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A REVIEW OF THE DIET AND INTESTINAL PARASITES OF PONTIC SHAD (*Alosa immaculata* BENNETT, 1835) IN THE DANUBE RIVER

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A bstract

The feeding habits and intestinal parasites of Pontic shad (*Alosa immaculata* Bennet, 1835) from the Danube river were investigated in 2016 and 2017. A total of 180 individuals were collected and examined. The ranges of total and mean length of examined migrants were: 20.3±30.6 to 30.5±36.3 cm for Prahovo locality, and 17.9±26.7 to 27.5±36.7 cm for the Danube Delta, respectively. Parasitic species were identified in 16 fish specimens (18.6%) from Prahovo and 94 fish specimens (100.0%) in the Danube Delta. Representatives of the phylum Nematoda, namely specimens from the Anisakidae family, *Contracaecum* sp., *Contracaecum siniperca* Dogiel & Achmerov, 1946 and *Contracaecum bidentatum* (Linstow, 1899) Skrjabin, 1917 were determined. Identified parasitic fauna shows low diversity, but the intensity and prevalence of infestation are relatively high. With regard to feeding habits, representatives of macrozoobenthos were identified in the intestinal contents, mostly the insect component (Diptera, Ephemeroptera, Plecoptera, Odonata and Planaria). Macrozoobenthos were more present in the intestinal content of Pontic shad captured in Prahovo than in the Danube delta. Also, the intestines of fish specimens from Prahovo contained other structures, such as algae, detritus, sand, and a few terrestrial insects. Even though the Pontic shad represents a commercially important fish species in the lower section of the Danube, research on it in this area has been performed only sporadically.

Key words: *feeding, macrozoobenthos, endoparasites, Danube*
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1. Introduction

Alosa immaculata Bennett, 1835 is a species of clupeid fish of the *Alosa* genus, native to the Black Sea and Sea of Azov basins (Navodaru 2001). It is an anadromous species that lives in deep water while at sea. It has a pelagic life and prefers to feed on small fishes and crustaceans. In spring it migrates to the lower and middle reaches of large rivers, spawning where the current is strongest, close to the surface, usually at 2-3 m depth in the main river channel. A Pontic shad spawns only once or twice in its lifetime (Ciolac 2004). Most spawning in the Danube River occurs between 180 km and 743 km upstream (Kolarov 1985; Schmutz 2006). Pontic shad is a commercially important fish of the Danube Delta (Ciolac & Patriche 2004) and the countries of the Lower Danube Region (Romania, Ukraine and Bulgaria). Populations of the Pontic shad have a declining trend, and according to the IUCN Red List of Threatened Species the species is classified as vulnerable (VU). Although its migratory route upstream in the Danube was shortened to rkm 863 after the construction of the Iron Gate II dam and even though it represents a commercially important fish species in the lower section of the Danube, the research on the Pontic shad has been performed only sporadically in this area (Višnjić-Jeftić 2012). The current threat to the species is overfishing, both at sea and in the rivers during spawning migration which is causing a population decline of unknown levels.
The present study was a novel challenge, to investigate the Pontic shad diet and intestinal parasites of migrants caught 861 km upstream in the Danube River and in the Danube Delta.

2. Material and Methods

Fish samples were collected using driftnets during April, May and June of 2016, and in May 2017, in two locations – Prahovo (rkm 861, Serbia) and the Danube Delta (Romania).
A total of 180 individuals of Pontic shad were collected and examined in the laboratory. For each fish, total length (± 0.1 cm), weight (± 0.1 g) and sex were recorded. Analyses of their intestines for endoparasites and diet were conducted. Appropriate identification keys were used for determination of parasitic fauna representatives, to the lowest possible taxonomic level (Bykhovskaya-Pavlovskaya *et al.* 1962; Bauer 1987; Moravec 1994).

Determination of the macrozoobenthic organisms found in the fish intestines was conducted to the lowest taxonomic level using the appropriate identification keys.

3. Results and discussion

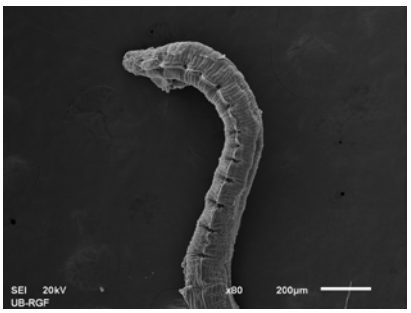
During this study, a total of 180 individuals of Pontic shad were collected and examined in two investigated locations - 86 individuals from Prahovo and 94 from the Danube Delta. The ranges of total and mean length of examined fish were: 20.3±30.6 to 30.5±36.3 cm, and 17.9±26.7 to 27.5±36.7 cm, for Prahovo and the Danube Delta, respectively.

By examination of fish intestines, parasitic species have been identified in 16 fish specimens (18.6%) in Prahovo and 94 fish specimens (100.0%) in the Danube Delta. Among endoparasites, representatives of the phylum Nematoda were identified. Specimens of the Anisakidae family, *Contracaecum* sp., *Contracaecum siniperca* Dogiel & Achmerov, 1946 and *Contracaecum bidentatum* (Linstow, 1899) Skrjabin, 1917 were determined.

The number of examined and infested Pontic shads, their prevalence and intensity of infestation are presented in Table 1.

Table 1. Infestation of Pontic shad with nematodes

Sampling locations	Time of sampling	Number of examined fish	Number of infested fish	Prevalence of infestation	Intensity of infestation
Prahovo	April 2016	10	3	30	Anisakidae (3-42) *Contracaecum* sp. (0-1)
	May 2016	44	13	29.5	Anisakidae(1-99), *Contracaecum* sp.(0-3)
	June 2016	13	0	0	0
	May 2017	19	0	0	0
Danube Delta	April 2016	24	24	100	Anisakidae(1-122), *Contracaecum* sp. (1-34), *C. sinipaerca* (1-2)
	May 2016	25	25	100	Anisakidae (4-163), *Contracaecum* sp.(1-39), *C. bidentatum* (1-15)
	June 2016	45	45	100	Anisakidae (2-173), *Contracaecum* sp.(2-22), *C. sinipaerca* (2-23), *C. bidentatum* (1-22)

a. 

b. 

Figure 1. Images of parasites from the intestines of Pontic shad (SEM), a-Anisakidae, b-*Contracaecum bidentatum*

Parasites of this member of the genus Alosa in the Danube River have been poorly researched (Totoiu et al., 2013) unlike those in the marine environment (Rokicki *et al.* 2009; Barzegar *et al.* 2012; Bao *et al.* 2015; Gerard *et al.* 2017). In all of these studies, nematodes were one of identified parasites.

The parasitic fauna of the Pontic shad from the Danube River is poorly diversified, but the intensity and prevalence of infestation are relatively high.

For all examined fish, there were few empty guts observed. In the intestinal contents of the sampled individuals representatives of macrozoobenthos were identified, mostly insect component (Diptera, Ephemeroptera, Plecoptera, Trichoptera, Odonata and Planaria). Abundance of identified macrozoobenthos is shown in the Figure 2.

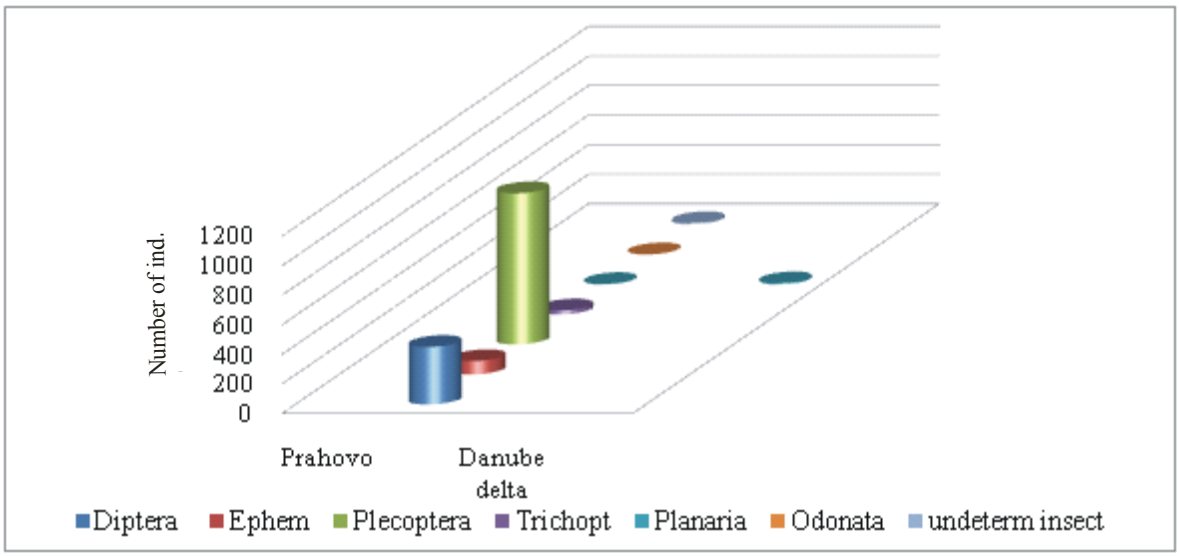


Figure 2. Abundance of the bottom fauna group in the intestinal content of Pontic shad in the Danube River

Pontic shads from Prahovo contained in their intestine 1542 individuals of macrozoobenthos in total, while in Danube Delta 8 in total.

Macrozoobenthos have been much numerous in intestinal content of Pontic shad captured in Prahovo than in the Danube Delta. Also, the intestines of fish specimens from Prahovo were also contained other structures, such as algae, detritus, sand, and a few terrestrial insects.

Many benthic organisms are intermediate hosts for the larval stages of parasites.The feeding habits of fish and their diet are influenced by the available local invertebrate fauna, which is, in turn, determined by water quality and habitat composition.

During upstream migration from the Danube Delta, Pontic shad feed of macrozoobenthos from the drift, as has been shown from intestinal content analysis. This is in contrast to the common view that during the spawning migration from the sea into the river the fish cease feeding (Rozdina *et al.* 2015). Upstream anadromous migration is typical energy-cost behaviour using stored lipids and proteins as energy sources, expending a lot of energy to reach the spawning sites and losing weight along the way (Leonard & McCormick 1999; Rozdina *et al.* 2015). When at sea, the Pontic shads feed on a wide variety of zooplankton (mainly crustaceans -gammarids) and small fish (Freyhof & Kottelat 2008).

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