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SHORT COMMUNICATION

Feeding ecology of sterlet *Acipenser ruthenus* L. in the Hungarian section of the Danube River

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Abstract. The aim of the study was to describe the feeding habits of sterlet, *Acipenser ruthenus* L., in the mid section of the Danube (km 1676-1694). The fish were caught in the summers of 1991 and 1992. The food composition of 85 sterlets (mean body length BL = 37.1 cm; body weight W = 540 g) was analyzed. Most of the fish analyzed (98.8%) had full digestive tracts. Sterlet is considered to be a typical benthic feeder. The food analyzed contained insect larvae and pupae (Trichoptera, Chironomidae), amphipods (*Corophium* sp., *Gammarus* sp.), bivalves (Bivalvia), polychaetes (Annelida) and barbel, *Barbus barbus* (L.). The dominant food items in the digestive tracts were larval caddisflies (Trichoptera), Corophium (Amphipoda), and larval Chironomidae. Regardless of sterlet body size, the fish consumed Chironomidae followed by Trichoptera. The remaining components were noted in the food rarely and in small quantities. One exception were bivalves that were a considerable dietary component of the largest sterlet size group.

Keywords: *Acipenser ruthenus*, diet, invertebrate fauna, river

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Introduction

Sturgeon catches all over the world decreased radically in the past century (Pikitch et al. 2005). This happened because access to spawning grounds was limited by the construction of artificial barriers on rivers, fisheries exploitation was too intense, and water pollution increased. Regulation works conducted on the Danube riverbed in the 1950s and 1960s, dam construction, and deepening the riverbed caused decreases in water levels in oxbow lakes. Constructions on the river deprived the sturgeon of most of their spawning and feeding grounds (Tóth 1979, Bloesch et al. 2006, Holčík et al. 2006, Guti and Gaebele 2009). Furthermore, inland shipping has also led to increased sturgeon mortality. These losses were not fully compensated for by stocking with material obtained from artificial spawning, the intensity of which also began decreasing in the mid 1980s (Hensel and Holčík 1997).

Five sturgeon species once occurred in the Hungarian part of the Danube River, but after 1970 they had all but disappeared from the ichthyofauna of the upper and mid segments of it. The decline in sturgeon population abundance was caused by the construction of various barriers on the Danube. Beluga, *Huso huso* L., and starry, *Acipenser stellatus* Pallas, sturgeon practically do not occur in this part of the Danube (Guti 2008). However, the bastard sturgeon, *Acipenser nudiventris* Lovetsky, and the non-migratory population of Russian sturgeon, *Acipenser guldenstaedti* Brandt, occur sporadically. The only sturgeon family representative that remains in greater numbers in this part of the Danube is the sterlet, *Acipenser ruthenus* L. This species has been able to survive as its life cycle is linked entirely with fresh water, and it is not as sensitive to pollution as are other sturgeon species.

Sterlet is a freshwater species and also the smallest of the family Acipenseridae. It inhabits rivers in the basins of the Black and Caspian seas and Siberian rivers from the Irtysh to the Yenisey (Kottelat and Freyhof 2007). It is listed as endangered on the IUCN 2006 Red List. In the past, the Danube population was distributed from Ulm to the Danube delta (Hensel and Holčík 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. Its numbers are very low in the Austrian part of the Danube (Schiemer and Spindler 1989), while this species does not occur in the German part of the river (Hensel and Holčík 1997). Sterlet is a typical benthic fish that prefers slow-flowing river segments with waters that are productive and rich in food. It also occurs in lakes and dam reservoirs. In delta areas it can form populations that migrate in search of food into marine areas where waters are freshened by river discharge (Holčík 1989, Kalmykov et al. 2010). The first food that larval sterlet consume are small forms of oligochaetes and larval Chironomidae. As the larvae grow, their food becomes more varied and by mid summer, the food composition does not differ from that of adults (Greze 1957). Under natural conditions, this species feeds mostly on larval Ephemeroptera and Chaoboridae, other insects that fall onto the water surface, and small benthic organisms including small snails and leeches (Ermolin 1977). In some regions of the Volga, this species feeds on the eggs of other sturgeon species in their spawning grounds (Kazančev 1981).

The food composition of sterlet in the Hungarian part of the Danube is not well known, which is why the aim of the current study was to determine the food composition and feeding strategies of individuals of various sizes.

Material and methods

The study focused on an 18-km (km 1676-1694) segment of the Danube located 40 km to the north of Budapest between the cities of Vac and Visegrad. This is a crucial stretch of the river known as the Danube Bend. In the 1950s, there were still eight larger islands. During river regulation, dams were built between the bank and the islands, and the river was deepened upstream from the islands near the water inflow to the islands. These changes resulted in the terrain between the bank and the islands became muddy. Currently, only when waters are high are these areas submerged, and then many species use these areas as spawning grounds; however, when the water levels fall, the eggs or larvae die. The sterlet used in the study were caught in July and August 1991 and 1992 at eight study sites (Table 1) with different bottom characters. The catches were made with drift-nets and beach seine with a wing length of 300 m. The fish caught were decapitated, the body length was measured (BL ± 1 mm) and body weight (W ± 10 g) was determined. Next, the entire digestive tract was prepared and preserved in a 5% formalin solution. In 1991, the contents of 35 digestive tracts were examined, while in 1992 that of 50 sterlet were examined (Table 2). The stomach contents were examined under a binocular magnifying glass to the lowest possible taxonomic unit. Weight standards were used to calculate the weights of the food components (Prejs and Colomine 1981). The food composition was determined based on the number and weight shares of the food components and on the index relative importance (Hyslop 1980). The graphical method modified by Amundsen et al. 1996 was applied to describe feeding, and to do this the fish were divided into six body length categories (I – 25.0-30.5 cm, II – 30.6-33.5 cm, III – 33.6-36.5 cm, IV – 36.6-40.5 cm, V – 40.6-45.5 cm, VI – 45.6-58.0 cm).

Table 1
Details of sites used for diets analysis

Station	Date	River section (km)	Bottom substrate	Depth (m)	Distance from bank (m)
1	4 August 1992	1676	mud, gravel	4-5	100
2	31 July 1992	1678	mud	1-5	120
3	28 July 1991	1680	mud, sand	3	60
4	15 July 1992	1683	mud	3-4	100
5	9 August 1992	1684-85	gravel	2-6	50-150
6	4 August 1991	1687-88	gravel	8-9	250
7	30 July 1992	1689	gravel, stones	8	50-200
8	6, 13 August 1992	1694	gravel, stones	6	20

Table 2
Sample size and total length and body weight characteristics of sterlet used in feeding ecology analysis

		Total length (cm)			Body weight (g)		
Date	N	Mean	SD	Range	Mean	SD	Range
July 1991	27	39.0	6.12	31.0-58.0	568	391	210-1980
August 1991	8	42.0	8.13	33.0-56.2	899	744	350-2300
July 1992	19	35.6	3.64	25.0-40.5	424	152	230-700
August 1992	31	35.1	5.18	28.0-50.3	494	327	200-1840

Results

Sterlet food contained insect larvae and pupae (Trichoptera, Chironomidae), amphipods (*Corophium* sp., *Gammarus* sp.), bivalves (Bivalvia), polychaetes (Annelida), and barbel, *Barbus barbus* (L.). In 1991, 97% of the sterlet analyzed had full stomach, but in 1992 all of the fish had full stomach. In the first year of the study, the most important components of the diet were Trichoptera and *Corophium* sp. (Table 3). The value of the index of relative importance of larval Trichoptera in the food of the sterlet analyzed was an average of 68.7% (88.9% – VII and 62.5% – VIII). Corophium (%N = 40.7, %W = 14.9, %FO = 51.4) was the second most important component of sterlet food. The remaining components were insignificant dietary constituents it the diets of the fish analyzed. The index of relative

Table 3
Diet of sterlet in Danube River in the 1991-1992 period: percent number (%N), percent biomass (%W), index of relative importance (%IRI) of the main food components

	Fish caught in 1991 (N = 35)				Fish caught in 1992 (N = 50)			
Food category	%N	%W	%FO	%IRI	%N	%W	%FO	%IRI
Corophium sp.	40.7	14.9	51.4	25.0	6.3	3.5	24.0	1.9
Gammarus sp.	5.9	5.9	20.0	1.8	0.8	1.4	10.0	0.1
Trichoptera	34.7	60.8	82.9	68.7	6.8	20.9	50.0	15.9
Chironomidae	18.0	11.0	14.3	2.3	82.7	46.7	92.0	81.4
Annelida	0.3	4.7	8.6	1.4	0.0	0.0	0.0	0.0
Bivalvia	0.3	2.6	17.1	0.8	3.4	27.4	8.0	0.7
Pisces (*Barbus barbus*)	0.1	0.1	5.7	0.0	0.0	0.1	2.0	0.1

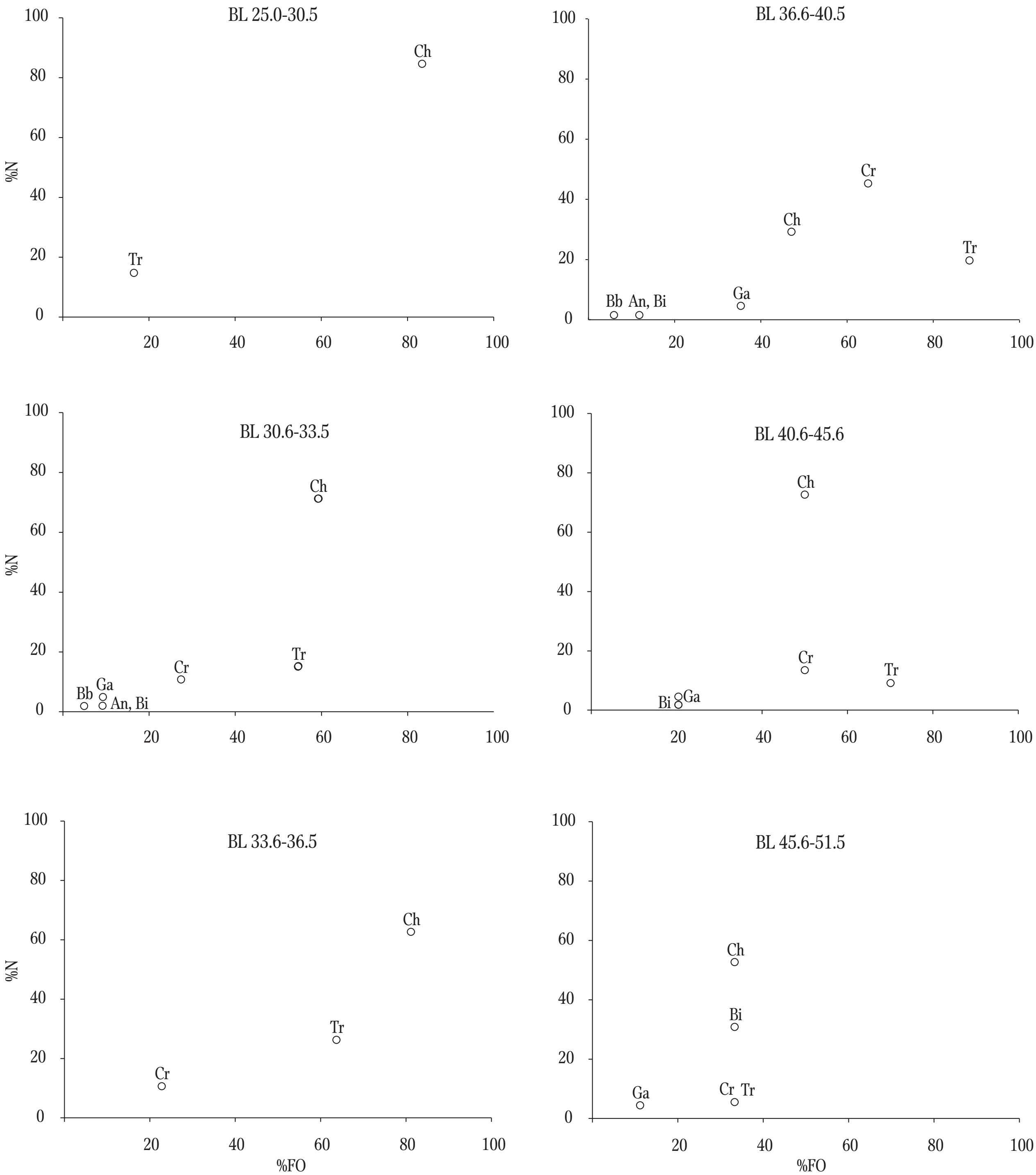

Figure 1. Feeding strategies of sterlet depending on body length (BL). %FO – frequency of occurrence, %N – prey species abundance, Cr – Corophium, Ga – Gammarus, Tr – Trichoptera, Ch – Chironomidae, An – Annelida, Bi – Bivalvia, Bb – *Barbus barbus*.

importance for these ranged from 0.8% (Bivalvia) to 2.3% (Chironomidae). In the second year of the study the most important dietary component of the sterlet diet was larval Chironomidae (%N = 82.7, %W = 46.7, %FO = 92), while the second most important component was larval Trichoptera (%N = 6.8, %W = 20.9, %FO = 50). The remaining components comprised a small portion of the sterlet diet (Table 3).

Regardless of body size, sterlet preferred consuming Chironomidae followed by Trichoptera (Fig. 1). The numerical share of larval Chironomidae in sterlet food ranged from 29 to 85% with a frequency of 33 to 83%. The numerical share of larval Trichoptera was from 6 to 26% at a frequency of 17 to 88% depending on fish size. Among the other groups of organisms identified in the digestive tracts of the sterlet, Corophium was often consumed by sterlet with body lengths from 36.6 to 40.5 cm. The other components of the sterlet diet were consumed occasionally at frequencies that rarely exceeded 30% at a numerical share of no more than 5%. The only exception was Bivalvia which comprised a 31% numerical share and a weight share as high as 90% in the diets of the sterlet from the largest length class analyzed (Fig. 1).

Discussion

Sterlet is considered to be a typical bottom feeder. Its diet comprises mostly larva Chironomidae, Trichoptera, and Ephemeroptera (Rusev 1963, Usynin 1978, Nagy 1987). In addition to this, sterlet food also contains larval stoneflies and dragonflies, hemipterans, isopods, amphipods, oligochaetes, small crustaceans, and, sporadically, fish. All of these organisms are small in size, and probably have little chance of escaping. In addition to these characteristics, the availability and abundance of the prey also impacts the composition of the sterlet diet. In the Bulgarian segment of the Danube, the dominant component of sterlet diets was larval Trichoptera, Ephemeroptera, and Chironomidae (Rusev 1963). However, in a study of the sterlet from the mid segment of the Danube, Nagy (1987) reported that the most important component of the sterlet food was larval Chironomidae, mayflies and caddisflies. The sterlet inhabiting the Saratov Dam Reservoir fed mostly on Amphipoda followed by crustaceans (Ermolin 1977). The stomach of the sterlet from the Hungarian segment of the Danube were dominated by caddisflies (Trichoptera), Corophium (Amphipoda), and larval Chironomidae.

The food composition changes with ontogenic development and growth in the body sizes of the fish (Peters 1983). Most of the fish analyzed were adult specimens (Fieszl 1993) which is likely why their diets were highly similar. Regardless of body size, the fish consumed Chironomidae and Trichoptera. The other food components were consumed only rarely and in small quantities. Bivalvia was the only exception as they were a significant component of the diets of the largest sterlet. The dietary composition of sterlet aged from 2 to 9 years in the Chulym River also varied depending on the age of the fish (Usynin 1978). Sterlet females and males exhibit different feeding preferences probably because they inhabit different ecological niches (Nagy 1987, Hensel and Holčík 1997). Females feed in calm segments of rivers where fine sediments are inhabited by abundant Oligochaeta (Nagy 1987), while males feed in river segments with faster flowing waters since they prefer larval rheophilic insects.

Among the sturgeon, the beluga and kaluga, *Huso dauricus* (Georgi), are typical piscivores (Billard and Lecointre 2001). Sterlet eat fish sporadically and in small quantities, and Nagy (1987) confirmed juvenile cyprinids in sterlet stomach contents. The results presented in this paper show that fish occurred in the stomach of sterlet with body lengths of 30.6-33.5 cm and 36.6-40.5 cm. In all, four juvenile barbel were identified. While their significance in the sterlet diet was not great, this finding does confirms earlier reports that the smallest species of sturgeon can also feed on fish.

In studies of sturgeon feeding, individuals with empty digestive tracts are noted frequently. Diadromous sturgeon often have empty stomachs during the freshwater phase of spawning migrations

(Billard and Lecointre 2001). Similarly, hatchery-reared juvenile Atlantic sturgeon, *Acipenser oxyrinchus* Mitchill stocked into the Drwęca River mainly have empty stomach (Bogacka-Kapusta et al. 2011). Individuals with empty stomach are noted among sterlet quite infrequently. Nagy (1987) studied the food composition of 41 specimens caught from March to December, mainly in the summer, and noted empty stomachs in 12% of the fish. The share of sterlet with empty stomach was ten-fold lower in the present study.

Danube River sturgeon populations are threatened by the long-term, concurrent impacts of many factors, but the most significant are constructions on the river, overfishing, habitat degradation, and water pollution (Lenhardt et al. 2006). There are very few populations of sterlet in the areas of its former distribution. The effectiveness of stocking the Danube with sterlet in Hungary is low (Guti and Gaebele 2009), which is why determining the food composition is an important element of the biology and ecology of this species which might be helpful when taking steps to protect it.

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Streszczenie

Odżywianie się sterleta *Acipenser ruthenus* L. w węgierskiej części Dunaju

Celem pracy było określenie odżywiania się sterleta, *Acipenser ruthenus* L. w środkowej części Dunaju (1676-1694 km). Ryby łowiono latem 1991 i 1992 roku. Zbadano treść pokarmową 85 sterletów (średnia długość ciała BL = 37,1 cm; masa ciała W = 540 g). Większość analizowanych ryb (98,8%) miała wypełnione przewody. Sterlet uważany jest za typowego bentofaga. W pokarmie analizowanych osobników stwierdzono występowanie larw i poczwarek owadów (Trichoptera, Chironomidae), obunogi (*Corophium* sp., *Gammarus* sp.), małże (Bivalvia), wieloszczety (Annelida) oraz brzana *Barbus barbus* (L.). W przewodach pokarmowych dominowały larwy chruścików (Trichoptera), Corophium (Amphipoda) i larwy Chironomidae. Niezależnie od rozmiarów ciała sterlet zjadał Chironomidae a w następnej kolejności Trichoptera. Pozostałe składniki były obecne w przewodach pokarmowych rzadko i w niewielkich ilościach. Jednym wyjątkiem były Bivalvia, które stanowiły znaczący komponent diety największej grupy wielkościowej sterleta.