Arch. Pol. Fish. (2011) 19: 113-117
DOI 10.2478/v10086-011-0013-8

SHORT COMMUNICATION

Feeding of hatchery-reared juvenile Atlantic sturgeon, *Acipenser oxyrinchus* Mitchill, released into the Drwęca River

Received – 12 January 2011/Accepted – 20 May 2011. Published online: 30 March 2011;

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Abstract. Atlantic sturgeon, *Acipenser oxyrinchus* Mitchill was once one of the largest European freshwater fish, and it was common in the Vistula River drainage. Since 2006, juvenile Atlantic sturgeon obtained by artificially reproducing wild spawners caught in the St. John River in Canada have been stocked into several rivers in Poland. The current study to assess the feeding of Atlantic sturgeon in the Drwęca River in Poland is part of a larger project to restore the species to this region. Hatchery-reared eleven-month-old Atlantic sturgeon were recaptured 2 to 10 days after their release into the river. This study provides the first data on the diet of *A. oxyrinchus* in the fresh waters of Europe. In June 2008, the stomach contents of the juvenile Atlantic sturgeon that had been recaptured were collected using gastric lavage. Of the 70 sturgeon the Drwęca River which were subjected to gastric lavage, 67% of them had empty stomachs. The diet of juvenile Atlantic sturgeon consisted of nine taxa of prey. Primarily, sturgeon eat small, soft-bodied larval Oligochaetae and Chironomidae.

Keywords: fish, Acipenseridae, hatchery, food components, invertebrate fauna, prey

Historically, the Atlantic sturgeon, *Acipenser oxyrinchus,* was abundant in the Baltic Sea, but its numbers began to decline at the beginning of the seventeenth century (Kulmatycki 1932, Gessner et al. 2006). The population size decreased dramatically because of overfishing, pollution, and habitat modification, and the last sturgeon was caught in the Vistula River in 1965. The Vistula and Oder rivers, together with their tributaries, were major spawning grounds for Baltic populations (Gessner and Bartel 2000, Bartel et al. 2006). Today, Atlantic sturgeon inhabit rivers and coastal waters from the Gulf of Mexico in Florida to Labrador in Canada (Smith 1985). Although the food and feeding relationships of juvenile *A. oxyrinchus* have been investigated extensively, knowledge of the diet of this species in its natural environment is very scarce (Smith 1985). The feeding of hatchery-reared fish is often inferior to that of wild fish, and, presumably, this is why mortality rates of hatchery fish are usually higher (Justice et al. 2009). The aim of the present study was to investigate the food of juvenile Atlantic sturgeon after they are stocked into natural waters.

This experiment was conducted in the Drwęca River, a tributary of the Vistula River in Poland. The Drwęca River drains an area of 5697 km^2 and its total length is 207 km. The mean annual discharge at the mouth is approximately 30 $m^3 s^{-1}$. The width of the river channel is 10-30 m and the mean depth is 2-3.5 m. Its natural flow, however, has been modified by several dams. Most of the river bank is bordered by meadows and forests, and land use in the drainage basin is primarily agricultural. Riparian cover, such as trees and bushes, is present along some stretches of the river. Woody debris and submerged roots are

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Table 1
Principal food categories and percentage of empty stomachs in juvenile Atlantic sturgeon in the Drwęca River

Date	N	Dominant prey	Most common prey	Empty stomachs (%)
5 June	3	Chironomidae	Chironomidae	0
6 June	10	Oligochaeta	Oligochaeta	60
7 June	13	Chironomidae	Chironomidae	46
8 June	11	Oligochaeta	Simmulidae	73
9 June	4	Oligochaeta	Oligochaeta	75
10 June	14	Simmulidae Chironomidae	Simmulidae Chironomidae	93
11 June	6	Oligochaeta	Oligochaeta	67
12 June	6	Oligochaeta	Oligochaeta	67
13 June	3	-	-	100

rare, but submerged vegetation is more frequent. The river was designated a National Nature Reserve in 1961. Historically, sturgeon spawning grounds were located in the Drwęca River (Kulmatycki 1932), and conditions here are still suitable for spawning, which is why the sturgeon restoration program that was initiated here in 2006 continues today.

Eggs were obtained through artificial reproduction from spawners caught in the St. John River (Canada). The eggs were incubated at the Department of Sturgeon Breeding (Inland Fisheries Institute, Poland). Following hatching, the larvae and early juveniles were fed live Artemia nauplii and dry starter. The juveniles were then fed *ad libitum* with Perla or Nutra commercial feed (Skretting, Norway). The fish were reared in a recirculating aquaculture system with temperature control. In total, 378 juvenile sturgeon (age 11 months, mean total length 423 mm ± 40.8 SD, mean body weight 239.8 g ± 74.7 SD) were stocked into the Drwęca River on June 3, 2008. The fish were transported from the Department of Sturgeon Breeding to the Drwęca River at Samborowo (a distance of about 250 km) in oxygenated basins. The sturgeon were recaptured between June 5 – 13 with a fyke net (20 m long, 18 mm mesh size) covering the whole width of the river about 30 km below the stocking site. The fyke net was checked every two hours during the night since juvenile Atlantic sturgeon are nocturnal. The fish were weighed (± 1 g), and total length was measured (TL; ± 1 mm). The stomach contents of juvenile Atlantic sturgeon were collected using gastric lavage (Brosse et al. 2002, Bogacka-Kapusta et al. 2007). The organisms in the food were counted and identified to the species if possible. The frequency of occurrence (defined as the proportion of fish containing a given prey category – %FO), the percentage of biomass (the weight of a given prey category in relation to total weight of the stomach contents – %W) and relative abundance (the number of a given prey category in relation to the total number of prey – %N) were quantified for each prey category. The results obtained were used to calculate the index of relative importance expressed as percentages (IRI (%)) to describe prey importance for the taxa compared (Cortés 1997). IRI is a compound index and is comprises the relative abundance of each food category found in the stomachs, the relative biomass of each food category, and the relative frequency of the fish that have fed on the food category. The graphic method by Costello (1990), and modified by Amundsen et al. (1996), was used to evaluate the feeding strategy of the juvenile Atlantic sturgeon.

A total of 150 juvenile *A. oxyrinchus* were recaptured. Almost all of the sturgeon were caught at night between days two and ten following stocking. The peak sturgeon catch time was between 21:00 and 03:00 h. The mean weight of the recaptured sturgeon was 220 g (± 73.4 g), and the total length was 428 mm (± 45.9 mm). There was a small but statistically significant difference in body weight ($P = 0.028$), but not in total length ($P = 0.326$). Of the total number of

Table 2
Number of prey items (N), percentage composition by number (%N), percentage composition by weight (%W), frequency of occurrence (%FO), index of relative importance (%IRI), mean size (mm), and mean weight (g) of prey items found in hatchery-reared and released juvenile Atlantic sturgeon stomachs in 2008 in the Drwęca River

Prey taxon	N	%N	%W	%FO	%IRI	Mean size of prey	Mean weight of prey
Coleoptera	3	1.44	6.76	4.3	0.5	6.81	6.0
Ephemeroptera	1	0.48	0.11	8.7	0.1	3.22	0.3
Diptera							
Chironomidae	27	12.92	30.88	43.5	26.4	7.59	8.2
Heleidae	1	0.48	0.08	4.3	0.0	5.03	0.2
Simuliidae	14	6.70	3.68	30.4	4.4	6.57	1.4
Tipulidae	1	0.48	0.26	4.3	0.0	7.90	1.0
Hirudinea	1	0.48	1.88	4.3	0.1	8.00	5.0
Oligochaeta	160	76.56	45.87	39.1	66.2	8.67	12.7
Trichoptera	3	0.48	10.48	13.0	2.3	5.73	9.3

fish examined (N = 70), the stomachs of 67% were found to be empty, and therefore were not analyzed further. There was a positive relationship between the percentage of empty stomachs and the length of time after stocking (Spearman correlation: r = 0.728; P<0.05; N = 9). A higher percentage of empty stomachs was observed during the final migration days in this river segment (Table 1). A total of nine prey taxa were found (Table 2). The two most important items in the diet of juveniles were larval Oligochaetae and Chironomidae (Fig. 1). Values of IRI in individual comparison units ranged from less than 0.1 to 66%. The mean number of prey varied between taxa and specimens. Chironomidae, Oligochaetae, and Simuliidae had the highest frequency in the diet. The number of prey items ranged from 1 to 136 (mean 9.2 indiv.), and the weight of prey ranged from 0.1 to 148.6 g (mean 11.4 g). Juvenile Atlantic sturgeon consumed prey of small sizes. Predators might prefer smaller prey than the optimum or than that predicted

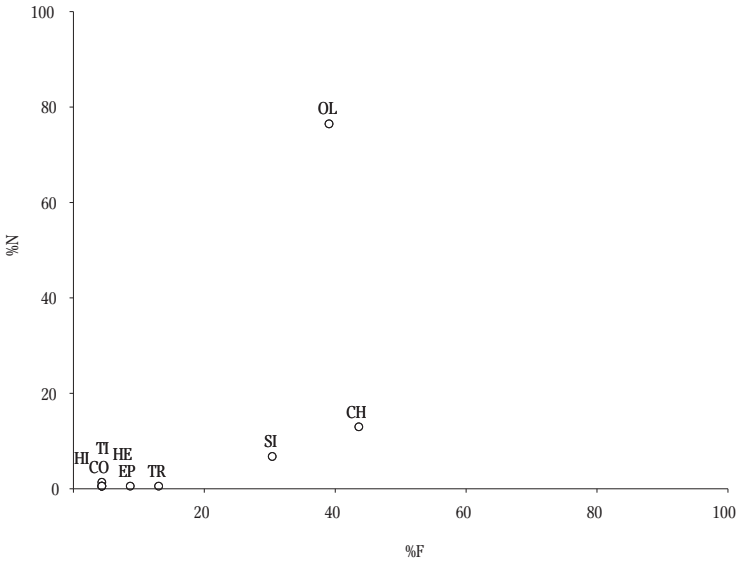

Figure 1. Feeding strategy plot of hatchery-reared released juvenile Atlantic sturgeon in the Drwęca River. Specific abundance of prey (%N) plotted against frequency of occurrence of prey (%FO). CO – Coleoptera, EP – Ephemeroptera, CH – Chironomidae, HE – Heleidae, SI – Simuliidae, TI – Tipulidae, HI – Hirudinea, OL – Oligochaeta, TR – Trichoptera. Please note that HE, TI, and HI have the same values.

from gape size because of reduced handling time (Hoyle and Keast 1987). Sturgeon consumed prey that was smaller than the maximum possible size suggested by their gape.

This dietary analysis is consistent with the few published reports on the feeding habits of juvenile *A. oxyrinchus*. Aquatic insects, and polychaete and oligochaete worms are the most common items previously reported for juveniles in fresh waters (Scott and Crossman 1973). Similarly to the juvenile Atlantic sturgeon from the Chesapeake Bay (Secor et al. 2000), they do not eat mollusks. Although the current results for juvenile *A. oxyrinchus* were generally in qualitative agreement with previous studies. This study describes juvenile Atlantic sturgeon as a benthic feeder that consumes small, soft-bodied prey organisms. *A. oxyrinchus* mainly feeds on annelids (oligachaetes and polychaetes) and arthropods (insect larvae and crustaceans), as does *Acipenser sturio* L. and *Acipenser stellatus* Pallas (Zolotarev et al. 1996, Brosse et al. 2000). The diet of juvenile and sub-adult *A. oxyrinchus* in coastal waters is based on polychaetes and isopods (Johnson et al. 1997). The sturgeon in the Drwęca River had a very high percentage of empty stomachs. Most fish have food in their stomachs for short intervals (Arrington et al. 2002). Sturgeon seems to be a group of fish that often has empty stomachs. For example, Secor et al. (2000) reported that 30% of yearling Atlantic sturgeon from Chesapeake Bay had empty stomachs, while Mason and Clugston (1993) noted empty stomachs among 72.5% of Gulf sturgeon, *Acipenser oxyrinchus desotoi* Vladykov, in the Suwannee River.

This paper is the first report of research data on the diet of *A. oxyrinchus* in the fresh waters of Europe. The principle food items of juvenile Atlantic sturgeon captured in the Drwęca River were Oligochaetae and Chironomidae. This study indicates that there are dietary similarities among the *A. oxyrinchus* inhabiting Europe and North America.

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Streszczenie

Pokarm wyhodowanych w wylęgarni juwenalnych jesiotrów ostronosych *Acipenser oxyrinchus* Mitchill w trakcie początkowej migracji w rzece

Skład diety i odżywianie się *Acipenser oxyrinchus* Mitchill w warunkach naturalnych są słabo poznane. Juwenalne jesiotry wyhodowane w Zakładzie Hodowli Ryb Jesiotrowatych w Pieczarkach zostały wpuszczone do Drwęcy. Łącznie wypuszczono 378 jedenastomiesięcznych jesiotrów (długość całkowita 423 mm ± 40,8 SD, masa ciała 239,8 g ± 74,7 SD), a odłowiono 150 osobników. Ryby odłowiono w okresie od 2 do 10 dni po zarybieniu. Skład pokarmu pobranego za pomocą płukania żołądków określono u 70 osobników. Większość złowionych jesiotrów (67%) miała puste żołądki. U pozostałych osobników odnotowano występowanie 9 taksonów bezkręgowców. Podstawą diety juwenalnych jesiotrów były Oligochaeta i larwy Chironomidae. Wskaźnik względnej ważności dla tych składników pokarmu wynosił odpowiednio 66,2 i 26,4%.