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Morpho-physiological characteristics of Russian sturgeon reared in net cages

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Abstract

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A study was carried out on morpho-physiological characteristics of male six- and eight-summer-old Russian sturgeon (*Acipenser gueldenstaedtii*) reared in a net-cage farm located in a warm water dam. The fish were fed with commercial granulated sturgeon feed. It was established that the age increase resulted in: statistically significant increase of the total weight, the total carcass weight and the meat content in the carcass, the weight of the intestines, liver, heart, gills and the head without the gills; the relative share of the separate organs did not change with statistical significance, with the exception of the gills, which increase in growth was statistically significant. The differences both in morphometric and morpho-physiological characteristics were insignificant. In general, the high-backed index, the gonadosomatic index and the condition indices decrease with age; the viscero-, hepato-, spleen- and heartsomatic indices increased and the broad-backed and hardness indices practically did not change. In the younger fish, the slaughter value 1 (eviscerated weight to total weigh) and slaughter value 2 (total weight without intestines and gills to total weight) were higher at the expense of the smaller head, while the slaughter value 3 (carcass weight to total weight) of both age groups was identical. The share of the more valuable part of the fillet (the dorsal one) was also higher in the fish of younger age, although the share of the fillet to the total weight in the cleansed carcass was higher in the older individuals.

Keywords: sturgeon; morphometric measures, exterior indices
Abbreviations: Ag_{5+} – *A. gueldenstaedtii* 6-summer-old; Ag_{7+} – *A. gueldenstaedtii* 8-summer-old

Introduction

Sturgeons are highly valued for their caviar and meat, and the demand for them is constantly increasing. At the same time, the condition of the natural sturgeon populations is critical and that is why their catching is banned (MZH, 2016). In this connection, the provision of valuable and delicate sturgeon production is possible through the development of sturgeon aquaculture.

In Bulgaria, sturgeon rearing has been developing since the end of the last century. According to latest data, 320-360 t of sturgeon fish are produced in aquaculture farms, with the Russian sturgeon accounting for 47-61% (MZH, 2017).

The Russian sturgeon is a critically endangered species all over the world. The condition of the natural populations of the species is getting worse (Raspopov et al., 2017), the main factors being the loss of the fish propagation areas, poaching and overfishing, water pollution (Sivkov et al., 2015). Gessner et al. (2010) pointed out that almost all the natural propagation sites are lost and species survival can only depend on stocking.

Kuderskiy (2015) noted that there is a worldwide tendency to preserve natural sturgeon populations by introducing the endangered species into new sites for commercial

rearing. Russian sturgeon easily gets accustomed to artificial feed, due to which the species is successfully cultivated in net cages, tanks and ponds (Filipova and Zuevskiy, 2009).

In the case of commercial rearing, the production efficiency and quality is of greatest importance. In aquaculture species, meat productivity and related morpho-physiological characteristics are usually studied (Bosworth et al., 2004; Miresan et al., 2012; Akbulut et al., 2013; Nikolova, 2013). In the recent years, sturgeon rearing in net-cages has been expanding in our country, the main production goal being caviar. Male individuals are mainly used for meat. In this regard, the authors of the present study set the aim of identifying morpho-physiological and slaughter yield characteristics of 6- and 8-summer-old male Russian sturgeon reared in net cages.

Materials and Methods

The study was carried out with male individuals of Russian sturgeon (*Acipenser gueldenstaedtii*) from a super-intensive net-cage rearing farm located in Kardzhali Dam. According to its type, the reservoir refers to large and deep dams. Its area is 16.07 km^2, the volume is 532.9 x 10^6 m^3. Kardzhali Dam is located in South-East Bulgaria, at 41°37' N latitude and 25°20' E longitude. It falls into the South Bulgarian climate zone, East Rhodope climate region. The average altitude is about 280 m.

Fish of different age groups and categories were grown in separate net-cages. The cages were 8×8 m in size, the water depth being 6 m. Each cage had a double polyamide net. Average stocking density during the vegetation period was 5.73 kg/m^3.

Fish sex was determined by ultrasound diagnosis. The males were separated and fattened for meat. Feeding was done with commercial granulated sturgeon feed (Table 1).

Five individuals were randomly selected from each age group (six- and eight-summer-old) at the end of the vegetation period (in November) for the morpho-physiological analysis. Classical methods were applied for the exterior measurements (Pravdin, 1966) and slaughter analysis of the fish (Pokorni, 1988; Prikryl and Janecek, 1991; Todorov and Ivancheva, 1992). Morpho-physiological and morphometric characteristics were calculated (Tables 2, 3). IBM SPSS Statistics 21 was used for statistical data processing.

Table 1
Composition of the commercial feed

Indices	Value	Indices	Value
Protein, %	46	Vitamin A, IU.kg^{-1}	10 000
Fat, %	15	Vitamin C, mg.kg^{-1}	520
Crude fiber, %	1.4	Vitamin E, mg.kg^{-1}	200
Ash, %	6.5	Vitamin D3, IU.kg^{-1}	2 303
Total P, %	1.03	Gross energy, MJ.kg^{-1}	21.0
Ca, %	1.4	Digestible energy, MJ.kg^{-1}	19.2
Na, %	0.3%		

Table 2
Investigated characteristics

Parameters	Sign
Total weight, g	TW
Total length, cm	TL
Standard length, cm	SL
Maximum body height, cm	BH
Maximum body width, cm	BT
Maximum body girth, cm	aO
Eviscerated weight, kg	EW
Total intestines, g	It
Gonads, g	GO
Liver, g	LW
Spleen, g	SW
Heart, g	Ht
Swim bladder, g	Sb
Pyloric appendage, g	Pa
Fins and tail, g	FT
Head without gills, g	Hw
Gills, g	G
Bone plates, g	Bp
Fillet with skin, g	FS
Fillet with skin without belly flap, g	FSwB
Carcass weight (Total weight without intestines and whole head), g	CW
Slaughter value 1 (Eviscerated weight/Total weight)*100, %	Sv1
Slaughter value 2 (Total weight without intestines and gills/ Total weight)*100, %	Sv2
Slaughter value 3 (Carcass weight/Total weight)*100, %	Sv3

Results and Discussion

Male 6- and 8-summer-old Russian sturgeon fish differ significantly in carcass characteristics (Table 4). All the

Table 3
Morphometric and morpho-physiological indices

Indices	Sign
Fulton's coefficient (TW/SL^3)*100), %	CFF
Clarc's coefficient (EW/ SL^3)*100), %	CFC
Condition index (TW/(SL*BH*aO) *100), %	IC
Modified Fulton's coefficient by Jones et al., 1999 (according Richter et al., 2000), ($TW/(SL^2BH)$)*100)	ICR
High-backed index (SL/BH)	IHB
Broad-backed index (BT/SL)*100, %	IBB
Hardness index (aO/SL)*100), %	IH
Viscerosomatic index (EW/TW)*100, %	VSI
Hepatosomatic index (LW/TW)*100, %	HSI
Gonadosomatic index (GO/TW)*100, %	GSI
Spleensomatic index (SW/TW)*100, %	SSI
Heartsomatic index (Ht/TW)*100, %	HtSI

studied characteristics showed differences in favor of the older fish. Live weight, carcass weight (15.5%), the weight of the fillet with skin (16.2%) and total intestines (21.4%) increased with age. The differences in the weight of gonads, spleen, fins and tail, bone plates and swim bladder were statistically insignificant. Liver and heart weight also significantly increased with age, the difference in favor of the 8-summer-old fish being 39% and 33.6%, respectively. The difference in the head weight was statistically significant, but the main difference was at the expense of the development of gills, which were heavier in older fish (38%). The greatest increase in absolute weight was found in the pyloric appendage (71.4%).

Sibikin (2015) pointed out that fish age had an effect on meat characteristics. Anisimova and Lavrovskij (1983) mentioned that the growth and development mechanisms of fish of different age differed, as energy and plastic exchange changed with age. The authors are of the opinion that the rate of linear growth decreases after reaching sexual maturity, but accumulation of body weight continues.

Against the background of an increase in absolute values, the relative shares of the separate organs did not change significantly with age, except for the gills (Table 5). In older fish, the relative share of the gills was 19% higher ($p < 0.05$), while the share of the fins and tail and of the head was smaller by 13.1% and 3.1%, respectively (Fig. 1a). The relative share of the swim bladder practically did not change, while that of the bone plates (7%) and of the pyloric appendage (48.2%) was higher in the older fish than in the younger. Jasdani (2006) found out a reduction with age of the relative share of the pyloric appendage in Siberian sturgeon. In the present study, despite the large difference in the relative share of the pyloric appendage, the differences between the age groups were statistically insignificant, due to the large individual variation in that characteristic.

Statistically significant differences in the slaughter values between fish of different age groups were not found (Table 5). As a whole, in younger fish, the SV 1 and SV 2 were higher and the SV 3 was practically the same. It indicated that the difference was due to the higher head weight of 8-summer-old fish.

Table 4
Results of the slaughter analysis of Russian sturgeon, g

Indices	Ag_{5+}			Ag_{7+}		
	X	±Sx	**CV**	X	±Sx	**CV**
Total weight	3863b	77.86	4.51	4459b	114.8	5.76
Carcass weight	2385b	68.62	6.44	2754b	35.02	2.84
Fillet with skin	2048c	86.52	9.44	2380c	82.29	7.73
Fillet with skin without belly flap	1795c	71.97	8.97	2053c	80.40	8.76
Total intestines	480.6c	21.38	9.95	583.6c	39.25	15.0
Gonads	127.2	6.70	11.5	142.2	14.74	23.2
Liver	60.21c	11.17	41.3	83.67c	5.219	13.9
Spleen	6.812	0.517	17.0	8.100	1.151	31.8
Heart	5.606c	0.221	8.81	7.488c	0.580	17.3
Fins and tail	206.8	16.27	17.6	207.8	17.16	18.5
Head without gills	681.8c	27.66	9.07	763.0c	30.57	8.96
Gills	109.0b	3.51	7.19	150.4b	9.35	13.9
Bone plates	149.6	19.91	29.8	186.7	39.82	47.7
Swim bladder	28.4	3.93	31.0	32.20	3.40	23.6
Pyloric appendage	2.800b	0.374	29.9	4.800b	0.860	40.1

Values with the same letters in the rows are significantly different: b – $p < 0.01$; c – $p < 0.05$

Table 5
Slaughter characteristics of fish, %

Indices	Ag_{5+}			Ag_{7+}		
	X	±Sx	CV	X	±Sx	CV
Slaughter value 1	87.54	0.61	1.56	86.96	0.66	1.69
Slaughter value 2	84.71	0.73	1.92	83.59	0.81	2.18
Slaughter value 3	61.74	1.34	4.85	61.87	1.04	3.75
Relative share of the live weight						
Head without gills	17.64	0.552	6.99	17.09	0.284	3.72
Gills	2.829c	0.125	9.86	3.368c	0.175	11.63
Fins and tail	5.335	0.341	14.31	4.636	0.273	13.15
Swim bladder	0.729	0.087	26.60	0.717	0.066	20.58
Pyloric appendage	0.073	0.010	29.89	0.108	0.019	39.61
Bone plates	3.865	0.489	28.31	4.138	0.785	42.42
Fillet with skin	53.10	2.33	9.83	53.50	2.05	8.58
Fillet with skin without belly flap	46.55	2.09	10.05	46.21	2.34	11.33
Relative share of the carcass weight						
Fillet with skin	85.97	3.01	7.82	86.44	2.80	7.25
Fillet with skin without belly flap	75.37	2.74	8.11	74.58	3.03	9.08

Values with the same letters in the rows are significantly different – $p < 0.05$

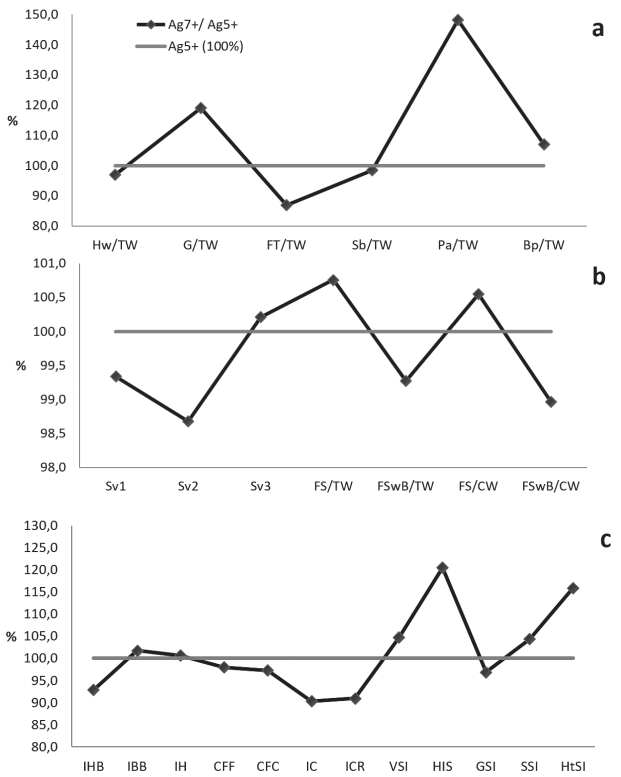

Fig. 1. Comparative characteristic of Russian sturgeon at different age: *a*) by the relative share of the separate body parts; *b*) by slaughter values; *c*) by morphometric and morpho-physiological characteristics.

In a study of sturgeon fish reared in an electric power plant, Krivoshein (2007) found out that the relative share of the carcass weight to the total weight increased with age: in Russian sturgeon that index increased from 87.5 to 88.5% from three to six years of age; in European sturgeon – from 83.4 to 88.1%; in Lena sturgeon – from 88.4 to 91.4%; in sterlet – from 85.3% for the three-year-old fish to 86.2% for the 5-year-olds, respectively. In Siberian sturgeon, Jasdani (2006) established an increase in the relative share of the eviscerated body and carcass and in the amount of muscle.

In the present study, the relative share of the fillet to total weight and in the carcass was higher in the 8-summer-old fish, but the weight of the fillet without the belly flap was, on the contrary, higher in the younger fish (Fig. 1b). That shows that the share of the more valuable part of the fillet was larger in the fish at the younger age. Krivoshein (2007) pointed out that the relative share of muscles in the body of Russian sturgeon is about 35.3-38.8%.

Kuritsyn et al. (2017) underlined the importance of studying morpho-physiological characteristics in fish reared in net-cages. The authors pointed out that liver size is an indicator of the physiological condition, the spleen is most sensitive to the nutrition factor, the heart weight is directly dependent on the swimming activity of fish, their working capacity and it is an indicator of their energy potential.

In the present study, significant differences in the studied characteristics between fish of both age groups were not found (Table 6, Fig. 1c). In general, the high-backed index

Table 6
Morphometric and morpho-physiological indices in Russian sturgeon at different age

Indices	Ag_{5+}			Ag_{7+}		
	X	±Sx	**CV**	X	±Sx	**CV**
IHB	6.925	0.224	7.24	6.432	0.263	9.13
IBB	13.71	0.602	9.82	13.95	0.219	3.51
IH	45.77	0.895	4.37	46.04	0.286	1.39
CFF	0.873	0.023	6.01	0.856	0.009	2.45
CFC	0.765	0.022	6.41	0.744	0.009	2.69
IC	13.23	0.588	9.94	11.95	0.460	8.60
ICR	6.044	0.229	8.46	5.497	0.198	8.04
VSI	12.46	0.612	11.0	13.04	0.657	11.3
HSI	1.559	0.293	42.0	1.878	0.115	13.7
GSI	3.293	0.167	11.4	3.190	0.330	23.1
SSI	0.176	0.021	15.3	0.184	0.030	36.3
HtSI	0.145	0.005	8.39	0.168	0.014	18.0

decreased with age (by 7.1%), while the broad-backed index and the hardness index practically did not change.

A number of condition factors are used in aquaculture, which are important not only as economic traits, but are also used in fish breeding. Fish condition depends on a number of genetic and paratypic factors. Kurovskaya et al. (2015) established an increase of the condition index in Bester sturgeon in the first year of life.

Badiani et al. (1997) established the condition factor from 0.4 to 0.9 (calculated to Fork length) in 42- to 54-month old Siberian, Adriatic and White sturgeon, the differences between the species being insignificant.

The condition indices, calculated in the present study, were lower in older fish, the difference in IC and ICR indices being greater – 9.7% and 9.1%, respectively (Figure 1c). In the 6-summer-old fish the value of the gonadosomatic index was higher (3.1%). In the 8-summer-old individuals there were higher values of viscero- (4.7%), hepato- (20.5%), spleen- (4.3%) and cardiosomatic (15.9%) indices. Jasdani (2006) reported a decrease of the spleensomatic and heartsomatic indices and an increase of the hepatosomatic index with aging of Siberian sturgeon.

Conclusions

In Russian sturgeon males, it was established that the total weight, the total carcass weight and the amount of meat in the carcass, as well as the weight of intestines, liver, heart, gills and the head without gills increased with statistical significance from 6 till 8 summers of age, while the relative share of the separate organs did not change with statistical significance, with the exception of the gills, which increase in growth was statistically significant. The differences both in morphometric and morpho-physiological indices were insignificant. In general, the high-backed index, the gonadosomatic index and the condition indices (especially IC and ICR) decreased with age; the viscero-, hepato-, spleen- and heartsomatic indices increased, while the broad-backed and hardness indices practically did not change.

In the case of younger fish, the slaughter value 1 (eviscerated weight to total weigh) and slaughter value 2 (total weight without intestines and gills to total weight) were higher at the expense of the smaller head, while the slaughter value 3 (carcass weight to total weight) of both ages was identical. The share of the more valuable part of the fillet (without the belly flap) was also higher in the fish of the younger age, although the share of the fillet to the total weight in the cleansed carcass was higher in the older age category.

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