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VARIABILITY OF BIOMETRIC CHARACTERS OF *ACIPENSER BAERII* BRANDT, 1869 IN THE HEATED WATER AQUACULTURE

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ABSTRACT

In the present paper changes of biometric characters of a total of 249 juvenile specimens of Siberian sturgeon in the heated water culture are discussed. Investigations were made on specimens from 0+ and 1+ age groups in the five total length classes. The analysis involved 11 meristic and 34 metric characters. In addition, the analyses of the so-called Soljan index – SOLJ, the relative position of barbels CA, width of snout FB as well as the length and weight of fish were performed. Most of the metric characters of the Siberian sturgeon show an allometric growth affected by the specific conditions of culture. Meristic characters of the species examined in the aquaculture are subjected to the significant variability in different directions.

Key words: aquaculture, meristic and metric characters, morpho-monitoring ,Siberian sturgeon

INTRODUCTION

Acipenserids are at present one of the most ancient and long-lived group of animals [29]. Despite the steady progress in acipenserid culture and rearing techniques, the fishes themselves are still insufficiently known. The knowledge of acipenserid systematics is far from complete, most existing data being useless for detailed comparisons and analyses [22,48]. Holotypes of most species have not even been collected and described [16]. Moreover, the taxonomic status of many species is also still not determined [2, 3]. Meanwhile, the non-endigenous species of acipenserids as escapees from fish farms since many years have appeared in the Polish natural waters [28,8,45,6,18,11,12,13,17]. The occurrence of non-endigenous species in the Polish natural waters is controversial especially with respect to the restitution of native species *Acipenser oxyrhinchus* L. [12].

Experiences from the sixties of 20th century, when acipenserids appeared in the Baltic Sea as result of the VNIRO experiments showed the little knowledge in Poland on their morphology, what resulted in incorrect identification of the juvenile individuals of Russian and Siberian sturgeons as the common sturgeon [21, 46, 49]. Permanent problems with the species identification of the genera *Acipenser* are caused by the great similarity among them as well as by the plasticity of not precisely known range as so far [39,43,38,31,1].

In addition, the identification is complicated by the individual variability and by the human interventions, like manipulations in the aquaculture or hybridization [25]. Therefore, extreme differences in culture conditions may elucidate adaptive potential of a species and its morphological variability as an expression of ecological plasticity.

Updated information may improve the existing identification keys and serve as a basis for a catalogue or atlas of all the common acipenserid species and hybrids with full systematic diagnosis [22].

Taking into consideration the stocking of natural waters with the Atlantic sturgeon fry within the project of its restitution [7, 20] and the occurrence of not-endigenous acipenserid species at the same time, it is necessary to held an informing action in the shape of a brochure on the species identification among fishermen, with the aid of simple and reliable taxonomical data, which can be obtained from the examinations performed in this paper.

The present study was aimed at performing a detailed biometric analysis of the Siberian sturgeon *Acipenser baerii* Brandt of Lena river in the first and second years of life and at finding out if, and how much, biometric characters of the fish change during growth in a heated water of fish farm.

MATERIAL AND METHODS

The material for study consisted of the Lena river sturgeon specimens, the offspring of the second pond generation (2F) from the fish farm. The first part of material examined had been brought to Poland in 1995 and the second one in 1997, as eyed eggs, from a hatchery in Krasnodar (Russia). The newly hatched individuals were grown out at a fish farm in Oleśnica near Chodzież (the Province of Wielkopolska).

The fertilized eggs were incubated for 2–3 days in the Weiss apparatus in water at about 14^0C; the newly hatched larvae were transferred to grow-out chambers, and from there to rotation tanks to complete the grow-out stage. Throughout the preliminary period of grow-out, the fry were kept in water at about 17^oC.

In the fish farm fish were fed an Aller Mölle feed containing 53,0% protein, 14% fat, enriched in A and D_3 vitamins. As a fry of about 10 g of weight, 2000 individuals were transferred to the Fisheries Research Station in Nowe Czarnowo, where from 25 May 1995 to 7 September 1996 were under experimental conditions in the cooling water canal of the Dolna Odra power station.

The water flow rate in the cooling water canal depends on the number of sections of the power station in work, however usually fluctuates within 1–1.5 $m \cdot s^{-1}$. The flow rate within the cages was lower and fluctuated within 0.3 $m \cdot s^{-1}$.

The mean individual weight of Siberian sturgeons fry examined in the end of experiment amounted to 350 g, while survival rate – 26% [10]. The sample investigated consisted of 104 individuals of weight ranged within 10–645 g, collected within May 1995 – September 1996.

The next part of material for study consisted of Siberian sturgeons aged 1+, from the offspring obtained in the end of March 1995, from the grow-out experiment carried within 15 July to 14 November 1996 by Filipiak et al. [9] in the Fisheries Research Station in Nowe Czarnowo as well.

The mean individual weight of 15 months old fry in the beginning of experiment amounted to 330 g/ind. (± 30g). Fish were fed with the extruded trout feed (Kraft, Dan-ex 3917, Safir, Danex 4,85). The cooling water temperature during the grow-out period was found to vary within 14–29.9^{o}C.

The sturgeons were kept in the cages of 0.9 m^3 water volume with the abundance of 40 individuals per cage, i.e. 35 ind./ m^3 . The fish for study were collected both before and after the experiment period. The total length of individuals in the sample ranged within 30.5–69.0 cm, and the weight 45–1245 g, respectively. The sample investigated consisted of 147 individuals of the Siberian sturgeon individuals.

Metric and meristic characters were carried out following Krylova [22], described in the paper of Keszka and Krzykawski [19]. A total of 251 individuals of Siberian sturgeon from the grow-out period in the cooling water of the power station was examined.

RESULTS

The length-weight relationship for the entire sample of the Siberian sturgeon examined, is described as follows: $W = 0.0023\ l.t.^{3.0994}$, with high coefficients of correlation and determination ($r = 0.9959$, $R^2 = 0.9919$, respectively).

Cooling waters – fish from 0+ age group

In this group 11 meristic characters were analyzed (Table1). As shown by the table, numbers of scutes in the dorsal row (SD) and anal ray count (A) were the most variable characters. The character which showed the lowest coefficient of variation, V, was the number of scutes in the lateral (SLL) row. When analyzed the quartile ranges, it is seen that most individuals are of high meristic characters values (except the gill rakers), what is illustrated by quartile ranges including maximum frequency of distribution ranges (e.g. SD – range 10–20, quartiles 14–16).

Table 1. Meristic characters of Siberian sturgeon in 0+ and 1+ age groups

I			Age group 0+								
Character	n	$\bar{x}$	Median	Min.	Max.	Lower quartile	Upper quartile	Quartile range	S	m	V
SD	102	15.35	15.00	10.00	20.00	14.00	16.00	2.00	1.72	0.17	11.21
SLL	102	48.61	49.00	41.00	58.00	46.00	50.00	4.00	3.22	0.32	6.62
SVL	102	10.36	10.00	8.00	13.00	10.00	11.00	1.00	0.92	0.09	8.88
D	102	46.14	46.00	39.00	55.00	44.00	49.00	5.00	3.31	0.33	7.18
A	102	28.58	29.00	22.00	34.00	27.00	30.00	3.00	2.94	0.29	10.30
V	102	25.18	25.00	21.00	30.00	24.00	26.00	2.00	1.98	0.20	7.85
P	102	37.65	38.00	31.00	44.00	35.00	40.00	5.00	3.01	0.30	8.00
$Sp.br._2$	101	25.29	25.00	12.00	36.00	24.00	26.00	2.00	3.28	0.33	12.98
$Sp.br._1$	101	25.49	25.00	15.00	35.00	23.00	27.00	4.00	3.58	0.36	14.06
II			Age group 1+								
Character	n	$\bar{x}$	Median	Min.	Max.	Lower quartile	Upper quartile	Quartile range	S	m	V
SD	147	15.59	16.00	8.00	21.00	14.00	17.00	3.00	2.00	0.16	12.82
SLL	147	45.97	46.00	38.00	56.00	43.00	48.00	5.00	3.61	0.30	7.85
SLP	147	45.74	45.00	37.00	55.00	43.00	48.00	5.00	3.47	0.29	7.59
SVL	147	10.49	10.00	8.00	14.00	9.00	11.00	2.00	1.29	0.11	12.34
SVP	147	10.69	11.00	8.00	15.00	10.00	12.00	2.00	1.30	0.11	12.19
D	147	42.95	43.00	35.00	52.00	40.00	45.00	5.00	3.12	0.26	7.28
A	147	27.07	27.00	22.00	34.00	25.00	29.00	4.00	2.66	0.22	9.83
V	147	23.29	23.00	15.00	31.00	22.00	25.00	3.00	2.30	0.19	9.89
P	147	36.37	36.00	29.00	44.00	34.00	39.00	5.00	3.20	0.26	8.81
$Sp.br._2$	147	31.23	31.00	26.00	38.00	29.00	34.00	5.00	2.90	0.24	9.29
$Sp.br._1$	146	31.89	32.00	25.00	39.00	30.00	34.00	4.00	2.80	0.23	8.79

Cooling waters – fish from 1+ age group

In this group 11 meristic characters were analysed (Table 1). As shown by the table, numbers of scutes in the dorsal (SD), lateral (SLL), and abdominal (SVL) rows were the most variable characters. The remaining characters were of high ranges, however coefficients of variation calculated for those characters (V = 7.28–9.89), did not exceed the significance limit. Over a half of characters number were characterized by quartile equals to 5, therefore the range of characters values should be regarded as high.

Comparison of meristic characters of the Siberian sturgeon from the cooling waters – fish from 0+ and 1+ age groups

The Mann-Whitney test and ANOVA Kruskal-Wallis test of ranges showed the significant differences in 7 for 9 characters investigated, between two examined groups of sturgeons of different age. Tests did not show the significant differences in number of scutes in the dorsal (SD) and left abdominal (SVL) rows. The significantly lower gill rakers count in younger fish, confirmed by both tests, suggested the increase of the gill rakers count with the fish growth. The analysis carried out showed a fairly significant dependence both for first and second rows of gill rakers ($r = 0.71054$ and $r = 0.691225$, respectively).

Metric characters
Indexes: Soljan, SOLJ; relative position of barbels, CA; snout width, FB

Descriptive statistics of frequency distributions of the complex characters: the Soljan index, SOLJ; the relative position of barbels, CA; and the relative snout width index, FB showed only one of the indices, i.e., the relative snout width (FB) to be of diagnostic utility (Table 2).

Table 2. Descriptive statistics of complex characters: Soljan index (SOLJ), relative position of barbels (CA) and relative snout width (FB) for the Siberian sturgeon from the heated waters

Character	Mean	Median	Min.	Max.	Lower quartile	Upper quartile	Quartile range	S	m	V
SOLJ	2.00	2.00	1.38	3.23	1.82	2.17	0.36	0.25	0.01	12.24
CA	-0.64	-0.60	-1.70	0.40	-0.90	-0.40	0.50	0.38	0.02	-60.08
FB	2.03	2.04	1.43	2.54	1.90	2.17	0.27	0.20	0.01	9.62

Its coefficient of variation V amounted for the Siberian sturgeon as 7.47%, indicates the parameter to be relatively stable. The most frequent FB value was > 2 (the mean was nearly equal to the median – 2.03 and 2.04, respectively). Although the remaining two parameters showed a fairly substantial variability, analysis of the Soljan index values allows to conclude that the snout length (rr) measured along the bottom of the head was most often 2 times the mouth width, what is confirmed by the quartile range (1.82–2.17).

Analysis of CA, an index of the relative position of barbels, showed the parameter to vary widely (V = 60.08%). The minimum is below zero (-1.7) and maximum is above zero (0.4). However the most of individuals have the values of index below zero (quartile ranged within -0.90 and -0.40), which indicates that the barbels were located always closer to the mouth than to the tip of the snout. In the sample examined, some individuals with shorter snout were recorded, however only in somewhat less than 4.5% of the total fish number (249 individuals) and only for them the CA index was above zero.

Length classes 10–19.9 cm and 20–29.9 cm

Metric characters analyzed in these length classes are presented in Table 3. The most variable characters were the length and height of fins: ventral, anal and dorsal (lV, lAs, hA, hD), where coefficients of variation, V, were higher than 10%. The table shows that the highest variability in the characters of head in these length classes were found in the length of the longest barbel l_1 and the head height (HC). Additionally, among the characters associated with the head, the eye diameter (O) showed a fairly substantial variability. Table 3 shows that, within the 20.0–29.9 cm length class, the body height (H), the anal fin base length and height (lA, hA), the dorsal fin height (hD), and the longest barbel length (l_1) expressed as head length percentages were variable.

Length classes 30–39.9 cm, 40–49.9cm, 50–59.9 cm, 60–69.9 cm

Metric characters within the 30–69 cm length classes are presented in Table 4. The table shows that, within the 30.0–39.9 cm length class, the caudal peduncle length (pl_1), the head height (HC) and width of head (BC) were the most relatively variable.

In the next analysed length classes: 40–49.9, 50–59.9 and 60–69.9 cm, the list of not stabilized characters is similar, including the parameters determining the anal fin (lA), the dorsal fin (lD), interruption in the lower lip (il), the length of longest barbel (l_1), as well as the distance from the tip of snout to the barbel base (rc). The variability of the last parameter especially indicated the variable shape of snout of individuals in the sample examined, confirming the occurrence of two snout form: shorter and longer one. When analysed the head characters, expressed as its percentages, the clear tendency of head proportion changes can be seen, namely of the snout shortening (R) and elongation of the postocular distance (OP). The stabilization of these tendencies is observed at 60 cm of the fish length.

In the 1+ age group the values of Fulton's coefficient of condition (K) ranged within 0.1586 and 0.5120, however the average (0.3597) and median (0.3537) were of the close values. In the quartile range the individuals were found with the K values ranged from 0.3373 to 0.3899. Individuals from the 0+ age group showed the coefficient values ranged within 0.2147–0.5651, with the average and median amounted to 0.3467. In the quartile range the individuals were noted with the K values ranged from 0.3187 do 0.3669.

Table 3. Metric characters of Siberian sturgeon in 0+ age group in the total length classes

Length class l.t.				10–19.9 cm					20–29.9 cm		
	Range		(% l.t.)	Mean	SD	V	Range		(% l.t.)	Mean	SD	V
Character	min	–	max				min	–	max			
L1	85.47	–	90.35	88.23	1.20	1.36	87.06	–	87.50	87.34	0.19	0.22
L2	79.33	–	83.66	81.60	1.04	1.27	80.33	–	81.47	80.96	0.47	0.58
L2-C	53.62	–	56.90	55.58	1.06	1.90	53.88	–	54.73	54.33	0.35	0.64
aD	55.49	–	61.40	59.13	1.50	2.54	59.41	–	61.21	60.11	0.79	1.31
aA	61.18	–	67.32	64.07	1.73	2.71	63.79	–	64.44	64.14	0.26	0.41
PV	23.70	–	29.63	26.81	1.36	5.08	24.69	–	25.87	25.33	0.49	1.93
VA	10.17	–	13.97	12.42	1.01	8.11	11.94	–	13.39	12.61	0.60	4.73
pl1	10.24	–	12.64	11.58	0.70	6.00	10.34	–	11.94	11.05	0.66	6.00
H	7.97	–	12.99	10.28	1.03	9.99	8.37	–	10.95	9.74	1.06	10.87
h	1.96	–	3.05	2.47	0.24	9.80	2.09	–	2.49	2.24	0.17	7.73
lP	12.35	–	15.94	13.83	0.82	5.90	13.43	–	15.52	14.39	0.86	5.97
lV	5.49	–	8.70	7.19	0.68	9.52	7.33	–	7.95	7.58	0.27	3.53
lA	4.85	–	7.41	6.31	0.72	11.43	4.18	–	5.97	5.11	0.73	14.30
hA	5.26	–	8.54	6.32	0.97	15.41	5.47	–	7.95	6.92	1.05	15.21
lD	9.21	–	11.49	10.42	0.52	4.96	9.48	–	10.04	9.82	0.24	2.49
hD	4.82	–	7.24	5.99	0.61	10.27	4.98	–	6.47	5.91	0.66	11.22
C	24.12	–	28.95	26.02	1.12	4.32	25.94	–	27.59	26.63	0.70	2.62
R	11.49	–	14.81	13.36	0.76	5.66	12.97	–	15.09	14.33	0.96	6.71
O	2.20	–	3.27	2.60	0.29	11.25	2.49	–	2.59	2.53	0.04	1.67
OP	9.58	–	11.59	10.30	0.54	5.23	9.45	–	10.46	10.09	0.45	4.46
hCo	5.23	–	6.17	5.65	0.26	4.66	5.44	–	5.60	5.51	0.07	1.29
HC	8.38	–	11.40	10.08	0.67	6.64	9.62	–	9.95	9.83	0.15	1.49
SO	5.99	–	8.77	6.96	0.58	8.33	6.47	–	6.97	6.71	0.20	3.04
rc	6.90	–	10.06	8.29	0.61	7.39	8.79	–	10.34	9.69	0.66	6.82
rl	4.79	–	7.41	5.97	0.52	8.75	5.44	–	6.03	5.81	0.27	4.59
rr	12.64	–	15.64	14.27	0.82	5.74	14.23	–	16.38	15.51	0.93	5.97
l1	4.71	–	7.14	6.02	0.67	11.08	4.74	–	5.97	5.38	0.50	9.35
	Range		(%C)	Mean	SD	V	Range		(% C)	Mean	SD	V
R	47.37	–	55.81	51.37	2.22	4.31	50.00	–	56.60	53.76	2.77	5.16
O	8.51	–	12.20	9.98	1.07	10.75	9.38	–	9.68	9.50	0.13	1.38
OP	37.21	–	43.90	39.60	1.59	4.00	35.85	–	40.32	37.89	1.85	4.87
hCo	19.51	–	24.39	21.75	1.18	5.44	20.31	–	20.97	20.68	0.27	1.32
HC	32.61	–	45.24	38.79	2.87	7.39	35.94	–	37.74	36.92	0.74	2.02
SO	22.92	–	30.30	26.76	1.86	6.95	23.44	–	26.42	25.22	1.28	5.09
rc	28.57	–	37.50	31.87	1.91	5.99	33.87	–	37.74	36.37	1.77	4.86
rl	18.60	–	27.91	22.98	1.95	8.50	20.97	–	22.64	21.83	0.68	3.13
rr	51.16	–	60.47	54.84	2.50	4.56	54.84	–	60.38	58.20	2.41	4.14
l1	18.60	–	26.83	23.14	2.37	10.25	17.19	–	22.64	20.27	2.28	11.26

Table 4. Metric characters of Siberian sturgeon in 1+ age group in the total length classes

Length class lt	30–39.9 cm						59–59.9 cm						60–69.9 cm					
Character	Range		(%l.t.)	Mean	SD	V	Range		(% l.t.)	Mean	SD	V	Range		(% l.t.)	Mean	SD	V
	min	–	max				min	–	max				min	–	max			
L_1	85.98	–	88.98	87.50	1.28	1.46	85.31	–	98.32	88.97	2.54	2.85	83.78	–	91.82	87.71	1.27	1.45
L_2	80.99	–	83.46	81.99	0.98	1.20	80.00	–	90.30	83.74	1.86	2.22	79.69	–	88.73	82.61	1.41	1.71
L_2-C	58.36	–	60.63	59.24	0.86	1.45	60.41	–	69.90	63.49	1.82	2.87	60.00	–	67.47	62.91	1.33	2.12
aD	57.14	–	59.84	58.44	0.96	1.64	57.31	–	64.72	59.16	1.51	2.56	54.83	–	61.52	58.63	1.30	2.22
aA	61.90	–	64.83	63.73	1.10	1.73	62.07	–	70.74	64.98	1.63	2.50	59.78	–	68.94	64.03	1.56	2.44
aV	50.69	–	52.49	51.51	0.69	1.35	47.68	–	54.85	50.00	1.45	2.90	45.81	–	53.64	49.39	1.31	2.65
PV	29.75	–	31.15	30.24	0.54	1.79	28.06	–	35.95	30.90	1.37	4.44	26.96	–	34.13	30.77	1.33	4.32
VA	12.17	–	14.96	13.27	1.09	8.24	13.39	–	18.01	15.14	0.96	6.31	12.25	–	17.77	15.03	1.18	7.85
pl_1	10.47	–	14.10	12.33	1.30	10.57	9.14	–	12.84	11.16	0.75	6.70	9.15	–	15.51	11.08	0.87	7.86
pl_2	15.98	–	18.69	17.56	1.04	5.91	13.79	–	18.15	16.60	0.81	4.88	9.98	–	17.79	16.17	1.25	7.71
H	11.29	–	12.34	11.85	0.41	3.45	9.64	–	12.94	10.92	0.72	6.62	9.13	–	13.12	10.76	0.80	7.39
h	2.38	–	2.75	2.60	0.14	5.20	2.34	–	3.18	2.72	0.18	6.69	2.25	–	2.94	2.59	0.17	6.70
lP	12.60	–	14.10	13.09	0.60	4.57	9.48	–	14.46	12.52	0.96	7.70	10.80	–	13.58	12.30	0.60	4.92
lV	6.08	–	7.44	6.96	0.52	7.45	6.16	–	8.95	7.62	0.68	8.94	5.97	–	8.58	7.52	0.47	6.20
lA	4.76	–	5.51	5.11	0.29	5.68	5.41	–	8.45	6.28	0.66	10.53	4.60	–	8.56	6.26	0.79	12.67
hA	6.61	–	7.35	6.95	0.34	4.86	5.96	–	9.83	7.63	0.84	11.05	5.88	–	9.50	7.43	0.72	9.65
lD	9.79	–	12.13	11.05	0.88	7.97	9.76	–	13.16	11.28	0.82	7.30	9.46	–	13.00	11.18	0.68	6.08
hD	6.34	–	6.56	6.45	0.11	1.68	5.89	–	8.61	7.12	0.69	9.63	5.67	–	8.85	7.07	0.63	8.85
	Range		(% C)	Mean	SD	V	Range		(% C)	Mean	SD	V	Range		(% C)	Mean	SD	V
R	48.10	–	52.05	50.62	1.55	3.06	41.07	–	49.60	45.03	2.08	4.61	38.79	–	49.21	45.26	2.26	4.99
O	8.22	–	10.13	8.94	0.79	8.82	6.40	–	9.02	7.97	0.64	8.08	6.43	–	9.24	7.92	0.57	7.20
OP	41.10	–	45.57	43.46	1.81	4.17	44.44	–	52.68	48.50	2.25	4.63	43.65	–	53.78	48.20	2.36	4.89
hCo	23.29	–	26.58	24.38	1.31	5.36	20.49	–	26.23	23.06	1.46	6.33	19.42	–	26.02	22.68	1.42	6.27
HC	32.88	–	43.68	38.72	4.72	12.19	37.60	–	50.44	43.56	3.23	7.41	32.85	–	48.76	43.12	3.57	8.28
iO	29.41	–	31.65	30.56	0.85	2.79	27.78	–	34.82	30.81	1.62	5.27	27.27	–	33.62	30.46	1.32	4.33
BC	40.51	–	50.57	44.71	4.12	9.22	42.06	–	55.75	47.04	3.11	6.62	40.15	–	54.46	46.53	2.85	6.12
SRC	23.53	–	26.03	24.72	0.99	3.99	20.51	–	28.32	24.60	2.05	8.31	20.00	–	29.41	24.07	2.15	8.95
SRr	38.82	–	41.77	40.43	1.20	2.97	33.33	–	42.48	37.57	2.14	5.70	31.25	–	41.96	37.28	2.34	6.28
SO	25.88	–	28.77	27.81	1.17	4.21	22.22	–	30.09	26.56	1.78	6.69	22.40	–	30.25	26.44	1.72	6.49
il	4.71	–	5.75	5.25	0.40	7.57	2.75	–	7.02	4.93	1.00	20.28	2.48	–	7.63	4.99	1.06	21.20
rc	27.85	–	32.18	30.53	1.65	5.40	19.30	–	32.00	26.31	2.72	10.35	20.18	–	33.33	27.11	2.61	9.64
rl	21.84	–	24.05	22.88	0.85	3.72	20.35	–	25.44	22.75	1.38	6.07	19.38	–	26.83	22.55	1.42	6.31
rr	49.37	–	54.02	51.80	1.65	3.19	43.44	–	53.17	48.00	2.24	4.66	41.23	–	54.33	48.48	2.59	5.35
l_1	18.82	–	20.69	19.74	0.76	3.86	18.03	–	26.55	21.61	2.09	9.68	14.63	–	28.95	21.16	2.83	13.40

DISCUSSION

Meristic characters of the Siberian sturgeon were relatively often were subjected to examination and analyses in details when compared to other species of acipenserids, however the number of investigation is still scarce. The objectives of analyses were either sturgeons from the natural populations or individuals obtained from the fish farms. The most valuable papers on the meristic investigation are as follows: Ruban and Sokolov [39], Ruban [37], Ruban and Panaiotidi [38], Ruban [37] and Prokeš et al. [35].

The results obtained for the farmed Siberian sturgeon in this study (mean values and ranges) should be regarded as high when compared with those reported by other authors (Table 5). Values of characters analyzed in this study seem to be opposed to the tendency reported by Ruban and Sokolov [39] and Ruban [37] concerned the distinct decrease of meristic elements in the Siberian sturgeon in the heated water aquaculture. Authors explain this phenomenon from one side as a possible modificationable reaction of genotype as a result of the selection of stabilization called the Baldwin effect, and from another side by higher water temperature, what is illustrated by the clinal variability of described characters from the north to the south in the wide distribution of the Siberian sturgeon. However neither own results nor given in Prokeš et al. [35] confirmed the above hypothesis.

Table 5. Comparison of ranges and mean values of meristic characters of the Siberian sturgeon from different areas

Area	References (year)	Character					
		D	A	SD	SLL	SVL	$sp.br._1$
Ob river	Menšikov (1947)	42.58	24.63	13.52	41.42	9.51	30.38
Ob river	Petkevich et al. (1950)	43.49	23.44	13.32	43.64	10.62	–
Yenisey river	Podlesnyi (1955)	44.9	24.8	14.5	46.9	10.7	35.2
Yenisey river	Ruban and Panaiotidi (1994)	44.1	24.7	14.8	48	10.9	35.5
Baikal lake	Egorov (1961)	44.07	25.51	15.07	50.06	12.01	35.04
Lena river	Sokolov et al. (1986)	43.45	25.11	14.69	45.9	10.29	36.61
Lena river	Ruban and Panaiotidi (1994)	43.25	25.14	14.76	45.77	10.29	36.64
Kołyma river	Sokolov and Novikov (1965)	43	24.62	14.17	43.48	11.2	37
Aquaculture (Czech Republik)	Prokeš et al. (1997a)	41.42	24.02	13.46	44.77	10.58	34.61
Aquaculture (Russia)	Ruban and Sokolov (1986)	34.36	16.1	12.78	43.03	9.97	–
Aquaculture (Poland)	This study	42.95	27.07	15.59	45.74	10.49	31.89

On the contrary to these results, the increase of the meristic elements was found, supported by the high means and other descriptive statistics, characterizing the material in own study. The explanation of this conversed trend can be found in the origin of material in own study; the individuals investigated were the third generation in the culture, while Ruban and Sokolov [39] and Ruban [37] carried out their examinations on the individuals from the second generation in culture.

Bearing in mind the variability of environmental conditions and possible genetic drift in the third generation, the conversion of tendency observed by these authors is not suprising. The period of over 20 years from the last examinations (the paper of Ruban from 1992 [37] was based on the material collected within 1983–84) is also not inconsequential, taking into consideration the relatively high plasticity of the species under study.

The certain confirmation of tendency observed in own study showed results obtained by Prokeš et al. [36], who noted similar mean values as well as ranges of meristic characters in the examined individuals of the Siberian sturgeon in aquaculture. However, when compared data obtained to the results for natural populations from different areas of study, recorded by other authors, the Czech scientists reckoned the mean values which characterized sturgeons living in the wild and they obtained the distinct statistical differences, which are not detected when comparing the mean values of selected data of the sturgeon population of Lena river.

The presumable reason of differences in the meristic elements counts, between the examined groups of age, is the culture selection, where randomly selected specimens with specific count of scutes or unbranched fin rays. The interesting aspect in own study was found in the differences between 0+ and 1+ age classes in the range of mean values of meristic characters. It is not advisable to explain these differences by increase of ray or scute counts owing to falling out (scutes) or fusing (rays) along with the fish growth, however the similar tendency for ventral scutes of the ship sturgeon *A. nudiventris* was recorded by Borzenko (in: Pecnikova [32]). The low range of variation in the count of some meristic characters is probably determined by temperature (typical tendency of the fish growing in heated water aquaculture), however the reduction of some meristic elements is not excluded.

The Siberian sturgeon is better determined in point of both metric and meristic characters when compared to other species. It results from more common utilization of this species in the aquaculture of many countries in the world. The available literature however basically lacks papers on the specific morphomonitoring. Only Ruban and Sokolov [39], Ruban [37], Krzykawski and Keszka [23], Prokeš et al. [36] dealt with this problem in their papers.

Analysis of variability of metric characters of the Siberian sturgeon in this study, based on the estimation of coefficient of variation for characters expressed as percentage of the total length and head length, showed the surprising results in comparison with the diagnoses described for this species. These characters are considered as significant taxonomically or diagnostic, which show the highest stability during the fish growth.

Sokolov and Vasil`ev [42] considered the longest babel length (l_1), the distance from the base of barbels to the cartilaginous vault of mouth (rl) as well as height and length of base of anal and dorsal fins (hA, lA, hD, lD) as diagnostic for the Siberian sturgeon. In this study, however, these characters showed high values of the coefficient of variation (>10%). It is especially visible in the 10–19.9 cm length class. The differences found between results obtained in this study and those from Sokolov and Vasil`ev [42] paper, can result from the differences in the length of fish investigated. In this study the small individuals prevailed. According to Holčik [16] and Snyder [41] criteria of the fully formation and the determination of fins dimension show the finish period of the larval stage. It seems that variability of these characters, especially of fins, results from the transition stage of fish life cycle, between the "alevin" as called by Balon" (after Castelnaud et al. [4]) and the juvenile period.

Analysis of the metric characters variability in the remaining length classes shows 60 cm of length as the moment of finishing the process of phenotype definition in the Siberian sturgeon. It is confirmed by the wide ranges of characters variability up to the length of about 60 cm. At this length the stabilization of snout length is performed, while the substantial fluctuations are recorded in the earlier period. Therefore, this length referred to the age group 1+ in the condition of aquaculture, can be accepted as the limit value where the morphological characteristics resembling the adult specimens is stabilized. As so far, the earlier stabilization of phenotype in acipenserids was found only in *A. sturio,* whose juvenile specimens as soon as in the first age group obtain the morphological characteristics specific for the adult specimens (Castelnaud et al. [4]).

The comparisons between the investigated length classes showed the differences in the most characters in both analyzed lengths. The higher relative values of the linear characters were noted, with the evident shortening of head length, what is visible in the initial phase of 10–19.9 cm length class. At the length of 20–29.9 cm, the opposite phenomenon was recorded: at the relative reduction of the linear characters elongation rate, in the individuals from the heated water fish farm, the head length was growing. The changes described probably result from the variable rate of growth and indicate the high recipience of metric characters on the change of the culture conditions. The initial trend of the head length shortening, became inverted fast just in the next length class. Therefore it seems correct to conclude that conditions of aquaculture intensify the effect of the allometric growth.

Comparison of mean values of the metric characters related to the body or head length, which characterize the natural populations [39, 37, 38], show substantial differences among them and own data (Table 6). It is seen especially in the case of some characters, being considered as relatively stable in the Siberian sturgeon life span, therefore utility them for the comparisons is reasonable. The differences appeared in the smaller length of pectoral fins (lP) in own study, as well as the bigger width of mouth (SO) and the distance between the barbel base and cartilaginous vault of mouth (rl), the shorter length of head (C) and the shorter preventral distance (aV).

The analysis of metric characters values in two compared length classes: 40–49 cm and 50–59 cm show that fish examined in this study have a shorter head, smaller preventral distance (aV), bigger width of snout at the base of barbel (SRc) and bigger interocular distance (BC). The similar tendency showed results presented in the paper of Ruban [37] who studied population living in the wild, in the lower and upper run of rivers Lena and Ałdan (the right-bank tributary of Lena) and the industrial population from the heated water aquaculture.

The comparison of the data obtained in this study with the data given by above cited author showed a convergence in the lower length classes. In the 60–69 cm length class the similar tendency can be seen only in the mean head length and preventral (aV) and interocular (BC) distances. The head width at the barbel base is characterized by lower mean that was determined by Ruban [37]. Probably this difference can result from the occurrence in own study two forms of sturgeon, differentiated just by the width of snout at the barbel base. This remark was also confirmed by the comparison of the more multiple characters, Soljan index (SOLJ), the relative position of barbel base (CA) and relative barbels width (FB).

On the polymorphism of the snout shape among the specimens from one population, Ruban and Panaiotidi [38] and Prokeš et al. [35] informed in their papers as well. Ruban and Panaiotidi [38] stressed that the occurrence of two forms of snout shape was the extremal variant of the usual unimodal distribution of this character. Nevertheless the specimens with the terminal values of this character (SRc) in the population affect the mean value for this population, therefore this character loses its diagnostic properties.

Table 6. Comparison of ranges and mean values of the relative metric characters of the Siberian sturgeon from different areas

Author	Prokeš et al. (1997a)				Ruban and Sokolov (1986)				Ruban and Panaiotidi (1994)				Ruban and Panaiotidi (1994)				This study				This study			
	Aquaculture				60–69 cm Aquaculture				30–39.9 cm Lena river				60–69.9 cm Lena river				Aquaculture				Aquaculture			
Character	Min.	–	max.	Mean	Min.	–	max.	Mean	Min.	–	max.	Mean	Min.	–	max.	Mean	Min.	–	max.	Mean	Min.	–	max.	Mean
l.t. (cm)	14.8	–	35	25.82	60	–	69	65	30	–	39.9	35	60	–	69.9	65	20.5	–	27.3	23.08	60	–	69	63.29
% l.t.																								
L_1	80.2		93.7	85.57	–	–	–	–	–	–	–	–	–	–	–	–	80.46	–	87.5	85.52	83.78	–	91.82	87.71
L_2	74.2		85.5	78.1	–	–	–	–	–	–	–	–	–	–	–	–	75.1	–	81.5	79.77	79.69	–	88.73	82.61
aD	53.3		62.2	57.72	–	–	–	60.19	–	–	–	61.1	–	–	–	61.7	54.41	–	65.35	58.02	54.83	–	61.52	58.63
aV	48.4		55.1	51.07	–	–	–	51.24	–	–	–	54.1	–	–	–	53.8	48.28	–	53.11	51.29	45.81	–	53.64	49.39
aA	59.6		69.3	63.66	–	–	–	66.54	–	–	–	67	–	–	–	67.8	59.77	–	67.8	63.5	59.78	–	68.94	64.03
PV	22.2		31.8	26.28	–	–	–	31.39	–	–	–	30.7	–	–	–	33.1	25.81	–	30.65	27.65	26.96	–	34.13	30.77
VA	10.4		16.6	13.29	–	–	–	15.76	–	–	–	13.9	–	–	–	14.5	10.85	–	14.85	12.8	12.25	–	17.77	15.03
pl_1	7.7		11.4	9.33	–	–	–	–	–	–	–	–	–	–	–	–	8.71	–	11.98	10.55	9.15	–	15.51	11.08
H	9.8		13.4	11.5	–	–	–	11.08	–	–	–	10.9	–	–	–	11.5	8.93	–	11.35	10.13	9.13	–	13.12	10.76
h	2.5		3.3	2.81	–	–	–	2.63	–	–	–	2.7	–	–	–	2.9	2.09	–	2.8	2.43	2.25	–	2.94	2.59
lD	6.9		12.2	10.26	–	–	–	11.27	–	–	–	10.6	–	–	–	10.4	10.26	–	12.5	11.26	9.46	–	13	11.18
hD	7.3		10.4	8.76	–	–	–	6.96	–	–	–	7.6	–	–	–	7.5	5.73	–	7.66	6.92	5.67	–	8.85	7.07
lA	2.7		6.5	4.73	–	–	–	4.49	–	–	–	4.8	–	–	–	4.8	4.76	–	7.33	5.93	4.6	–	8.56	6.26
hA	6.3		10.4	8.18	–	–	–	7.12	–	–	–	7.7	–	–	–	8.1	5.51	–	7.59	6.45	5.88	–	9.5	7.43
lP	10.2		16.2	13.02	–	–	–	12.9	–	–	–	15	–	–	–	14.9	12.55	–	15.45	14.23	10.8	–	13.58	12.3
lV	6.2		8.9	7.32	–	–	–	6.84	–	–	–	8.1	–	–	–	8.4	5.85	–	8.1	7.46	5.97	–	8.58	7.52
C	21.3		27.5	24.55	–	–	–	20.45	–	–	–	24.2	–	–	–	21.5	22.61	–	27.31	25.28	17.95	–	21.52	19.7
w % C																								
R	45.3		60	54.03	–	–	–	48.6	–	–	–	54.3	–	–	–	47.6	48.33	–	56.9	52.68	38.79	–	49.21	45.26
O	5.1		9.4	7.33	–	–	–	7.41	–	–	–	7.7	–	–	–	7.3	7.41	–	10.53	8.91	6.43	–	9.24	7.92
OP	31.5		41.6	36.23	–	–	–	45.11	–	–	–	36.7	–	–	–	44	35.09	–	42.37	38.72	43.65	–	53.78	48.2
iO	24.7		32.5	28.07	–	–	–	28.41	–	–	–	25.1	–	–	–	27.9	21.67	–	28.07	25.36	27.27	–	33.62	30.46
HC	29.8		41.3	34.31	–	–	–	40.04	–	–	–	35.2	–	–	–	42	27.59	–	35.85	32.1	32.85	–	48.76	43.12
hCo	19.8		30	23.61	–	–	–	21.89	–	–	–	20	–	–	–	24.3	17.74	–	22.64	20.31	19.42	–	26.02	22.68
rr	53.8		67.8	60.18	–	–	–	52.08	–	–	–	59.2	–	–	–	51.1	52.63	–	60.94	56.74	41.23	–	54.33	48.48
rc	32		48.3	36.97	–	–	–	33.03	–	–	–	39.3	–	–	–	30.7	30.91	–	42.19	35.62	20.18	–	33.33	27.11
rl	20.1		27.7	23.9	–	–	–	21.22	–	–	–	20.6	–	–	–	20.6	18.64	–	24.07	21.76	19.38	–	26.83	22.55
l_1	14.4		21.7	19.99	–	–	–	17.42	–	–	–	22.8	–	–	–	23.9	17.54	–	25.93	21.79	14.63	–	28.95	21.16
SRC	21.1		32.1	26.13	–	–	–	25.17	–	–	–	23	–	–	–	23.5	24.19	–	31.75	26.99	20	–	29.41	24.07
BC	39		53.1	44.88	–	–	–	–	–	–	–	–	–	–	–	–	36.84	–	45.28	40.13	40.15	–	54.46	46.53
SO	23.1		32.5	27.69	–	–	–	27.47	–	–	–	19.2	–	–	–	22.1	22.58	–	28.81	25.55	22.4	–	30.25	26.44
SRr	32.3		47.6	38.49	–	–	–	36.76	–	–	–	35.7	–	–	–	37.6	31.58	–	38	35.03	31.25	–	41.96	37.28
il	1.9		6.7	3.5	–	–	–	3.15	–	–	–	4	–	–	–	4.4	1.59	–	4.62	2.62	2.48	–	7.63	4.99

Prokeš et al. [35] found differences among the individuals in culture and those from the natural populations in the following characters: shorter distance between pectoral and ventral fins (PV), higher dorsal fin (hD), longer distance between the barbels base and cartilaginous vault of the mouth (rl) as well as substantially bigger mouth (SO) in individuals from the aquaculture. Among the characters mentioned, in own study the similar tendency was noted with respect to the mouth wide (SO). The tendency discussed concerning the remaining characters are not affected by the aquaculture on the variability of these characters, but resulted from the small size of the fish investigated by these authors, what is confirmed by this study results on the material of similar length ranges.

The characters discussed (PV, hD, rl) of fish in own study show different tendencies with the fish growth and change the values which differentiated them from the individuals from natural populations. It is confirmed by the results obtained by Ruban and Sokolov [39], from the individuals living in the heated water fish farms and which are in agree with results obtained for fish living in the wild. Therefore, the most significant character differentiating the Siberian sturgeons in this study from the individuals from the wild populations seems to be the mouth width (SO). It can indicate the domestication of the Siberian sturgeon. It is the most likely, bearing in mind the fact that it is the third generation in culture, therefore the effect could become preserved and strengthen by the natural and artificial selection as well as the multiple activated. Part of the results and notes of Prokeš et al. [35] is in agree with this contention. It is also confirmed by the results obtained for the meristic characters, which differ in the mean values of meristic characters when compared to the population living in the wild. Their instability can be an effect of this process.

The enlargement of mouth seems to be an effect of granular trout feed utility, being the specific adaptable reaction to kind of the food given. Data recorded by Ruban and Sokolov [39] confirmed this hypothesis, although the sturgeons investigated by them were fed with the minced meat of less valuable fish species. The artificial selection of weaker individuals, who probably did not adapt to the kind of feed, might affect the presence in the genetic pool the individuals with wide mouth, what was fixed in the next generation. The similar tendencies were noted by Rudziński [40] and Steffens [46] in the investigations of wild and cultured carps, where the latter fish had substantially bigger mouths. Wankowski [49] stated the effect of dimension and kind of the feed on the changes of mouth structures in the juvenile salmon *Salmo salar* L. It seems that the process of domestication will be intensified and in near future can lead to the formation of "domesticated" form of this species, not only characterized by dissimilar morphology but by the biological characters as well, as it was noted in the salmon *Salmo salar* L. [14].

CONCLUSION

Summing up all above considerations: although the morphological investigations are considered as reasonable in the morphological concept of species, which is criticized on the assuming it as a simple assemblage of similar individuals, and not as e.g. in the biological aspect, as a genetic or ecological assemblage, nevertheless the substantial convergence is stated between the morphological characters of species and the nature of extensive genetic pool, divided into the collection of its members. This phenomenon justifies and in the matter of fact, demands the use of morphological criteria [26]. Genetic information determines only the range of developmental possibilities, whose expression affected by the environmental factors, leads to the phenotype formation. In this kind of changes the ecological variability plays more important role when compared to the geographical variability [30].

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