

ECOLOGICAL, MORPHOLOGICAL-TAXONOMIC AND CHEMATOLOGICAL CHARACTERISATION OF PIKE PERCH (*Sander lucioperca*, LINNAEUS 1758) FROM RESERVOIRS ON THE RIVER NERETVA

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Summary

Ecological, morphological-taxonomic and haematological features of pike perch (*Sander lucioperca*, Linnaeus 1758) as introduced species in reservoirs on the river Neretva in Bosnia and Herzegovina is presented in this paper. Field research has been carried out in the period from November 2009 to November 2010. The analysis of morphological-taxonomic parameters has been carried out on 103 specimens, with 54 used for the analysis of haematological parameters. From an ecological standpoint, populations of pike perch from the „lakes“ on the river Neretva exhibit trends towards an increase in density. These populations include specimens of various age, and they show a high degree of adaptability to the reservoir's ecosystems. Morphological features of specimens show the presence of several generations, which indicates that this species successfully spawns in the investigated ecosystems. The largest variation coefficient by season, within seven measured haematological parameters, have haematological indices MCV, MCH and MCHC.

Key words: *Sander lucioperca*, reservoirs on the river Neretva, ecological, morphometric, haematological

INTRODUCTION

From the standpoint of ichthyological research, the reservoirs on the river Neretva have been sporadically in the focus of scientists, which resulted in data on the state of

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ichthyopopulations of both autochthonous and allochthonous fish species (A g a n o v i ć, 1965, 1966; K o s o r i ć et al., 1980, 1982; K o s o r i ć, 1989; Š k r i j e l j, 1991, 1995; M a š o v i ć, 2000). The investigations of pike perch populations in the river Neretva basin from its first discovery (Š k r i j e l j, 1995), to the analysis of its populations (Š k r i j e l j and M a š o v i ć, 2001), to the nutrition of this species (T r o ž i ć – B o r o v a c and Š k r i j e l j, 2007), indicate that this species has attracted serious attention of scientists from Bosnia and Herzegovina. The goal of the investigations presented in this paper include the ecological, morphological-taxonomic and haematological features of pike perch as an introduced species into the reservoirs on the river Neretva.

The river Neretva is the longest, and with the greatest volume of Balkan tributaries of the Adriatic sea. It originates at 1227 meters altitude, under the peak Grdelj on the slopes of the mountain Lebršnik. It is 230 km long. During spring, part of the river Neretva valley is 600 meters deep. Its upper part is called Borac, while in its lower part (by the mouth of the river Rama) it is called Župa (Š k r i j e l j, 2002). Maximal length of Jablanica lake is 30 km, with the surface of cca. 1440 ha. The maximal depth is 80 m, and oscillations of water level are up to 25 and even 30 m. In the period from 1981 to 1987, three new dams were constructed on the river Neretva and new reservoirs have been formed. The reservoir Salakovac exists since 1981, is 20 km long, with a surface area of 314 ha. Its maximal depth is 40 m, with oscillations of water level up to 5 m. A year later, in 1982, the Grabovica reservoir was constructed, with a length of 12 km, and a surface area of 130 ha, with the maximal depth of 34 meters and oscillations of water level up to 5 m. The last constructed reservoir on the river Neretva was Mostar, in 1987, with a length of 10 km, and surface area of 112 ha. The maximal depth is 20 m, with oscillations of water level of 5 m (Š k r i j e l j, 2002). The Neretva river runs through a valley which is surrounded from the north by the mountains Bitovnja (1700 m) and Vranica (2112 m.). To the south there are mountains Prenj (2103 m) and Čvrsnica (2226 m), and to the west where is Bjelašnica mountain (2062 m). The reservoir Jablanica is wider on the north where it borders the Rama reservoir.

MATERIALS AND METHODS

Field investigations and samplings have been carried out at several profiles within reservoirs on the river Neretva in the period from November 2009 to November 2010. The investigations included reservoirs Jablanica, Grabovica, Salakovac and Rama. The reservoir Mostar, although it was scheduled for investigation, was excluded due to the objective reasons. Namely, in the investigation period this reservoir was selected, and for these reasons all activities related to the fishing have been banned. Fishing from the reservoir ecosystems on the river Neretva has been carried out using nets on the longitudinal profiles in the deeper parts within each of investigated reservoir. Standard fishing gear was used in fishing: gillnets with various height and mesh diameter in order to avoid selectivity of the sample. In coastal vegetated areas, and in the shallow parts of the reservoirs electrofishing gear of 1.2 kW and 2.0 kW was used. Equipment used, among other things, included monitoring of the distribution of pike perch in the deeper

area in the reservoirs. During the investigations, 103 specimens of pike perch *Sander lucioperca* (Linnaeus 1758) from three reservoirs on the river Neretva and Rama reservoir have been gathered. Determination of the species level has been carried out in the field according to the Vuković (1977), and it was verified in the laboratory of the Ichthyology and Fishing center at the Faculty of Science Sarajevo. Blood sampling from fish has been carried out in the field, and all gathered material was fixed using 4% phormaldehyde, and it was transported to the laboratory. Morphological-taxonomic investigations have included detailed analysis of morphometrical features of all gathered material.

The analysed morphometrical features included:

- total body length (td),
- body length from the tips of middle rays of tail fin (a-b1.),
- body length without tail fin (sd),
- antedorsal distance (Ad.r),
- the length of basis of the first back fin (d.olp1),
- the length of the basis of the second back fin (d.olp2),
- head length (d.g.),
- proboscis length (p.p.),
- eye diameter (d.o.),
- area behind the eye (z.p.),
- anteventral distance (v.r.),
- anteanal distance (Aa.r.) i
- body mass.

The investigations of hematological parameters have included concentration of hemoglobin, value of hematocrit, number of erythrocytes, *mean corpuscular volume* (MCV), *mean corpuscular hemoglobin* (MCH), *mean corpuscular hemoglobin concentration* (MCHC) and the number of erythrocytes.

RESULTS

The results are based on a sample of 103 pike perch specimens gathered during field research on the reservoirs on the river Neretva. Hematological investigations were carried out on 54 fish specimens.

1. Ecological features of the population

The results of the investigations on the pike perch carried out in 2010 have shown that this species, introduced to the reservoirs on the river Neretva, has demonstrated an increased population density. Specimens of various age have been found in the sample, which indicates a high degree of adaptability to the environmental conditions. Migrations of specimens within reservoirs during the year have both horizontal and vertical character, and they are directly related to the changes of ecological conditions throughout the seasons on one hand, and meeting the biological needs of this species on the other hand.

The results of these investigations have shown that pike perch in „the lakes“ on the

river Neretva return to deep waters after November. This patterns of distribution of pike perch individuals in the „lakes“ was confirmed during fishing carried out for the purpose on this study. Also, this fact in the field confirm statements of spor fishermen For short intervals at the beginning and through the night, perch appear on the surface searching for food in certain parts of „the lake“. This is related to the migration of its prey, which usually stay in deeper parts of „the lake“ in April and May during spawning.

2. Morphological-taxonomic features of the species

The analysis of morphological-taxonomic features of pike perch from the reservoirs on the river Neretva include 13 parameters. The results of basic descriptive statistical analysis of investigated characters, that is its relative values in relation to the standard body length (SD), in all gathered specimens are presented in Table 1.

Table 1. Values of morphometric parameters of pike perch from the reservoirs on the river Neretva (n=103)

Tablica 1. Vrijednosti morfometrijskih parametara smuđa iz neretvanskih hidroakumulacija (n=103)

	mass (g)	t.d. (mm)	a-bl.	s.d. (mm)	Ad.r.	d. olp1	d. olp2	d.g.	p.p.	d.o.	z.p.	Av.r.	Aa.r.
Average prosijek	311.8	310.4	94.8	266.7	32.8	25.1	24.5	27.7	6.8	4.6	16.1	30.6	63.4
st. dev. standard error – stand. greška	270.4	66.3	1.8	60.3	17.5	1.3	1.4	1.3	0.5	0.4	1.1	3.2	1.6
minimum	36.0	177.0	91.5	150.0	28.4	21.7	22.2	22.9	5.2	3.8	11.6	2.8	60.0
maximum	2099.0	540.0	107.4	501.0	208.9	28.3	29.34	31.1	8.0	6.2	18.6	34.5	69.7

- total body length (td), body length to the tips of middle rays of tail fin (a-bl.), body length without tail fin (sd), antedorsal distance (Ad.r), length of the first back fin (d.olp1), length of basis of the second back fin (d.olp2), head length (d.g.), proboscis length (p.p.), eye diameter (d.o.), area behind the eye (z.p.), anteventral distance (v.r.), anteanal distance (Aa.r.) and body mass.

- totalna dužina tijela (td), dužina tijela do vrhova srednjih zrakova repnog peraja (a-bl.), dužina tijela bez repnog peraja (sd), antedorzalno rastojanje (Ad.r), dužina osnove prvog lednog peraja (d.olp1), dužina osnove drugog lednog peraja (d.olp2), dužina glave (d.g.), dužina rila (p.p.), dijametar oka (d.o.), zaočni prostor (z.p.), anteventralno rastojanje (v.r.), anteanalno rastojanje (Aa.r.) i masa tijela.

The data from Table 1 show that pike perch population from the reservoirs on the river Neretva include specimens of various length, body mass, and of varying age. Without entering into detailed elaboration of these data it is important to stress that the sample includes specimens of fingerlings of 36.0 g and 177.0 mm, as well as large specimens of 2099.0 g and 540.0 mm.

3. Haematological status of pike perch from the reservoirs on the river Neretva

The blood from 15 specimens of age 2.5+, was analysed in the spring and the largest variation coefficient was recorded for haematological index MCH. In the summer, 15 specimens of mean age 2.5+ were analysed, as in the spring, but with the largest variation coefficient for parameter MCV. 13 specimens (4.6+) in the autumn season and 11 specimens (3.8+) in the winter season exhibited the largest variation coefficient for haematological index MCHC.

Table 2. Values of haematological parameters of pike perch in various seasons

Tablica 2. Vrijednosti hematoloških parametara smuđa u sezonskom aspektu

Seasons	statistics	Hct (l/l)	Hb (g/l)	Number of erythrocytes ($\times 10^{12}/l$)	MCV (fl)	MCH (pg)	MCHC (g/l erc)	Number of leukocytes ($\times 10^9/l$)
Spring n=15 proljeće n=15	mean	0.351	113.72	1.763	201.64	65.80	330.26	3.183
	stand. deviation	0.06	21.10	2.45E+11	40.09	15.93	59.91	5.017E+08
	minimum	0.285	74.10	1.350	156.41	40.27	148.20	2.250
	maximum	0.500	151.24	2.290	271.74	96.09	403.49	3.940
	variation coefficient	17.250	18.556	13.906	19.881	24.217	18.140	15.761
Summer n=15 ljetó n=15	mean	0.393	101.85	2.040	196.79	50.77	264.91	3.159
	stand. deviation	0.056	11.23	3.15E+11	40.60	8.52	48.38	4.416E+08
	minimum	0.315	78.43	1.580	121.62	40.43	153.78	2.450
	maximum	0.510	120.00	2.770	262.89	69.91	341.37	3.940
	variation coefficient	14.205	11.023	15.455	20.629	16.772	18.262	13.977
Autumn n=13 jesen n=13	mean	0.377	122.52	1.662	229.87	74.08	334.80	4.140
	stand. deviation	0.055	25.66	2.03E+11	41.48	14.88	100.75	3.456E+08
	minimum	0.295	78.30	1.450	131.70	45.52	180.41	3.740
	maximum	0.500	168.44	2.240	293.10	108.74	570.98	4.870
	variation coefficient	14.495	20.941	12.218	18.044	20.092	30.091	8.348
Winter n=11 zima n=11	mean	0.397	126.48	1.735	230.86	73.372	336.56	5.888
	stand. deviation	0.071	22.96	1.67E+11	46.98	14.24	124.48	4.302E+08
	minimum	0.255	98.30	1.550	147.20	54.01	203.10	5.140
	maximum	0.494	159.46	2.140	283.85	97.23	625.33	6.640
	variation coefficient	17.852	18.152	9.610	20.352	19.408	36.984	7.305

Mean values of haematocrit have been largest in the winter season (0.397 l/l), and the lowest in the spring season (0.351 l/l). The lowest mean values of hemoglobin have were found in the summer (101.85 g/l), and the largest in the winter season (126 g/l). Pike perch specimens have the largest values of erythrocyte number in the summer 2.040 ($\times 10^{12}/l$), and the lowest in the autumn 1.662 ($\times 10^{12}/l$). This is significantly different from the values

for leucocytes, which have shown the largest values in the winter 5.888 ($\times 10^9/l$), and the lowest in the summer 3.159 ($\times 10^9/l$). The results of the analysis of haematological indices (MCV, MCH and MCHC) indicate that all mentioned parameters have exhibited a similar trend, with the lowest values in the summer. The highest mean values for MCV and MCHC were found in the winter, while MCH had the highest value in the autumn. Detailed overview of haematological parameters is presented in Table 2.

DISCUSSION

Ecological, morphological-taxonomic and haematological characterisation of pike perch in this paper provides a continuation of the scientific monitoring of this species in the system of reservoirs on the rivers Neretva and Rama following its uncontrolled introduction between 1985 and 1991. The data describing its initial discovery were presented in investigations from 1990 (Škrijelj, 1995), when the presence of pike perch was recorded in the composition of ichthyofauna from the reservoir Rama. In that work it was stressed that pike perch will very soon migrate, either naturally or again by uncontrolled transport by sport fisherman, from the reservoir Rama into „lakes“ on the river Neretva, which actually was observed. Latter investigations of populations of this species (Škrijelj and Mašović, 2001) have shown that without any doubt they, thanks to their biological features, have a high degree of adaptability, covering all ecological niches in the mentioned ecosystems. Additional investigations have included the nutrition of this species in reservoirs on the river Neretva (Trožić-Borovac and Škrijelj, 2007). The results of analysis of the content of the digestive tract of 27 pike perch specimens indicate diverse nutrition caused by the capacity of the water ecosystem and size of the specimens. In the reservoirs Salakovac and Mostar there was a pronounced cannibalism of pike perch, typical for specimens of 30 cm length. The specimens from the reservoir Grabovica with a length less than 30 cm fed on zoobenthos, with stomach contents even including algae. Tendency for predation on other fish species was pronounced in the reservoirs where higher competition was present. High levels of predation of pike perch (in larger specimens) endangered autochthonous fish species (*Salmonidae* and *Cyprinidae*), which caused increased ecological changes in the middle course of the river Neretva in the negative sense. Concerning nutrition, this species have pronounced predator features which jeopardize survival of other fish species in the investigated ecosystems. It is important to stress that water level oscillations caused by hydro power plants, high levels of precipitation, or an extreme decrease in precipitation could significantly modify water level, and therefore had a direct impact on the distribution of pike perch in the reservoirs.

Investigations of haematological parameters (hemoglobin concentration, hematocrit value, number of erythrocytes, average volume of erythrocytes (MCV), medium value of hemoglobin quantity per erythrocyte (MCH), medium value of hemoglobin quantity per liter of erythrocyte (MCHC) as well as the number of leucocytes) on the specimens of pike perch from the reservoirs on the river Neretva have been carried on 26 females and 28 males trought four seasons.

On the basis of the data presented in Table 2 it could be noted that investigated hae-

matological parameters show seasonal variations. The values of hematocrit and hemoglobin show slight tendency of increase in the period from the spring to the winter, when the highest values have been recorded. On the other hand, the highest values of erythrocyte have been recorded in the summer season, and they decrease to the winter. The results of the analysis of haematological indices MCV, MCH and MCHC show slight trend of increase of these values from the spring to the winter, which was also recorded for the values of leucocyte number. Obtained results indicate seasonal variation of haematological parameters in both sexes. Statistically significant variation for values of MCHC and the number of leucocytes has been recorded in females. For males, statistically significant variation have been recorded for values of the number of erythrocytes, MCHC, and the number of leucocytes. On the basis of these data it could be concluded that in both sexes exist seasonal variations in the number of leucocytes and values of haematological index MCHC.

Although there is just a small number of papers focused on the investigations of haematological status of pike perch, it is possible to compare obtained results with the results from literature.

Muller et al. (2006) stress that increased sensitivity of pike perch to the changes in the dissolved oxygen concentration and that this could be one of the factors responsible for sensitivity of this species to growth in aquaculture.

However, above mentioned researchers do not give reliable information about parameters involved in the sensitivity, and particularly there are no any data about influence on dissolved oxygen concentration on hemoglobin values and the other indicators of haematological status.

The investigations in this paper complete knowledge on the morphological-taxonomic and haematological features of populations of pike perch.

In the future, on the basis of molecular biological comparative investigations it will be possible to provide more precise answers concerning the origin of introduced specimens resulting in already rich population of pike perch in the reservoirs on the river Neretva.

Sažetak

EKOLOŠKA, MORFOLOŠKO-TAKSONOMSKA I HEMATOLOŠKA KARAKTERIZACIJA SMUĐA (*sander lucioperca*, LINNAEUS 1758) IZ NERETVANSKIH HIDROAKUMULACIJA

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U radu su prikazane ekološke, morfološko-taksonomske i hematološke značajke smuđa (*Sander lucioperca*, Linnaeus 1758) kao introducirane vrste u hidroakumulacijama na rijeci Neretvi u Bosni i Hercegovini. Terenska istraživanja provedena su u periodu od studenog 2009. godine do studenog 2010. godine. Ukupno je analizom za morfološko-taksonomske parametre obuhvaćen uzorak od 103 jedinke od kojih je 54 podvrgnuto istraživanjima hematoloških parametara. S aspekta ekologije populacija smuđa u neretvanskim „jezerima“ ima tendenciju povećanja gustine, obuhvaća jedinke različite životne dobi i pokazuje visok stupanj adaptiranosti u ekosustavima hidroakumulacija. Morfološke karakteristike jedinki pokazuju prisustvo većeg broja generacija što ukazuje da se ova vrsta uspješno mrijesti u istraživanim ekosustavima. Od ukupno sedam hematoloških parametara najveći koeficijent variranja po sezonama utvrđen je kod hematoloških indeksa MCV, MCH i MCHC.

Cljučne riječi: *Sander lucioperca*, neretvanske hidroakumulacije, ekološki, morfometrijski, hematološki

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