The presented results are the first one related to the entire Zeta River regarding the fish's resources in terms of absolute and relative biomass. Unfortunately data confirms that we are facing dramatically low abundance and biomass of salmonid species which indicates that repopulation measures should be implemented urgently.

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