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Short communication

FEEDING INTENSITY AND GROWTH OF SIBERIAN STURGEON *ACIPENSER BAERI* BRANDT IN POND CULTIVATION

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ABSTRACT. This paper presents the results of studies on the feeding and growth of Siberian sturgeon in the first year of life in monoculture in earthen ponds. The digestive tracts of the fish contained the following orders of invertebrate fauna: Cladocera, Coleoptera, Copepoda, Diptera, Heteroptera, Mollusca, Oligochaeta and Trichoptera. Diptera and Cladocera dominated. Small amounts of Copepoda, Heteroptera, Mollusca and Trichoptera were also noted. The average indexes of weight contribution reached the highest values (1.09 – 1.70 g) in the spring-summer season, while the value in the fall sample was 1.41 g. The highest values of frequency of occurrence (100%) of the dominant Cladocera and Diptera in the food and of feeding intensity (179 – 275‱) also occurred in the spring-summer season. The highest values of the percentage indexes (> 50% - eudominants) were reported for plankton crustaceans from the order Cladocera in spring and summer. After the spring sturgeon had adapted to the new environmental conditions, a clear increase in the growth rate was observed, and after the water temperature dropped below 13°C growth stopped.

Key words: SIBERIAN STURGEON (*ACIPENSER BAERI*), FOOD, GROWTH, MONOCULTURE

The Siberian sturgeon *Acipenser baeri* Brandt is a migratory fish which is especially skilled at adapting to changes in its environment and food supply; thus, it can occur and attain satisfactory growth in various climatic zones (Milstein 1975, Sokolov and Vasilev 1989). Sturgeon is usually cultured under fully controlled conditions, i.e. in ponds supplied with temperature-controlled water, most commonly in closed water recirculation systems and in ponds located in cooling waters as well as in trout ponds with artificial feed (Gordienko et al. 1970, Kolman et al. 1990, Reichle et al. 1991). In some countries sturgeon and sturgeon hybrids are reared in earthen ponds, either in monoculture or polyculture with calmly feeding species (Slivka 1994a, b, Krylova and Sokolova 1976, Slivka and Tichonova 1977, Steffens et al. 1990, Berczenyi and Bergler 1991). Polish sturgeon culture was initiated in 1992 (Kolman 1993).

Siberian sturgeon has been the focus of much attention to date because it is a particularly interesting species in terms of rearing value. However, the feeding patterns of this species on natural food have only been studied on a small scale. This is especially true of the juvenile stage, which is the most critical stage in the life-cycle of the fish. Some information on Siberian sturgeon feeding under natural conditions was reported by Maljutin and Stroganov (1971), Sokolov (1981), Ruban and Aklimova (1991) and Pyka and Kolman (1997).

The quality, quantity and availability of natural food in ponds shape the proper growth and satisfactory survival rate of sturgeon at various stages in the life-cycle. The future of Siberian sturgeon culture in cyprinid ponds might be very promising. This justifies undertaking studies focused on this species' feeding patterns on natural food at various developmental stages.

The aim of this work was to determine the feeding intensity of Siberian sturgeon juveniles in monthly cycles, identify variability in the quality-quantity composition of food, and determine growth rate variations under pond conditions.

The studies of Siberian sturgeon feeding and growth rate were carried out in a pond with an area of 600 m^2 and a maximum depth of 1.8 m (average - 1.4 m), which is located at the Montowo Hatchery, Polish Anglers' Association, Toruń (Brodnicki Lake District, central Poland). Fish samples were collected monthly from June to October. The material used in the studies consisted of fish with an average body weight of 60.7 g (38.8 – 77.6 g) in the initial sample and 89.4 g (64.7 – 115.9 g) in the final sample, while the average total body length was 21.4 cm (18.2 – 23.3 cm) and 24.9 cm (22.6 – 26.7 cm), respectively. A total of 41 sturgeon specimens were examined.

The sturgeon were caught with trap placed behind the monk to take advantage of the phenomenon of negative rheotaxis, which this species exhibits by rapidly reacting to water movement and migrating downstream even at low flow rates. During sampling, the water temperature was measured and the quality of the food composition and its quantity (zooplankton and zoobenthos) in the pond were determined. Zooplankton was collected at five stations using a Patalas sampler with a volume of 1 dm^3. The number of organisms caught was recalculated per 1 dm^3. Zoobenthos samples were also collected at five stations using a pipe sampler with an area of 20 cm^2. The number of organisms was recalculated per 1 m^2.

The fish were preserved in a 4% formaldehyde solution. In the laboratory, excessive moisture was removed using blotting paper (until the wet spot disappeared), then body length (Lc) and total length (Lt) were measured to the nearest 1 mm and the sample weight was determined to the nearest 0.1 g. The content of the digestive tracts of particular fish were weighed to the nearest 0.01 g. The composition of the food was determined by weight (g) and the indexes of the frequency of occurrence (%) of particular components, feeding intensity (‰) and numerical domination (%).

The relative average fish weight gain (RGR, in % d^{-1}) was determined with the following formula:

$$RGR = (W_f - W_b)\, W_f^{-1}\, n^{-1}\, 100 \quad (1)$$

where:

W_f - average final weight of fish (g);

W_b - average initial weight of fish (g);

n - duration of the study period (days).

The Fulton condition coefficient (K) was calculated as follows:

$$K = (W\, Lc^{-3})\, 100 \quad (2)$$

where:

W - fish body weight (g);

Lc - fish body length (cm).

The organisms identified included plankton and zoobenthos from the following orders: Cladocera, Coleoptera, Copepoda, Oligochaeta, Trichoptera, Diptera, Heteroptera, Insecta and Mollusca. Cladocera was dominated by typical plankton species such as *Bosmina* sp., *Daphnia cucullata* G.O. Sars, *D. magna* Straus, *Moina* sp., *Scapholeberis mucronata* (O.F. Müller), *Simocephalus* sp. Copepoda were represented by typical free-living, permanent plankton components *Acanthocyclops* sp. and *Cyclops strenuus* Fischer. The following benthic Oligochaeta were observed sporadically *Lumbriculidae* and Trichoptera – *Polycentropus flavomalatus* Pictet. Coleoptera were represented only by *Agabus* sp. larvae, and Diptera - by the benthic species of *Ceratopogon* sp., *Chaoborus* sp., *Chironomus plumosus* Linné, *Culicoides* sp., and *Pericoma* sp. Of the Heteroptera, only the presence of the cladoceran *Corixidae* was confirmed, while the Insecta were represented by *Anax imperator* Leach larvae, which are characteristic for different water types. The Mollusca were dominated by *Physa* sp.

The following systematic groups of invertebrate fauna from the pond were confirmed in the digestive tracts of Siberian sturgeon: Cladocera, Coleoptera, Copepoda, Diptera, Heteroptera, Mollusca, Oligochaeta and Trichoptera. The leading role in sturgeon food was played by zoobenthos from the order Diptera, including *Ceratopogon* sp., *Chaoborus* sp., *Chironomus plumosus* Linné, and *Ceratopogon* sp., which were found in all samples. Cladocera were also noted and were represented by *Daphnia cucullata* G.O. Sars., which was found in four samples. The following organisms were found in smaller numbers: *Bosmina* sp., *D. magna* Straus, *Moina* sp. and *Scapholeberis mucronata*

TABLE 1

Indexes of the various components in sturgeon food

Food component	Weight percentage (g)	Frequency of occurrence (%)	Feeding intensity (‰o)	Domination	Sample collection, date and water temperature
1) Cladocera	1.09	100	179	1) eudominant	June 20, 21°C
2) Diptera		100		2-4) subdominant, not numerous and sporadic	
3) Coleoptera		20			
4) Trichoptera		20			
1) Cladocera	1.70	100	275	1) eudominant	July 20, 22°C
2) Diptera		100		2) subdominant and not numerous	
1) Diptera	0.79	100	109	1) eudominant	August 20, 19.5°C
2) Heteroptera		75		2) dominant, subdominant and not numerous	
1) Diptera	1.47	88	169	1) subdominant, not numerous and sporadic	September 20, 13°C
2) Cladocera		77		2-3) not numerous and sporadic	
3) Copepoda		77			
4) Trichoptera		11		4) sporadic	
1) Cladocera	0.54	87	60	1-2) from eudominant to not nume-rous	October 20, 10.5°C
2) Diptera		87			
3) Copepoda		75		3) not numerous and sporadic	
4) Heteroptera		12		4-5) not numerous	
5) Oligocheta		12			

(O.F. Müller). Insignificant roles were played by Trichoptera, Heteroptera, Copepoda and Mollusca, which were observed in two samples, and by Cladocera and Oligochaeta, which were observed in one sample. The data in Table 1 shows that the average values of the indexes of the food weight contribution were the highest (1.09 – 1.70 g) in spring and summer and were the lowest in fall (0.54 g), when there was a significant drop in water temperature (Fig. 1). The highest frequency of occurrence indexes (100%) were observed for Cladocera and Diptera, which dominated the food of sturgeon in spring and in one sample from summer. The average values of feeding intensity indexes were the highest in spring (179‰o) and in summer (109 – 275‰o), while the lowest values (60 – 169‰o) were recorded in fall, which were also related to a drop in water temperature. The highest indexes of number contribution (> 50% - eudominants), which determine the significance of the present food components, were observed for plankton crustaceans of the order Cladocera in spring and summer.

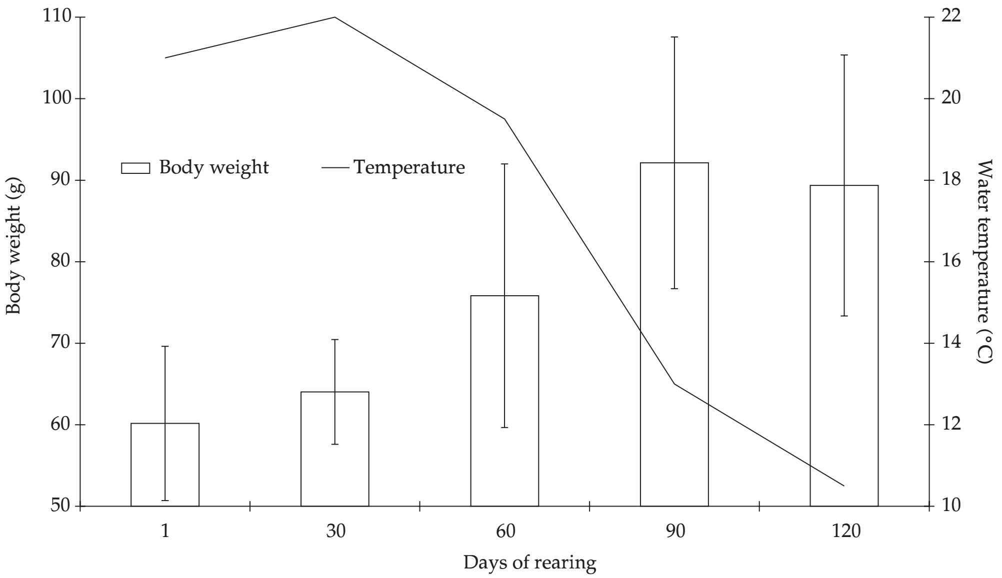

Fig. 1. Changes in Siberian sturgeon body weight and water temperature during the study (average ± SD).

After adapting to the new environmental conditions (from 20 June to 20 July), the sturgeon exhibited clearly accelerated weight gain; this occurred when there were favorable thermal conditions (Fig. 1). The end of growth clearly coincided with the drop in water temperature. In the final stage of adapting to pond conditions, the relative growth rate (RGR) of the fish was only 0.2% of body weight per day. The growth rate in the second month of rearing was satisfactory at average, diurnal increments of 0.6 – 0.7% of body weight per day. The decrease in water temperature mentioned above caused a rapid decrease in this index, and negative values of it were reported in the final stage of rearing (Fig. 2). Feeding effectiveness was also reflected in the condition coefficient values which decreased during the adaptation period from 0.67 to 0.63 (Fig. 2). During intensive growth the condition coefficient stabilized at this level, but later it fell again to 0.57.

The results of the studies of the food composition of juvenile stages of Siberian sturgeon in monthly cycles indicate that the larvae of the order Diptera (*Ceratopogon* sp., *Chaoborus* sp., *Chironomus plumosus* L.) dominated along with planktonic forms of

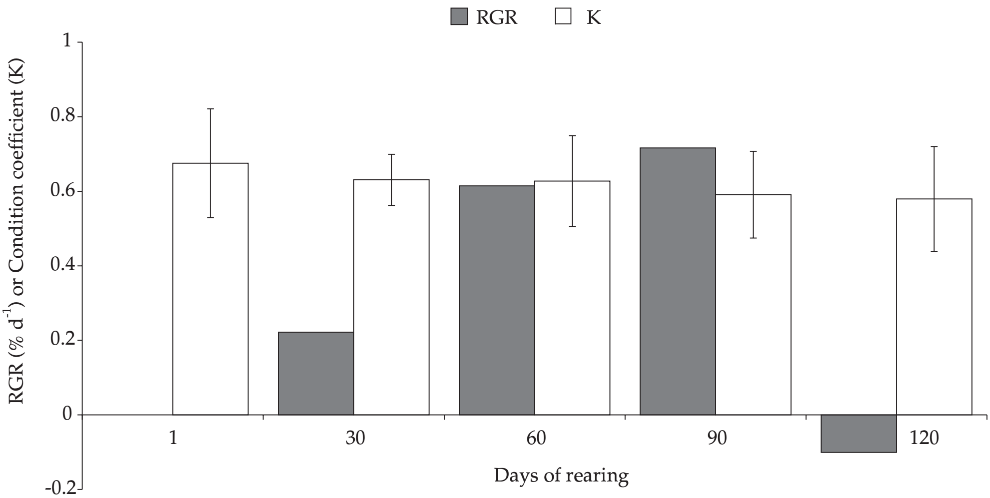

Fig. 2. Variations of the condition coefficient (K) and the relative growth rates (RGR) of Siberian sturgeon juvenile during a 24-hour period (average ± SD).

Cladocera – mainly *Daphnia cucullata* G.O. Sars. These sturgeon feeding preferences were the result of availability which is shaped by the quantitative and qualitative composition of food organisms in the pond. The composition of sturgeon food is also affected by the lack of stable specialization and the occurrence of significant feeding flexibility. Studies by Maljutin and Stroganov (1971) and Ruban and Aklimov (1991) indicated that the Siberian sturgeon is very flexible with regard to food in all its developmental stages, including both juvenile and mature stages. Feeding flexibility, which is the ability of fish to alter the food components it consumes, may play an important role in rearing sturgeon in polyculture with other, more active species. In an attempt to avoid food competition, Siberian sturgeon might opt for organisms not consumed by their co-inhabitants in the ponds. This would help to utilize more fully the natural food resources available in ponds. The level of food consumption is strictly related to water temperature, which influences the metabolic rate (Backiel and Horoszewicz 1970), and it also depends on the type of organisms consumed and fish age. The feeding effectiveness of Siberian sturgeon juveniles, which is determined by water temperature, had a clear impact on its growth rate. The results of this study indicated that sturgeon attained satisfactory weight gain under pond conditions when the water temperatures were above 13°C. At lower water temperatures weight gain ceased or the fish even lost weight. This is confirmed by the results obtained while rearing Siberian sturgeon in trout ponds using industrial feed (Kolman et al. 1994, Kolman 1998).

CONCLUSIONS

The food of Siberian sturgeon at an average body weight from 60.7 to 89.4 g and an average body length from 20.7 to 24.9 cm was dominated by benthic organisms of the orders Diptera - *Ceratopogon* sp., *Chaoborus* sp., *Chironomus plumosus* Linné; and Cladocera - *Daphnia cucullata* G.O. Sars. Organisms which were avoided included benthic Turbellaria, Oligochaeta and Coleoptera larvae.

Sturgeon feeding intensity, as determined by indexes of weight contribution, frequency of occurrence, feeding intensity and domination, was the highest in the spring-summer season and the lowest in fall.

The growth rate of Siberian sturgeon was the highest in summer at water temperatures above 13°C.

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STRESZCZENIE

INTENSYWNOŚĆ ŻEROWANIA I WZROST JESIOTRA SYBERYJSKIEGO A*CIPENSER BAERI* BRANDT W WARUNKACH CHOWU STAWOWEGO

W pracy przedstawiono wyniki badań dotyczące odżywiania się i tempa wzrostu jesiotra syberyjskiego w cyklach miesięcznych, podchowywanego na pokarmie naturalnym w stawie ziemnym o powierzchni 6 arów, głębokości maksymalnej 1,8 m (średniej 1,4 m). Obliczono wskaźniki udziału wagowego pokarmu (g), częstości występowania (%), intensywności żerowania (%*oo*) i dominacji (%). Materiał badawczy stanowił narybek o średniej masie jednostkowej 60,70 g (próba początkowa) i 89,40 g (próba końcowa) oraz średniej długości ciała wynoszącej odpowiednio 20,7 i 24,9 cm. Dominujące składniki w pokarmie jesiotrów to bezkręgowce z rzędu Diptera – *Ceratopogon* sp., *Chaoborus* sp., *Chironomus plumosus* Linne, (występujące we wszystkich próbach) i Cladocera – *Daphnia cucullata* G.O.Sars (stwierdzone w czterech próbach). Podrzędną rolę w odżywianiu się jesiotrów odgrywały: Copepoda, Heteroptera, Mollusca i Trichoptera występujące w dwóch próbach oraz Coleoptera i Oligochaeta stwierdzone w jednej próbie. Jak wynika z tabeli 1, średnie wartości wskaźników udziału wagowego pokarmu jesiotrów były najwyższe w miesiącach wiosennych i letnich, a najniższe jesienią (odpowiednio 1,09-170 g oraz 0,54 g). Najwyższe wskaźniki częstości występowania (100%) osiągały Diptera i Cl;adocera, przeważające w pokarmie jesiotrów również w okresie wiosny i lata, najniższe (77-87%) w okresie jesieni. Wskaźniki napełnienia, określające intensywność żerowania, były najwyższe również wiosną i latem i wynosiły odpowiednio 179 oraz 109-279%*oo*. Najwyższe wartości wskaźników udziału liczbowego (> 50%), określające dominację organizmów w pokarmie jesiotrów, osiągały także skorupiaki planktonowe z rzędu Cladocera również w okresie wiosenno-letnim. Temperatura była głównym czynnikiem regulującym poziom spożycia pokarmu przez badane jesiotry.

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