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Journal of Natural History

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tnah20>

Review of sterlet (*Acipenser ruthenus* L. 1758) (*Actinopterygii*: *Acipenseridae*) feeding habits in the River Danube, 1694–852 river km

V. Djikanovic^a, S. Skoric^b, M. Lenhardt^a, M. Smederevac-Lalic^b, Z. Visnjic-Jeftic^b, S. Spasic^b & B. Mickovic^b

^a Institute for Biological Research “Sinisa Stankovic”, University of Belgrade, Belgrade, Serbia

^b Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia

Published online: 04 Apr 2014.

To cite this article: V. Djikanovic, S. Skoric, M. Lenhardt, M. Smederevac-Lalic, Z. Visnjic-Jeftic, S. Spasic & B. Mickovic (2015) Review of sterlet (*Acipenser ruthenus* L. 1758) (*Actinopterygii*: *Acipenseridae*) feeding habits in the River Danube, 1694–852 river km, *Journal of Natural History*, 49:5-8, 411–417, DOI: [10.1080/00222933.2013.877991](https://doi.org/10.1080/00222933.2013.877991)

To link to this article: <http://dx.doi.org/10.1080/00222933.2013.877991>

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Review of sterlet (*Acipenser ruthenus* L. 1758) (Actinopterygii: Acipenseridae) feeding habits in the River Danube, 1694–852 river km

V. Djikanovic^{a*}, S. Skoric^b, M. Lenhardt^a, M. Smederevac-Lalic^b, Z. Visnjic-Jeftic^b, S. Spasic^b and B. Mickovic^b

^aInstitute for Biological Research “Sinisa Stankovic”, University of Belgrade, Belgrade, Serbia;

^bInstitute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia

(Received 31 October 2012; accepted 18 December 2013; first published online 4 April 2014)

The aim of this work is to present the variation in the sterlet's (*Acipenser ruthenus* L. 1758) diet along the course of the River Danube, from 1694 to 852 river km. The diet of sterlet mostly comprised 12 bottom fauna taxa. Sterlet in the Danube feed mainly on larvae of Trichoptera, Chironomidae (Diptera) and Gammaridae (Amphipoda), with a reduction in food composition variability close to the Djerdap I dam and in the reservoir between the two dams. The other components of the diet were *Corophium* sp., *Asseus* sp., Mollusca, Oligochaeta, Annelida, Insecta, Nematoda and Hirudinea. The organisms typical of lithorheophilic and psammorheophilic biocoenoses play a considerable role in the diet of the sterlet. Composition of bottom fauna as food items varies due to changes in environmental conditions induced mainly by the construction of two dams: Djerdap I (943 river km, 1970) and Djerdap II (863 river km, 1984).

Keywords: sterlet; bottom fauna; diet; invertebrate; spatial variations; sturgeon; River Danube

Introduction

The sterlet (*Acipenser ruthenus*) is a potamodromous and bottom-feeding sturgeon species for which a commercial fishery still exists in the River Danube (Ristić 1970). However, as have other sturgeon species in the River Danube, the sterlet has been affected by a combination of hydropower development, over-harvesting, habitat degradation and pollution (Lenhardt et al. 2006). In the past, the Danube sterlet population extended from Ulm to the Danube delta (Hensel and Holcik 1997). Currently, this species is the most widely distributed sturgeon in the Danube even if its occurrence in the mid and lower sections is limited. Significant changes in sterlet populations were observed in the Serbian part of the River Danube after construction of the Djerdap I [943 river km (rkm), 1970] and Djerdap II (863 rkm, 1984) dams. Mass migration was observed toward upstream regions with faster river flow rates (Janković et al. 1994). Dams are also blamed for a decrease in sterlet catches, preventing their migrations from the lower parts of the River Danube downstream from the Iron Gate gorge (Guti 1995).

The first food that larval sterlet consume are small oligochaetes and larval Chironomidae (Fieszl et al. 2011). The main food of the sterlet in all rivers is benthic organisms. The most important of these are insect larvae, chiefly species of

*Corresponding author. Email: djiki@ibiss.bg.ac.rs

Chironomidae, Trichoptera, Ephemeroptera and Simuliidae. Also included in the diet are larval Plecoptera and Heleidae; small molluscs of the genera *Sphaerium*, *Pisidium* and *Viviparus*; Oligochaeta, Polychaeta, Hirudinea, and other invertebrates (Holčik 1989). During the spawning periods of other fish, sterlet feed readily on the eggs, including those of other acipenserids (Holčik 1989).

Construction of two dams (Djerdap I, Djerdap II) significantly changed the flow regimen in the middle and lower part of the River Danube and the present study was conducted to analyse how this impacted feeding of sterlet in different sectors of the River Danube.

Material and methods

For this work, data were used from four publications (Janković 1958; Janković et al. 1994; Fieszl et al. 2011; Strelnikova 2012) as well as from our material collected from professional fishermen, using nets of different mesh sizes (32–50 mm), at river sectors 1173–1132 rkm during the period 2002–2003. Maps showing nine locations along the River Danube (rkm 1694–852) where diet of sterlet was analysed are presented in Figure 1.

Data concerning total length, total weight, number of examined stomachs and period of catch of the analysed sterlet in the River Danube, 1694–852 rkm are presented in Table 1.

To analyse benthic fauna, frequency of taxa groups ($F\%$) was presented and calculated as the percentage contribution of the groups to the total abundance at each location (rkm).

Results and discussion

During the investigation period, in different seasons, the stomachs of 850 sterlet were analysed.

Analysis of data for sterlet diet at nine locations along the River Danube identified 12 taxa of invertebrate fauna as the main components of the diet (Figure 2). Trichoptera (3.16–54.43%), Chironomidae (4.32–95.77%) and Gammaridae (0.51–98.61%) comprised the main part of sterlet diet, especially in sector 1189–1043 rkm. The remaining components of the diet were insignificant (Mollusca, Insecta, Oligochaeta, *Asellus* sp., Nematoda). Sterlet diet consisted of two or three taxon groups after 956 rkm, with gammarids dominant (96.74–98.61%), whereas Chironomidae larvae (95.77%) dominated at the most downstream locality (852 rkm). Between 1189 and 937 rkm representatives of Hirudinea were identified in the sterlet diet with frequency 1.07–27.36% (Figure 2).

Comparisons of sterlet diet in the 1950s and in 1986 in the River Danube are presented in Table 2. The main prey taxa as representatives of aquatic macrozoobenthos in the studied river sectors, after and before dam construction, were Trichoptera, Chironomidae, Oligochaeta, Hirudinea, Gammaridae and *Corophium* sp. (Janković 1958; Janković et al. 1994).

Bottom fauna groups such as Trichoptera, Chironomidae and Gammaridae were present during both sampling periods, in varying proportions. *Corophium* sp. was abundant in the 1950s along the investigated sector of the river (1215–991 rkm)



Figure 1. Map with nine locations along the River Danube (1694–852 river km) where sterlet diet was analysed.

(Janković 1958) whereas investigations from 1986 to 2003 revealed *Corophium* sp. only in the Hungarian part of the Danube (1694–1676 rkm, Fieszl et al. 2011).

The present study on the sterlet's diet in the River Danube revealed that food composition depended on river sector. The larvae of trichopterans and chironomids, along with gammarids and leeches, were the main prey of the studied fish. Molluscs, oligochaetes, amphipods, isopods and nematodes slightly enriched the feeding spectrum of danubian sterlet.

Comparing seasonal aspects of sterlet feeding in the River Danube shows that the same bottom fauna groups participate in its diet throughout the year with some differences in prey proportions according to season. Stomach contents depend on the bottom fauna composition of each river sector as well as of sampling season. In May, Trichoptera, Amphipoda and Hirudinea were most abundant, whereas in September and October, representatives of Chironomidae, Oligochaeta, Gammaridae and *Corophium* sp. were mainly present in the diet (Janković 1958; Janković et al. 1994; Strelnikova 2012).

Table 1. Total length (TL), total weight (W), number of stomachs examined and period of catch for analysed sterlet; period of catch from 1950 to October 2013, river sector 1694–852 river km.

River sector (river km)	Number of stomachs	TL (cm)	W (g)	Month/year of catch
1694–1676	85	25.0–58.0	200–2300	Jul, Aug 1991/92
1402	*	**	**	May 1986
1189	*	**	**	May 1986
1173–1170	144	24–45	109–943	Nov 2002, Jun-Oct 2003
1132	*	**	**	Sep 1986
1043	*	**	**	May 1986
956	*	**	**	Sep 1986
937	*	**	**	May 1986
852	*	**	**	Sep 1986
1215–1173	136	17.0–63.5		1950s
1173–1077	115	27.0–62.0		1950s
991	198			1950s

Notes: *During the Danube survey in this project 172 individuals were analysed
**TL in range 28.0–54.5 cm, W in range 110–1200 g.

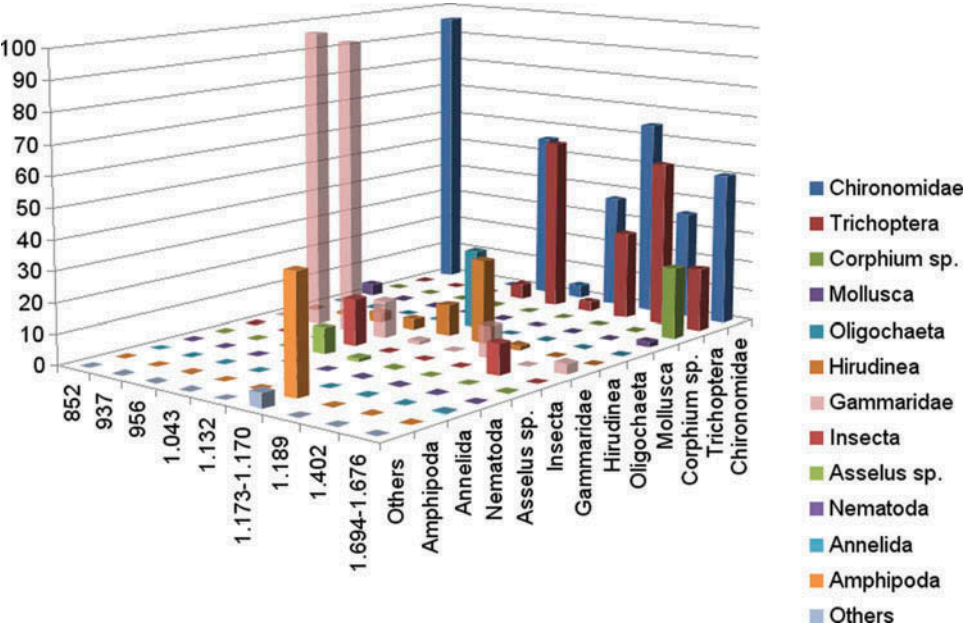


Figure 2. Relative abundance of food items (bottom fauna taxa) found in the stomach contents of sterlet sampled from the River Danube.

Upstream of the Belgrade section, Chironomidae and Trichoptera have great importance in the sterlet diet. In the Belgrade section Amphipoda and Hirudinea are also important, whereas Oligochaeta, Gammaridae and Chironomidae are also

Table 2. Comparison of the main prey taxa relative abundance (sterlet diet) in 1950s and 1986 in the River Danube.

Year	Relative abundance of bottom fauna taxa (%)					
	1950s	1986	1950s	1986	1950s	1986
River sector (river km)	1.215–1.173	1.189	1.173–1.170	1.132	991	1.043
Trichoptera	34.8	29.0	44.9	57.3	10.8	4.9
Chironomidae	13.2	64.7	40.1	4.3	11.8	55.6
Oligochaeta	0	0	0.3	25.9	0	0.2
Hirudinea	0	0.6	0	10.3	0	3.3
Gammaridae	15.3	5.3	0.1	1.1	0.2	12.0
<i>Corophium</i> sp.	35.0	0	7.8	0	76.6	0
Others	1.7	0.4	6.7	1.1	0.6	23.9

important in the downstream sector (Janković 1958; Janković et al. 1994; Strelnikova 2012). The large amount of Gammaridae found in the stomach contents in the downstream river sector is in line with a statement by Holčík (1989), who noticed that in the section of the Volga near its mouth, gammarids play a large role in the diet of the young fish, accounting for over 90% of all contents. Under natural conditions, *Acipenser ruthenus* feeds mostly on larval Ephemeroptera and Diptera, other aquatic insects that fall onto the water surface, and small benthic organisms including small snails and leeches (Ermolin 1977).

Prey selection in sturgeon often follows a seasonal sequence due to prey availability. Hence, the samples from the river sectors above dams, or samples from below the dams, came from different times of the year and different years, as well. Analysis of data on the structure of the macrozoobenthos community before construction of the Iron Gate Dam on the River Danube and after its construction indicates that certain global changes have occurred in the structure of this community. Among these changes are decreases in the abundance of populations of amphipods, some species of gastropods and bivalves, and increases in the abundance of pelophilous and phytophilous forms of the group Oligochaeta and pulmonate gastropods (Simić and Simić 2004). The abundance of amphipod crustaceans, especially species of Ponto-Caspian origin, has declined in the Iron Gate region. Representatives of Gammaridae and *Corophium* sp. were encountered in later years (Simić and Simić 2004). It can be seen from the results that Ponto-Caspian species such as *Corophium* sp. is more sensitive than Gammaridae (Simić and Simić 2004). During research conducted under the international project “Joint Danube Survey 1 and 2”, Mollusca dominated both in terms of the number of species and their relative abundance, followed by representatives of Chironomidae and Oligochaeta (Paunovic et al. 2010).

Janković (1958) showed that Trichoptera, Chironomidae and Amphipoda were present in the sterlet diet throughout the year and represented the main part of its diet and are partly in accordance with works of Rusev (1963), Usynin (1978) and Nagy (1987), which found that the diet comprises mostly larval Chironomidae, Trichoptera and Ephemeroptera, as well as with the most recent studies of sterlet nutrition (Lapkina et al. 2005) which showed that Chironomidae and Hirudinea were dominant sterlet food. A remarkable reduction of variability in sterlet diet composition

occurred after the dams' construction and the formation of reservoirs, probably resulting from changes in the invertebrate benthic fauna due to alterations in the environmental conditions (Jankovic et al. 1994).

Dam building and habitat destruction highly impacted the sterlet's spawning places through the accumulation of silt, as stated by Strelnikova (2012), as well as its feeding grounds. This work presents a review of sterlet diet in the lower and middle parts of the River Danube, which are impacted by dam building.

Acknowledgement

The present work was carried out within the framework of activities of a project funded by the Ministry of Education, Science and Technical development of the Republic of Serbia (Project No. 173045).

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