Turkish Journal of Fisheries and Aquatic Sciences 7: 153-160 (2007)

Diet and Growth of 1+ Siberian Sturgeon, *Acipenser baerii* in Alternative Pond Culture

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Received 16 July 2007
Accepted 20 September 2007

Abstract

The culture of 1+ Siberian sturgeon (*Acipenser baerii*) was performed in concrete storage ponds with natural water temperature regime during the growing season. Fish were separated into two groups – with supplementary feeding using trout pellets (FF) and control variant (CF). Specific growth rates in FF and CF were 0.26 and 0.16%.day^{-1} in length and 0.53 and 0.18%.day^{-1} in weight, respectively. The average indices of weight condition rose from initial 0.377 and 0.372 to final values of 0.393 and 0.322 in FF and CF, respectively. Fish diet consisted of 25 food items. Chironomid larvae, cladocerans (*Daphnia* sp.) and detritus prevailed in fish guts with 40.4 – 52.8, 19.1 - 28.8 and 16.3 – 19.4%, respectively. Pelleted feed occurred in 8.7% proportion in one third of examined FF fish. The highest indices of preponderance were found for chironomid larvae (40.06 – 62.90) and *Daphnia* (17.50 – 29.00). The index of preponderance for artificial feed was only 3.53; however, its role in the growth performance and condition of Siberian sturgeon in pond culture was very important.

Key words: feeding, weight condition, length-weight relationship, Acipenseridae.

Introduction

Due to continuously decreasing proportion of sturgeons in world fish production, the technologies of their aquaculture farming became of raising importance during the past two decades (Steffens *et al.*, 1990; Bronzi *et al.*, 1999; Prokeš *et al.*, 2000; Chebanov and Billard, 2001; Williot *et al.*, 2001; Hamlin *et al.*, 2006 and others). Besides the attempts on sturgeon culture under controlled conditions in recycling and heated systems, much attention is paid also to pond farming technologies of several acipenserid species and their hybrids (Filipiak *et al.*, 1997). Siberian sturgeon (*Acipenser baerii* Brandt, 1869) is considered as a new prospective fish species for pond aquaculture under conditions of the temperate zone. In opinion of Pyka and Kolman (1997), Siberian sturgeon grows due to higher temperature even better in European waters in comparison with their native environment.

Although it is a typical benthophagous species (Ruban and Konoplja, 1994), in individual cases it can shift its feeding habits into predatory nutrition (Ruban, 2005). The data on the developmental growth and feeding biology of Siberian sturgeon were summarised in particular in the monographs of Gershanovitch *et al.* (1987), Sokolov and Vasilyev (1989) and Ruban (2005) and in the review paper of Gisbert and Williot (2002).

Siberian sturgeons were first introduced into the Czech Republic in nineties of the 20th century (Prokeš *et al.*, 2000) as fertilised eggs from Russia. Principal data about their exterior and growth features under various experimental and nutritional conditions were presented by Prokeš *et al.* (1996; 1997a; 1997b; 1997c).

In spite of extensive studies devoted to various aspects of Siberian sturgeon biology and farming, only comparatively low attention was paid to the composition of their natural diet in the concrete (cement) storage ponds with earth-sandy-gravel bottom. The aim of the present study was to assess the growth performance and diet of 1+ juvenile Siberian sturgeons under conditions of alternative farming (or eventually long-term storage) in the concrete (cement) storage ponds with and without supplementary feeding with trout pelleted feed for the first time under South-Moravian (Czech Republic) climatic conditions.

Material and Methods

Rearing Facility

In total, 84 specimens of 1+ juvenile Siberian sturgeons were cultured in two sets (2 x 42 individuals) in concrete (cement) storage ponds (200 m^2, 0.75-1.12 m deep) with earth-sandy-gravel bottom in the Nový Dvůr Fish Farm (Pohořelice Pond Fisheries Ltd., Czech Republic) during the growing season (May – September).

One set of experimental fish (FF) was supplied with dry 2 mm pelleted trout feed – ALMA 6050 Forellenfutter 45 (45% crude protein, 14 % crude fat) from 12 May until 2 July and ALMA 6020 Forellenfutter 42 (42% crude protein, 13% crude fat) from 3 July until 25 September in the total feeding rate of 1.55% stock biomass in the first phase of experiment (see Prokeš *et al.*, 1997c) and 0.75% in the end of experiment. The feeding frequency was once a day. No pelleted feed was supplied to the control group (CF). In both variants, 5 kg of fresh mowed meadow plants were applied on pond water surface in one-week intervals as this measure was found to be very reasonable under these conditions (Adámek and Sukop, 1995).

Environmental Conditions

The favourable environmental conditions in ponds were kept by continuous water inflow of one litre per second via supplying channel from the Jihlava River, providing the water retention time at 2.2 days.

Basic hydrochemical and hydrobiological (phytoplankton, zooplankton, macrozoobenthos and phytophilous macroinvertebrates in the floating plant substrate) parameters were monitored in monthly intervals. Temperature and oxygen were monitored in one-day intervals. For hydrochemical monitoring, oximeter Horiba OM14, pH meter HI1295 and Secchi disc were applied. Phytoplankton composition was assessed quantitatively from a 50 ml sample taken from 10 l of pooled pond water. For zooplankton sampling, the total volume of 10 l of pooled pond water was taken by 2 l Patalas´ sampler and filtered through a 53 μ net. Macrozoobenthos samples were collected by Eckman´s grab (20 x 20 cm). Two subsamples were pooled from each pond.

Fish Examination

Individual measurements of fish total length (TL) and weight (w) of all specimens to the nearest mm and g, respectively, were performed in one-month intervals. For the growth rate description, the fundamental statistical values found in the feature sets and specific length and weight growth rates (SLGR, SWGR) were used. For the weight condition characterisation, the Fulton’s factor of weight condition (FWC) and the length-weight relationship was applied (Prokeš *et al.*, 1997c). For statistical comparison, the Student´s t-test was used. Correlation between the parameters examined was assessed using the powered (TL : w) and polynomial (TL, W, FWC : days of experiment) regressions ($y=ax^b$, $y=a+bx+cx^2$, respectively).

Fish diet composition was evaluated from 35 gut contents preserved in 4% formaldehyde. Nine of them originated from fish examined after harvesting from the overwintering pond in early April. The proportion of separable food items was defined by indirect volumetric estimation according to Hyslop (1980). Food weight was assessed to the nearest mg and the index of gut fullness was assessed in ‱ as a proportion of food weight on fish total weight. The grading of food items was performed using the index of preponderance (I) by Natarajan and Jhingran (1961) as $I = (v_i o_i)/ (\Sigma v_i o_i) \times 100$, where v_i = volume percentage and o_i = occurrence percentage of food item i.

Results

Environment

The concentration of dissolved oxygen, pH values and Secchi disc transparency fluctuated between 9.28–14.62 mg l^{-1}, 7.22–8.34 and 35–115 cm, respectively. Water temperature rose from 8.7–8.8°C after overwintering in April upon 18.5–24.7°C during June - September. Phytoplankton (236–130 232 cells per ml) consisted mainly of algal species belonging to the groups Chlorophyceae, Chrysophyceae and Volvocales. Its saprobiological Pantle-Buck index (Sládeček, 1973) fluctuated in the range of beta-mesosaprobity (SI = 1.64 – 2.57), which corresponds to the water quality suitable for fish farming.

Growth

During experimental investigations (137 days) of the growth rate in 1+ juvenile specimens of Siberian sturgeon, their mean total length (TL) increased in FF from 432.9 mm to 613.2 mm, which corresponds to the specific length growth rate (SLGR) of 0.256%.day^{-1}. In the control variant (CF), the TL rose from 441.3 mm to 546.9 mm, which corresponds to SLGR of 0.16%.day^{-1}. In the weight growth rate, the FF sturgeon weight increased from 308 g to 910.9 g (SWGR = 0.5284%.day^{-1}), and the CF sturgeon weight increased from 324 g to 528.6 g (SWGR = 0.1822%.day^{-1}) (Table 1, Figure 1 and 2).

The Fulton’s factor of weight condition (FWC) rose from initial 0.3765 to 0.3927 in FF (Table 2, Figure 3). Its mean values declined during first two months of farming to 0.3272 and began to rise afterwards. In CF, a continuous decline was registered during first three months of farming from 0.3721 to 0.3143 with subsequent slight increase at the end of experimental period up to 0.3219 (Figure 3). The above-mentioned finding was also confirmed using the parameters of length-weight relationship (Table 2). Initial significant differences ($P \leq 0.001$) in fish growth rate both in length and weight appeared after the first month of farming and progressed during the whole period of observations (Tables 1 and 2; Figure 1 and 2).

Food Resources

Cyclopoid larvae (nauplii and copepodits) and *Daphnia galeata* dominated among 18 taxa in

Table 1. The weight (w) growth rate and specific weight growth rate (SWGR) of 1+ juvenile Siberian sturgeon (*A. baerii*) under pond conditions

Date	Day ex.	n	w (g) mean	w (g) S.D.	Interval (days)	SWGR ($\%.day^{-1}$)	Variant
12 May	1	42	308.0	63.30	0	0	
18 June	38	40	444.0	67.59	37	0.9884	
18 July	68	37	528.1	81.06	30	0.5782	FF
19 Aug.	100	31	709.4**	119.50	32	0.9223	
25 Sept.	137	29	910.9**	162.07	37	0.6757	
TOTAL	1-137				136	0.5284	
12 May	1	42	324.0	75.00	0	0	
18 June	38	42	412.6	79.36	37	0.6533	
18 July	68	39	488.7	93.62	30	0.5642	CF
19 Aug.	100	33	498.7**	83.24	32	0.0633	
25 Sept.	137	29	528.6**	92.20	37	0.1574	
TOTAL	1-137				136	0.1822	

Explanations: FF = fed variant, CF = control variant, statistical differences after Student´s t-test ** = P≤0.01.

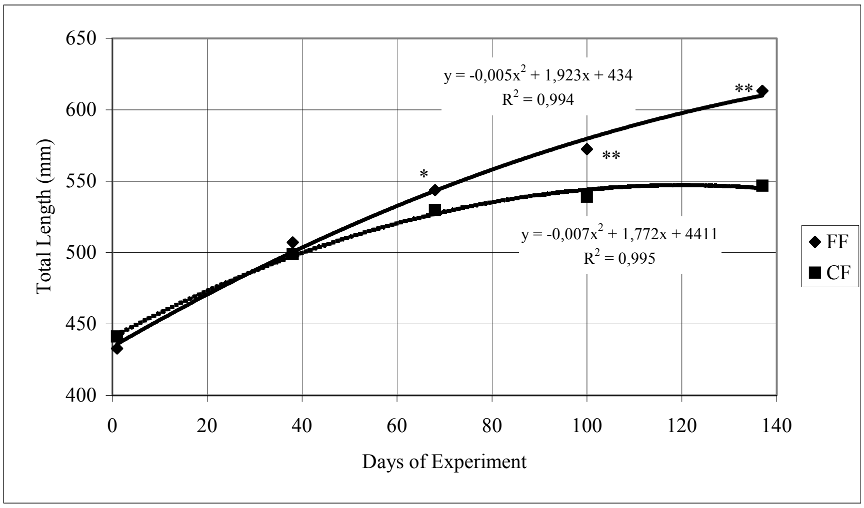

Figure 1. The length growth rate (TL) of 1+ Siberian sturgeon (*A. baerii*) in a concrete storage pond culture.
Explanations: FF = fed variant, CF = control variant, statistical differences after Student´s t-test * = P≤0.05, ** = P≤0.01.

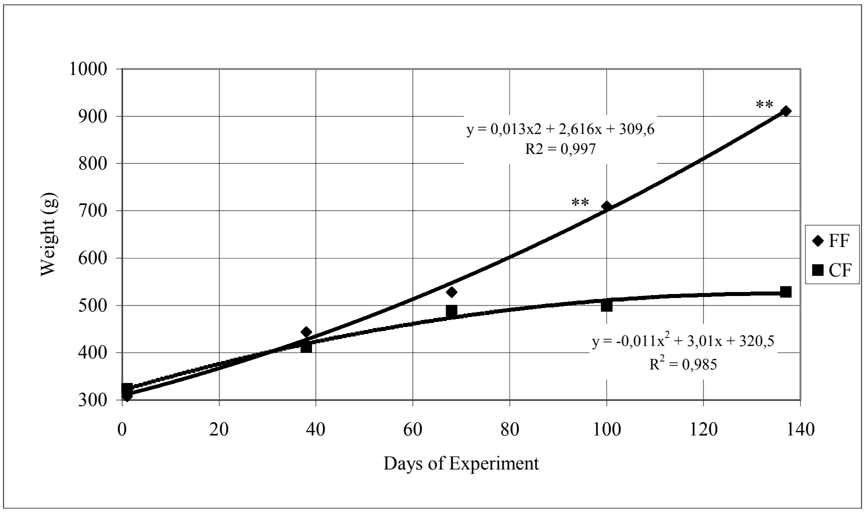

Figure 2. The weight growth rate (w) of 1+ Siberian sturgeon (*A. baerii*) in a concrete storage pond culture.
Explanations see Figure 1.

Table 2. Factor of weight condition (FWC) and length-weight relationship ($y=ax^b$) of 1+ juvenile Siberian sturgeon (*A. baerii*) under pond conditions

Date	Day	n	FWC		w=a.TL^b			Age	Variant
			mean	S.D.	a	b	R^2		
12 May	1	42	0.3765	0.0408	1E - 05	2.8423	0.7441	440	FF
18 June	38	40	0.3386	0.0202	2E - 05	2.7244	0.8505	478	FF
18 July	68	37	0.3272	0.0303	2E - 05	2.7464	0.6458	508	FF
19 Aug.	100	31	0.3760**	0.0396	2E - 05	2.7482	0.6830	540	FF
25 Sept.	137	29	0.3927**	0.0451	6E - 05	3.6425	0.8219	577	FF
12 May	1	42	0.3721	0.0417	3E - 06	3.0187	0.7911	440	CF
18 June	38	42	0.3305	0.0389	5E - 06	2.9413	0.7595	478	CF
18 July	68	39	0.3256	0.0322	4E - 06	2.9650	0.7770	508	CF
19 Aug.	100	33	0.3143**	0.0343	0.0001	2.4381	0.6448	540	CF
25 Sept.	137	29	0.3219**	0.0368	0.0002	2.3880	0.6883	577	CF

Explanations: FF = fed variant, CF = control variant, Age = in days after hatching, statistical differences after Student´s t-test ** = P≤0.01.

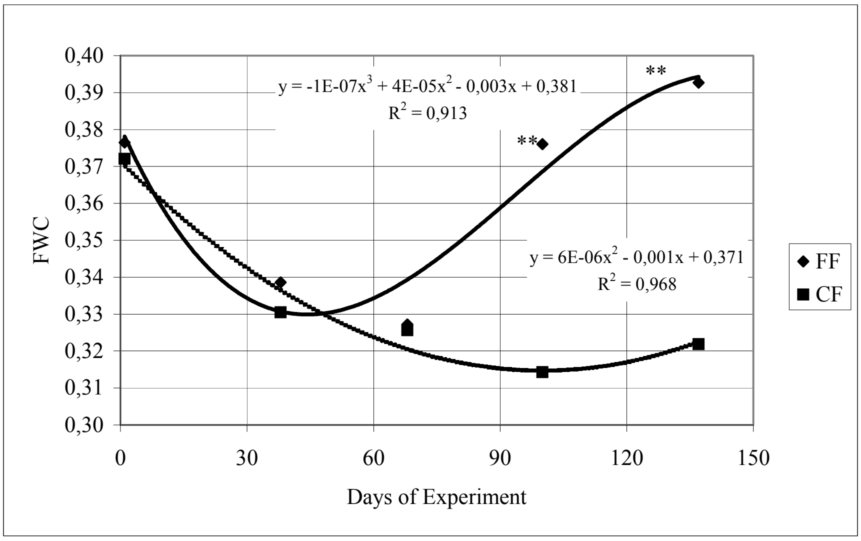

Figure 3. Fulton's factor of weight condition (FWC) of 1+ Siberian sturgeon (A. baerii) in a concrete storage pond culture. Explanations see Figure 1.

Table 3. Average values of zooplankton abundance in experimental ponds with 1+ juvenile Siberian sturgeon (*A.baerii*) during June – August. Explanations: + = < 1 ind.l^{-1}, FF = fed variant, CF = control variant

Taxon	FF	CF
Euchlanis dilatata	1	
Filinia longiseta		4
Asplanchna sp.	2	
Brachionus rubens	19	11
B. quadridentatus	2	
B. calyciflorus	1	6
Polyarthra sp.	4	1
Keratella quadrata		3
K. cochlearis		13
Daphnia galeata	368	81
D. magna	+	7
D. pulicaria	1	9
Chydorus sphaericus	3	3
Scapholeberis mucronata	4	7
Bosmina longirostris	8	48
Nauplius	102	184
Copepodit	18	442
Acanthocyclops sp.	+	+
TOTAL	533	819

zooplankton (Table 3). Mean numbers of planktonic animals amounted to 533 and 819 ind.l^{-1} in FF and CF, respectively. In the macrozoobenthos assemblage (7 taxa), chironomid larvae (mostly *Chironomus* ex gr. *plumosus*) and *Limnodrilus hoffmeisteri* were the most abundant. The mean values of their abundance and biomass were 692 and 2.09, and 690 ind.m^{-2} and 3.05 g.m^{-2} in FF and CF ponds, respectively (Table 4). Altogether, 19 macroinvertebrate taxa contributed to the colonisation of floating plant substrate with average abundance of 17 203 and 13 252 ind.m^{-2} and biomass of 24.26 and 19.33 g. m^{-2} in FF and CF ponds respectively. Diptera larvae and pupae (Chironomidae, Sciomyzidae and Culicidae) prevailed among the animals utilising this substrate (Table 4). Besides typical phytophilous macroinvertebrates, also enormous numbers of pleustonic (Hymenoptera, Diptera, *Gerris*) and planktonic animals (*Daphnia*, *Scapholeberis*, *Ceriodaphnia*, Cyclopoidea) were observed associated with this type of substrate.

Diet Composition

The diet of Siberian sturgeon consisted of 25 food items (Table 5). After overwintering, chironomid larvae and detritus prevailed in all fish guts with 37.3 and 46.3 % proportion on the total bulk of food consumed. In the majority of fish after overwintering appeared also nematodes (likely the genus *Hydromermis*) with average 10.6% proportion. The preponderances of chironomid larvae and detritus in Siberian sturgeon diet (40.4 and 19.4% in FF, and 52.8 and 16.3% in CF, respectively) were supplemented by big amounts of *Daphnia* in fish alimentary canals during summer. The average proportion of *Daphnia* on the total food bulk was 19.1% and 28.8% in CF and FF, respectively. The proportion of other natural food items did not usually exceed the level of 1–2%. Dry feed particles occurred in 8.7% proportion in 31% of fish examined in FF variant. After overwintering, the indices of gut fullness were 41±47, 61±36 and 135±66 in FF and CF, respectively. Significant difference ($P \leq 0.01$) was found for the values of gut fullness in FF and CF variants. The respective values of indices of gut fullness in April, June, July and August were 41±50, 91±90, 85±28 and 134±74 $^{o}/_{ooo}$ with significant differences ($P \leq 0.05$) between April versus July and August data. Not one single fish was found without food particles in the alimentary tract among those examined. The highest indices of preponderance (Table 6) were found for chironomid larvae (40.06-62.90), followed by *Daphnia* during June – August (17.50-29.00) and detritus (51.87 after overwintering and 13.70-14.95 during June – August). The index of preponderance for artificial feed submitted in FF was only 3.53.

Discussion

Fish growth rate was uneven in successive one-month periods of the experiment. The growth rate differences between specimens in FF and CF variant occurred only beginning from the onwards of second

Table 4. Average values of macrozoobenthos and phytophilous macroinvertebrates abundance (ind.m^{-2}) and biomass (g.m^{-2}) in experimental ponds with 1+ juvenile Siberian sturgeon (*A.baerii*) during June – August. Explanations: FF = fed variant, CF = control variant

Taxon	Macrozoobenthos		Phytophilous macroinvertebrates	
	FF	CF	FF	CF
Stylaria lacustris		10	173	41
Naididae g.sp.			907	
Limnodrilus hoffmeisteri	118	10		
Bathyomphalus contortus			10	
Ostracoda g.sp.				10
Carinogammarus roeselii	8		10	
Hydracarina g.sp.				10
Corixa affinis			122	41
Cloeon dipterum			21	41
Chironomus ex gr. *plumosus*	422	460	82	31
Chironomidae larva g.sp.	128	170	8239	10805
Chironomidae pupa g.sp.	8	8	143	21
Ceratopogonidae g.sp.			10	
Culicidae larva g.sp.			825	632
Culicidae pupa g.sp.			2363	1365
Sciomyzidae pupa g.sp.	8	32	4165	204
Eristaltis sp.			21	41
Laccophilus sp.			10	
Helophorus sp.			102	
Hydraena sp. larva				10
Abundance Total	692	690	17203	13252
Biomass Total	2.09	3.05	24.26	19.33

Table 5. Diet composition (DC) in % and frequency of occurrence (FO) in % of individual food items in juvenile 1+ Siberian sturgeon (*A. baerii*) in pond culture

Item/Period	April Overwintering Pond		June – August FF		June – August CF	
	DC	FO	DC	FO	DC	FO
Spirogyra sp.			+	8	+	8
Lemnaceae g.sp.					+	8
cf. *Hydromermis* sp.	10.6	67				
Tubifex tubifex	+	11				
Daphnia sp.	+	44	28.8	77	19.1	77
Cyclopidae g.sp.					+	8
Diaptomidae g.sp.					0.6	15
Ostracoda g.sp.	+	11			+	8
Asellus aquaticus	+	11			1.5	15
Carinogammarus roeselii					+	8
Corixa affinis	+	11	+	15	2.2	69
Naucoris cimicoides			+	8		
Mystacides sp.			1.0	31	2.0	38
Chironomidae larva g.sp.	37.3	100	40.4	100	52.8	100
Chironomidae pupa g.sp.			+	23	0.5	31
Ceratopogonidae g.sp.	+	22			+	23
Culicidae pupa g.sp.			+	8	+	8
Tabanus sp.					0.5	8
Eristaltis sp.					1.9	15
Berosus larva sp.			+	15		
Rhantus larva sp.			+	8		
Terrestrial insects			1.3	23	0.6	54
Detritus	48.3	100	19.4	54	16.3	77
Plant debris	3.8	11	0.4	31	2.1	23
Feed pellets			8.7	31		
n examined fish	9		13		13	
TL - mean ± S.D. (mm)	376 ± 17		516 ± 23		498 ± 31	
w - mean ± S.D. (g)	217 ± 46		472 ± 74		405 ± 77	
IF - mean ± S.D. ($^{o}/_{ooo}$)	41 ± 47		61 ± 34		135 ± 64	

Explanations: + = < 0.05 %, FF = fed variant, CF = control variant, IF – index of gut fullness.

Table 6. Index of preponderance in important food items in the diet of juvenile 1+ Siberian sturgeon (*A.baerii*) in pond culture. Explanations: FF = fed variant, CF = control variant

Item/Date	April Overwintering Pond	June – August FF	June – August CF
cf. *Hydromermis* sp.	7.63		
Daphnia sp.		29.00	17.50
Diaptomidae g.sp.			0.11
Asellus aquaticus			0.27
Corixa affinis			1.81
Mystacides sp.		0.41	0.91
Chironomidae larva g.sp.	40.06	52.82	62.90
Chironomidae pupa g.sp.			0.18
Tabanus sp.			0.05
Eristaltis sp.			0.34
Terrestrial insects		0.39	0.39
detritus	51.87	13.70	14.95
Plant debris	0.45	0.16	0.58
Feed pellets		3.53	

month of observations. The weight condition in sturgeons of both variants was decreasing currently during the first and second month of the experiment. During the third month, a considerable difference arose in the curves describing the FWC course on behalf of the FF group. The decrease of FWC in CF group stopped during the fourth month with subsequent moderate increase. In sturgeons of FF group, the FWC increase was continuous (Table 2).

The growth rate variability in individual subspecies and populations of Siberian sturgeons in natural waters of Siberia was described and analysed especially in the monographs of Gershanovitch *et al.* (1987), Sokolov and Vasilyev (1989) and Ruban (2005). In general, the growth rate of this species shows a sharp decline from the western part of its range to the east.

The differences found in the specific growth rate between specimens in FF and CF groups suggest that the pelleted feed administered was utilised efficiently for somatic growth. Despite the low proportion of pelleted feed mixtures as found in examined guts, their importance was significant for the growth performance of farmed sturgeon since the differences in daily length and weight increments between FF and CF amounted to 72.32% and 12.12%, respectively.

Feed application appeared to be advantageous especially during the second part of the growing season (August - September), i.e. during the time period, when the development of natural food resources in Mid-European ponds is usually considerably reduced. Also Kolman (1998) emphasised the importance of artificial feeding in sturgeon pond culture since natural food should be considered (in his opinion) only as a complementary source of nutrition supporting above all fish physiological condition.

Also the differences in FWC values at the end of the experiment between FF and CF individuals (0.3927 in FF and 0.3219 in CF – Figure 3) gave evidence of supplementary feeding reasonability. In general, the FWC values in Siberian sturgeon are very low, similarly to the other sturgeon species (due to their body shape), and differences in hundredths of the FWC value usually represent significant differences in their weight condition. According to our previous results, the mean FWC values ranged in Siberian sturgeon usually between 0.3 – 0.4 during the first two years of life. E.g. in fed 0+ (D = 261 days) specimens, the value was 0.345 in 1994 (Prokeš *et al.*, 1996) whilst in 0+ fish raised in tanks (Prokeš *et al.*, 1997a) and troughs (Prokeš *et al.*, 1996, 1997c), the FWC values were 0.38 and 0.340–0.410 (according to pelleted feed quality), respectively.

The composition of Siberian sturgeon diet in ponds was characterised by high proportion of chironomid larvae, which corresponds to the benthivorous feeding habits in this species. The other macrozoobenthos representatives (Trichoptera, Simuliidae etc.) mentioned in its diet in Siberian rivers are naturally quite rare in ponds; however, they appeared in examined fish as well (e.g. *Mystacides*). The role of chironomids in the nutrition of pond farmed Siberian sturgeon was emphasised also by Kolman (1998). This author recommended the support of macrozoobenthos development in ponds with sturgeon to maintain the biomass of benthic macroinvertebrates above 5 $g.m^{-2}$, which is more than what was present in our experimental ponds. He also advises to apply the cut reed plants as a substrate for chironomid development. Big amounts of detritus and plant debris in Siberian sturgeon guts are a result of considerable benthivory in its feeding habits. Comparatively big clumps of nematods cf. *Hydromermis* in various (usually low) degree of digestion processing appeared in 6 of 9 fish guts in April after overwintering. Their proportion was up to 90% of gut content (0.49 g in 199 g fish from April). Individuals found in fish guts were parasitic and post-parasitic larvae living in the body cavity of water arthropods – larvae of Chironomidae, Simuliidae etc. Nematods were probably ingested with their host animals and were released after their digestion – their own digestion was delayed due to the epidermal cuticula layer. Thus they accumulated in the stomach and gut. Signs of *Daphnia* occurrence in April diet were noticed as ephipia, which however originated rather from bottom than planktonic feeding.

Since June, cladocerans (*Daphnia* in particular) made a considerable part of Siberian sturgeon feeding. The way of their collecting is rather difficult to explain in sturgeon around 500 g, but they made e.g. up to 90% (4.16 g) and/or 80% (4.25 g) of food ingested by 340 and 500 g fish in July. Siberian sturgeons are probably able to employ the sites of higher concentration of *Daphnia* in typical aggregations and/or along the concrete walls of ponds. Swimming along the walls is a typical trait of sturgeon behaviour in captivity so they may use it for collecting daphnids and other associated food organisms. On average, cladocerans appeared in the food of 77% of examined fish in July as 32% of food ingested, but dropped to 2% (50% frequency of occurrence) in August. Pyka and Kolman (1997) also reported daphnids as the important item of the diet of 0+ Siberian sturgeon aged 52 – 130 days from pond culture. The occurrence of macroinvertebrates from floating grass clumps (e.g. Culicidae, *Tabanus*, *Eristaltis*) in the food of Siberian sturgeon gives evidence about their ability to swim underneath the floating substrate and collect also the food organisms from it. Emerging caddis flies subimagines ("terrestrial insects" in Table 5) appeared in sturgeon diet in August in 42% frequency of occurrence, which documents the ability of sturgeon to employ also occasional food resources.

The indices of preponderance (Table 6) show clearly the most important food items of Siberian sturgeon in a concrete (cement) storage pond culture. Explicitly highest values were found for chironomid larvae (52.82 – 62.90) followed by daphnids (17.50 - 29.00) and detritus (13.70 – 14.95). The other natural food items exceeded the level of one only occasionally (water bug *Corixa affinis*) or not at all. Chironomids were regularly reported by many authors (e.g. Ruban and Konoplja, 1994; Sokolov and Vasilyev, 1989) as the most frequently consumed food items also in rivers. Despite the low index of preponderance for artificial feed submitted in FF (3.53), its role in the growth performance and condition (FWC, TL: w relationship) of Siberian sturgeon in a concrete (cement) storage pond culture was very important (Figure 1-3). The applicability of feed mixtures for successful fattening of Siberian sturgeon was documented also e.g. by Filipiak *et al*. (1997) and Kolman (1998).

Acknowledgement

The study was supported by the USB RIFCH grant no. MSM 6007665809 "Biological backgrounds of freshwater aquaculture" (Z.A. and I.S.) and by the Ministry of Agriculture of the Czech Republic, grant. No. QH 71305 (M.P. and V.B.).

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