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The Effects of Introduction of Pike-perch (Sander Lucioperca Linnaeus, 1758) on Native Species in Hydroaccumulations on the River Neretva

Sanel Riđanović[1*], Lejla Riđanović[1], Rifat Škrijelj[2] and Pavle Spasojević[1]

[1]Department of Biology, Faculty of Education, University Džemal Bijedić, Univerzitetski kampus bb88000 Mostar, Bosnia and Herzegovina

[2]Department of Biology, Faculty of Science Sarajevo, University of Sarajevo, Bosnia and Herzegovina

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***For Correspondence**

Sanel Riđanović, University Džemal Bijedić, Faculty of Education, Department of Biology, Bosnia and Herzegovina, Tel: +387 36 514 217.

E-mail: sanel.ridjanovic@unmo.ba

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ABSTRACT

Introduction of allochtonous fish species is a form of biological water pollution. These species are biological entities distributed outside the scope of their own natural distribution range. When an introduced fish species successfully adapt to new ecological conditions, they significantly reduce the number of indigenous species. This papers aims to determine impacts that introduction of allochtonous, invasive species Sander *lucioperca* Linnaeus, 1758 has on native fish species in lakes on the river Neretva. The research was conducted from August 2012 to March 2013. Fieldwork was conducted at three selected sampling sites, Slatina, Ostrožac and Ribići. The content of gastrointestinal tract of Sander *lucioperca* was examined in order to determine its main diet and elucidate whether it preferably feeds on native or other introduced species. The main findings of the study suggest that Sander *lucioperca* mainly feeds on *Alburnus arborella*, Bonaparte, 1841, occassionally on *Carasius auratus gibelio*, Bloch, 1783 and rarely on *Gasterosteus aculeatus*, Linnaeus, 1758.

INTRODUCTION

Construction of dams and subsequent water accumulations irretrievably changes ecological conditions of streams. It often happen that prior to conversion into artificial lakes, these streams are not researched at all and thus ichthyofauna remains unexplored. In the middle catchments of the Neretva River, Bosnia and Hercegovina, four large dams were constructed with accompanying accumulation lakes. Neretva is the largest tributary of the entire eastern coast of the Adriatic Sea. Ichthyological research of Neretvian lakes is increasingly becoming a subject of interest for many scientists. Eleven introduced species have been found in the basin of the river Neretva, including its accumulation lakes. These species are biological entities distributed outside the scope of their own natural areal. They usually fail to establish themselves in new environments due to aggressiveness of local predators, the lack of adaptation to a new way of life or the lack of available ecological niches. However, in other cases, when an introduced fish species successfully adapt to new ecological conditions, they significantly reduce the number of indigenous species. Especially, this is the case with predatory species such as pike-perch (*Sander lucioperca* Linnaeus, 1758), which was introduced into Neretva.

Sander lucoperca is an invasive species in many countries of Europe with a long history of introduction outside its natural habitat. In some cases this species has been used as a biological regulator of unwanted cyprinid populations [1,2]. The natural areas of *S. lucioperca* covers the river basins of the Caspian Sea, the Baltic, Black and Aral sea basins, the river Elbe basin (the basin of the North Sea) and the river Marica (basin of the Aegean Sea) in the north to about 65°N in Finland [3]. As a result of uncontrolled introduction, this species is now present in the greater part of the European continent, as well as the parts of Asia (Turkey) and Africa. Areal of *S. Lucioperca* at this moment, includes countries such as Netherlands [4-8]. *S. Lucioperca* in most cases was introduced into lakes and then spread out to rivers, such as Gudenaa in Denmark. In Sweden and other countries restocking was done by species such as *S. Lucioperca* in order to meet the needs of local anglers [9]. There are also reports of illegal stocking by anglers [10].

In the past, areal of *S. Lucioperca* in Bosnia and Herzegovina was limited to the waters of the Black Sea basin. The first

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official record of the species *Sander lucioperca* Linnnaeus, 1758 in the Nereva river basin (the Adriatic sea basin) was recorded in 1990, when it was determined that an introduction to this basin was unplanned and uncontrolled, without official records neither of the time of stocking nor of quantity, age and origin of the introduced fish [11]. It is recorded that in an artificial lake Jablanica, allochtonous species *Sander lucioperca* was well established and had grown into a numerous population (25.42%) [12]. The population of this species is more sparsely present in the lake of Salakovac (6.84%), while in the lake of Grabovica its population is slowly establishing itself (3.85%). Jablanica lake, after its establishment was inhabited by numerous native and endemic species from the families *Salmonidae Cyprinidae*. Introduction of *S. lucioperca* led to disappearance of endemic species such as: *Salmo obtusirostris*, *Salmo marmoratus* i *Phoxinellus alepidotus,* which in addition to anthropogenic pressures on the habitat is a direct consequence of a predatory way of feeding of *S. lucioperca*. The present study aims to determine impacts of *Sander lucioperca* on native fish species of Neretvian lakes.

MATERIALS AND METHODS

Jablanica Lake was established in 1953, completed by a dam with a total height of 85 m on the river of Neretva. The total surface area of the lake is 14.3 km², with the length of 31 km and elevation of 220 m [13]. The maximum capacity of Jablanica reservoir is around 290 km with the surface area of 1,440 ha.

The maximum depth is 80 m, and the water level ranges from 25 to 30 m [14]. The present study was conducted between August 2012 and March 2013. Field investigations and fishing were conducted at three sites, Slatina, Ostrožac and Ribići. The fishing nets of different diameters were used, including sports fishing equipment. All individuals were measured upon capture. After measurements of their body length, the analysis of the digestive tract content was performed. All samples were preserved in 96% alcohol solution Determination of species found in the digestive tract was performed using the appropriate keys **(Figure 1)**.

Figure 1. Digestive tract contents of *Sander lucioperca* Linnaeus, 1758 samples from the lake Jablanica.

In the analysis of the feed intake of *Sander lucioperca,* the following parametres were used: the number of coefficient organisms found in the digestive tracts; coefficient of emptiness of the digestive tract; and the method of domination. The number of each nutritional category was expressed as a percentage of the number of organisms found. This method gives an indicaton of organisms that are found in greater numbers, but does not provide information on their quantity, nor it takes into account certain categories that are poorly digested. This method is very quick and easy, but it underestimates the importance of larger prey. The coefficient of the number of empty digestive tracts was expressed with respect to the total number of all investigated intestinal tracts and were used for determination of seasonal activity patterns and rhythm of feeding. Coefficient of emptiness of digestive tract was calculated according to the formula:

$$V = \frac{\text{Number of empty digestive tracks}}{\text{Total number of all examined digestive tracks}} \times 100$$

The method of domination includes determination of food type which is numerically and volumetrically a main component of all examined intestinal tracts. It is expressed as a percentage of all examined intestinal tracts. This method is very similar to a percentage of frequency of occurrence, even though the results are expressed as the number of fish in whose intestinal tract there were found species that are represented in percentages in relation to the total number of fish. With this method it can be

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determined what represents the main source of nourishment for *Sander lucioperca*. The method of domination was calculated according to the following formula:

$$D\%=\frac{si}{\sum S}\times 100$$

Where:

si – represents number of digestive tracts which contain certain categories of pray.

$\sum s$ – total number of digestive tracts including empty ones [15].

RESULTS

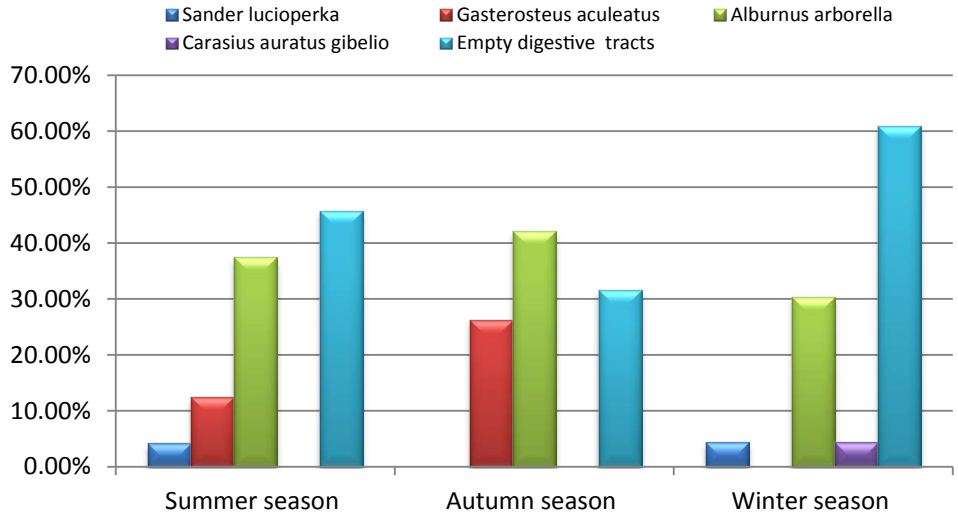
Over the three seasons of the research, a total of 66 individuals of *Sander lucioperca* were caught. The largest number of *S. lucioperca* was caught during the summer season, with 24 individuals in total. This represents 36.37% (24/66–expressed as percentage) of the total sample. Fishing in this season began after spawning in the spring (April–June). The total length of analysed *Sander lucioperca* individuals ranged from 32 to 75 cm. In the autumn season, 19 individuals were caught, representing 28.80% of the total sample, while during winter on the Jablanica lake, 23 individuals were caught (34.84% of the total sample). The total length of analysed samples of *Sander lucioperca* was between 21 and 44 cm **(Table 1)**.

Table 1. Absolute and relative abundance represented in percentages (%) of individuals of *Sander lucioperca* Linnaeus, 1758 caught in the Jablanica lake.

Season	Number of samples caught	%
Summer 2012	24	36.37
Autmn 2012	19	28.79
Winter 2013	23	34.84
Total	66	100

In the summer season, 24 digestive tracts of *Sander lucioperca* individuals were examined. Digestive tracts were found empty in 45.83% of the total sample. In 54.17% of the sampled individuals, a several different fish species were found. The analysis of digestive tracts during summer shows that 4.17% samples fed on individuals of its own species, 12.50% fed on *Gasterosteus aculeatus*, Linnaeus, 1758 and 37.50% of samples fed on *Alburnus arborella*, Bonaparte, 1841, which was accidentally introduced into this lake. There was no evidence of presence of phytoplankton and zooplankton in digestive tracts as was reported in previous studies. During the winter season, out of 19 analysed samples, five individuals of *Sander lucioperca* (26.32%) where found to feed on *Gasterosteus aculeatus*, Linnaeus, 1758, eight individuals (31.58%) fed on *Alburnus arborella*, Bonaparte, 1841 and six individuals (42.10%) had an empty digestive tract.

According to these findings it can be stated that *Sander lucioperca* mainly feeds on *Alburnus arborella*, Bonaparte, 1841. It is interesting to note that within digestive tracts of *S. Lucioperca,* neither indigenous fish species from the *Salmonidae* family nor insect larvae nor algae were found. The results show that most individuals of *Sander lucioperca* from the lake of Jablanica had an empty digestive tract. The main diet of *S. Lucioperca* consists of individuals of *Alburnus arborella* species **(Graph 1)**.



Graph 1. Diet of *S. Lucioperca* individuals from Jablanica lake.

DISCUSSION AND CONCLUSION

Previous studies show that individuals of *Sander lucioperca* from the Jablanica lake feed on fish [16]. However, they further

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state that in the other lakes of the Neretva basin the diet of *Sander Lucioperca*, besides fish, consists of insects and algae. After introduction of *Sander lucioperca* in the Ramsko lake in 1990 this species had rapidly settled in the Neretva's lakes and had the most abundant population in Jablanica Lake [12]. An uncontrolled introduction of this predatory species had a negative effect on the alredy reduced population of endemic *Salmonid* species. Assert that indigenous *Salmonid* species no longer inhabit this water ecosystem [17]. The results obtained in 2003 suggest that Jablanica Lake was inhabited by two newly introduced species: *Alburnus arborella*, Bonaparte, 1841 with a significant population abundance (52.42%) and *Lepomis gibossus*, Linnaeus, 1758 with much smaller population (1.74%). After extinction of indigenous endemic *Salmonid* species, *Sander lucioperca* fed on introduced *Cyprinid* species, which is confirmed in the current study. According to Korjenić et al. in Jablanica Lake there was a significant number of the indigenous *Cyprinid* species, thus *Sander Lucioperca* did not negativelly impact these populations. The current study can certainly contribute to the notion of an almost apsolute extinction of indigenous endemic *Salmonid* species as a result of introduction of allochthonous *Cyprinid* species. Considering these findings, it can be suggested that *Sander lucioperca* mainly feeds on *Alburnus arborella*, Bonaparte, 1841 and occassionaly on *Carasius auratus gibelio*, Bloch, 1783. On the rare occasions individuals of *Sander lucioperca* also feed on *Gasterosteus aculeatus*, Linnaeus, 1758.

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