Metric Characters and Body Indices of Juvenile Sterlet *Acipenser ruthenus* Raised in a Recirculating Aquaculture System (RAS)

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Abstract
Our research was performed on juvenile sterlets (*Acipenser ruthenus*), aged between 346-431 days, maintained in five round pools (Ø=3 m, V=6 m^3, h-100 cm) and fed with a commercial extruded pellet (3 mm granulation, 48% CP, and 10% EE). Body weight and total body length on 30 individuals from each tank were determined every two weeks. Weighing and somatic measurements achieved at the end of experimental period (standard length-l, body weight-G, maximum body high–H, maximum body perimeter (P_{max}), head length–$l_{h,}$, caudal peduncle length-l_p) allowed us to calculate the following body indices: profile index, thickness index, Fulton index, Kiselev index, meat index.
Statistical analysis was performed by using the SPSS IBM 22 and Minitab 16 software. Data were reported as Mean±Sx at a significant level of p<0.05. Testing differences between means was realized by ANOVA completed with post-hoc Tukey test.
Results obtained led to conclude that specimens analyzed had a good maintenance and feeding, an adequate development, a high proportion of meat, an elongated body and a straight back, and they are eligible for selection.

Keywords: *Acipenser ruthenus*, body indices, recirculating aquaculture system (RAS), somatic measurements

1. Introduction

Farming of sturgeon species in recirculation aquaculture systems can offer controlled and optimal conditions for a fast growth [1].
Sterlet is the third most widely cultured sturgeon species, being farmed in 15 countries including such traditionally caviar producers as Russia or Iran [2]. Early maturation and a small size are favorable features recommending starlet for caviar production in recirculating aquaculture system.
The morphological characteristics analysis by biometry is a frequently used method in the study of systematic fish groups. Performing weighing and somatic measurements it can deduce the particular state of fish maintenance and adaptability to environmental conditions to which they are exposed [3].
The purpose of the present work was to monitor evolution of some morphological characters of juvenile sterlet *Acipenser ruthenus* between 346-431 days of age and to calculate various indicators and tangible factors that make possible the evaluation of considered fish population.

2. Materials and methods

Our research was conducted between February 25 2014-21 May 2014 within the recirculating aquaculture system for sturgeon raising from

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Herneacova village, Timis county, on a population of juvenile sterlet *Acipenser ruthenus,* aged between 346-431 days.

Feed administration was done automatically, the bunker screw feeder having a working duration of 10 to 11 h/day at the beginning of the experimental period, and up to 10-13 hours/day to end. Given that sturgeon is "slow" fish, slowly consuming, the feeders were adjusted so that the feed was given 2 times/h (33 g/s). The daily feed ration was calculated based on sterlets biomass: at the beginning of the experimental period it was 1% of the stock biomass, and then it was reduced to 0.9% in March-April, and to 0.75% in May. Pellet had a grain size of 3 mm and the following composition (Table 1).

Table 1.Feed composition

Table1 Components	Unit	Value
Crude Protein	%	48
Crude fat	%	10
Crude fiber	%	0.8
Ash	%	8.6
Phosphorus	%	1.3
Calcium	%	1.6
Sodium	%	0.4
Vitamin A	(U.I)	13.750
Vitamin C	mg/kg	1.015
Vitamin E	mg/kg	276
Vitamin D (mg/kg)	mg/kg	1.782
Iron (ferrous sulphate monohydrate)	mg/kg	117
Iod (anhydrous calcium iodate)	mg/kg	7.8
Copper (copper sulfate pentahydrate)	mg/kg	7.8
Manganese (manganese oxide)	mg/kg	31
Zinc (Zinc sulfate monohydrate)	mg/kg	125

Water's physical-chemical parameters (temperature, dissolved oxygen, pH) were recorded using a system consisting of controller to which a probe was connected.

The other chemical parameters, nitrates, nitrites, hardness, chlorine, were calorimetrically determined with a photo flex colorimeter and using rapid testers.

Biological material was hatched on 03/17/2013 and it was obtained from F2 generation of breeders. On arrival in the fish farm (27/07/2013) they have recorded an individual average weight of 55-60 g. At the beginning of the experiment, studied sterlet specimens were aged 346 days, average weight 390 g, and an average body length of 45.5 cm. 5 growth pools and a total number of 150 individuals (30 individuals/pool) were targeted in the experiment.

Metric (length, width, height, perimeters) and gravimetric characters (weight) where obtained using measuring instruments: ruler, centimeter ribbon, caliper, electronic balance.

The measurements of measurable characters were taken in vivo on the left side of the body after the fish had been anesthetized with clove oil (10 ml/50 l water).These measurements (Figure 1) were:

- *total length (L)*: straight line along the body axis from the tip of the snout to the tip of the tail (not following the curvature of the body) [4].
- *standard length (l)*: refers to the length of a fish measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the midlateral portion of the hypural plate. Simply put, this measurement excludes the length of the caudal fin**.** Standard length has the advantage of not being affected by minor damage to the tail fin, nor does it give too much credit to a fish for the relatively light weight tail when calculating a fish's condition
- *head length* (l_h): straight line along the body axis from the tip of the snout to the posterior edge of the bone that forms the gill cover (i.e., excluding the soft opercular flap) [4].
- *caudal peduncle length*-l_p: the straight-line distance from the posterior end of the anal fin base to the caudal base [5].

- *maximum body high–H*: the greatest straight-line height or depth of the body, from the dorsal to the ventral surface [5].
- *maximum body perimeter (P_{max})*: measured around the widest part of the body.

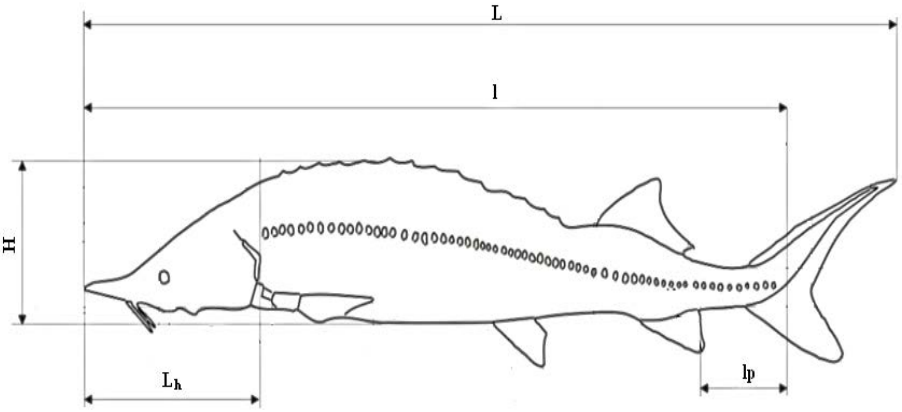

Figure 1. A schematic of some *Acipenseridae* measurements

- *maximum thickness of body (G)*: measured in the area where the body have the greatest thickness; The measurement should be taken perpendicular to the length of the fish.
- *body weight-G*: determined by weighing;

Weighing and somatic measurements above mentioned allowed us to calculate the following body indices: profile index, thickness index, Fulton index, Kiselev index, meat index with the standard formulae:

- *Profile index (height)*–highlight fishes' corporal format and allow framing of population individuals in a certain profile type. To calculate this index the following formula has been applied:

  $$Ip = l/H$$

  where:

  Ip=profile index; l=body standard length (cm); H=maximum body high (cm).
- *Thickness index (width of back)* expresses the width of musculature from back region in rate with maximum body height. Thickness index could be calculated using the formula:

  $$I_g = (G \times 100)/H$$

  where:

  G=maximum thickness of body (cm); H=maximum height of body (cm)

  -*Fulton's Condition Index* is a sensitive measure of change and differences in body form. It assumes isometric growth (b =3, fish shape does not change with growth) and is calculated as the ratio between the observed weight and an expected weight dependent on the fish's length [6]. The comparison of weight for a reference length is necessary because the length-weight relationship is generally not isometric in lake sturgeon (slope>3) [7]. The formula for its calculating is:

  $$I_f = (m \times 100)/l^3,$$

  where:

  l=body standard length (cm);

  m=body weight
- *Quality index (Kiselev)* is established based on Kiselev formula and offers information on fish growth rate. Quality index is calculated as follows:

  $$I_c = l/C$$

  where:

  l= body standard length (cm);

  C=body circumference (cm).
- *Meat index* express the percentage rate of head from the body standard length or the proportion of caudal peduncle in standard length of fish. To calculate this index the following formulas were applied:

  $$I_{m1}=(l_h \times 100)/l$$

  $$I_{m2}=(l_c \times 100)/l$$

  where:

  l_h = head length (cm);

  l_c=caudal peduncle length (cm);

  l=body standard length (cm).

Statistical analysis was performed by using the SPSS IBM 22 and Minitab 16 software. Data were reported as Mean±SD at a significant level of $p<0.05$. Testing differences between means was realized by ANOVA completed with post-hoc Tukey test.

3. Results and discussion

Statistical analysis of the values obtained during these measurements between the 5 five pools does not indicate statistically significant differences in terms of standard length-l (Table 1), head length-l_h (Table 2) and caudal peduncle length-l_p (Table 3).

Table 2. Indices and statistical significance on the standard length of juvenile sterlet at 431 days of age

Statistical indices								
Pool	n	Min.	Max.	Sum	X	Sx	SD	Variance
I	30	36.00	43.00	1200.00	40.00	0.31	1.72	2.96
II	30	37.00	46.00	1213.00	40.43	0.40	2.19	4.80
III	30	34.00	44.00	1185.00	39.50	0.42	2.31	5.36
IV	30	37.00	44.00	1226.00	40.86	0.40	2.22	4.94
V	30	35.00	44.00	1162.00	38.73	1.26	6.90	47.72

Statistical significance				
Pool	II	III	IV	V
I	0.99	0.98	0.89	0.65
II		0.85	0.99	0.36
III			0.60	0.92
IV				0.16

Table 3. Indices and statistical significance on head length–l_h of juvenile sterlet at 431 days of age

Statistical indices								
Pool	n	Min.	Max.	Sum	X	Sx	SD	Variance
I	30	9.00	11.00	286.00	9.53	0.10	0.57	0.32
II	30	9.00	12.00	327.00	10.65	0.20	0.85	0.67
III	30	9.00	11.00	291.00	9.70	0.12	0.70	0.49
IV	30	9.00	12.00	308.50	10.28	0.14	0.80	0.65
V	30	9.00	11.00	302.00	10.06	0.12	0.67	0.46

Statistical significance				
Pool	II	III	IV	V
I	0.40	0.87	0.39	0.71
II		0.38	0.86	0.58
III			0.92	0.99
IV				0.98

Table 4. Indices and statistical significance on the caudal peduncle length-l_p of juvenile sterlet at 431 day of age

Statistical indices								
Pool	n	Min.	Max.	Sum	X	Sx	SD	Variance
I	30	2.50	6.00	107.30	3.57	0.14	0.79	0.63
II	30	3.00	4.00	102.00	3.40	0.09	0.49	0.24
III	30	2.00	4.00	97.00	3.23	0.10	0.56	0.32
IV	30	3.00	4.00	9900	3.30	0.08	0.46	0.21
V	30	3.00	4.00	96.00	3.20	0.07	0.40	0.16

Statistical significance				
Pool	II	III	IV	V
I	0.80	0.13	0.27	0.07
II		0.73	0.91	0.59
III			0.99	0.99
IV				0.97

However, compared to each other, corresponding values to the others parameter: maximum body high–H, maximum body perimeter (P_{max}), have led to the different degrees of significance between the five growth pools (Table 5-6). Thus, significant differences appear for the maximum body perimeter (P_{max}), when specimens from pool I are compared with those of pools III ($p<0.001$), IV ($p<0.01$) and V ($p<0.01$) (Table 5). For the parameter maximum body high–H, significant differences ($p<0.01$) can be observed between individuals belonging to pool II and III, and II vs. V respectively (Table 6).

Table 5. Indices and statistical significance on maximum body perimeter (P_{max}) of juvenile sterlet at 431 days of age

Statistical indices								
Pool	n	Min.	Max.	Sum	X	Sx	SD	Variance
I	30	17.00	22.00	576.00	19.20	0.25	1.39	1.95
II	30	10.00	23.00	531.00	17.70	0.63	3.48	12.14
III	30	14.00	21.00	523.00	17.43	0.28	1.56	2.46
IV	30	15.00	20.00	532.00	17.73	0.27	1.52	2.34
V	30	16.00	20.00	517.00	17.23	0.22	1.22	1.49

Statistical significance				
Pool	II	III	IV	V
I	1.31	0.001***	0.04**	0.002**
II		0.54	0.99	0.62
III			0.79	1.00
IV				0.85

*** significant difference at $p<0.001$; ** significant difference at $p<0.01$

Table 6. Indices and statistical significance on maximum body high–H of juvenile sterlet at 431 days of age

Statistical indices								
Pool	n	Min.	Max.	Sum	X	Sx	SD	Variance
I	30	5.30	7.30	185.20	6.17	0.09	0.49	0.24
II	30	5.40	7.90	193.00	6.43	0.12	0.67	0.45
III	30	4.80	7.70	179.80	5.99	0.11	0.64	0.42
IV	30	5.00	7.30	184.80	6.16	0.11	0.64	0.41
V	30	5.20	7.10	178.10	5.93	0.08	0.44	0.19

Statistical significance				
Pool	II	III	IV	V
I	0.35	0.69	1.00	0.52
II		0.01**	0.31	0.008**
III			0.72	0.99
IV				0.55

** significant difference at $p<0.01$

Analyzing Pearson's correlation coefficients from table 31, it can note that the standard length-l is poorly correlated with body thickness (r=0.29), head length-l_h (r=0.20), and caudal peduncle length-l_p (r=0.33), but is medium correlated with maximum body high–H (r=0.5). The thickness of the body is negatively correlated with head length-l_h (r=-0.39), but is moderately correlated (r=0.64) with maximum body high–H and poorly correlated with caudal peduncle length-l_p (r=0.42). Head length-l_h is poorly correlated (r=0.27) both with maximum body high–H and with caudal peduncle length-l_p (r=0.18), while the maximum body high–H is weakly to moderately correlated (r=0.48) with caudal peduncle length-l_p.

Table 7. Pearson's correlation coefficient between the somatic measurements performed at 431days of age

Somatic parameters	maximum body perimeter (P_{max})	head length–l_h	maximum body high–H	caudal peduncle length-l_p
	r	r	r	r
standard length-l	0.296**	0.206*	0.454**	0.333**
maximum body perimeter (P_{max})		-0.396**	0.648**	0.420**
head length–l_h			0.270**	0.186*
maximum body high–H				0.484**

** significant correlation at $p<0.01$; * significant correlation at $p<0.0$

Calculated *profile index* (Table 8) recorded relatively closes values with a minimal of 6.49±0.09 in specimens from pool II and a maximal one of 6.53±0.014 in specimens from pool IV. A lower value of this index suggests a pronounced convexity of the superior line of bodies. Breeding selection aims fish with the lowest profile index, because the bulging aspect of back is correlated with a rich muscular mass [8]. Simeanu, et al., [9] and Szelei et al., [10], found similar profile indices in sturgeon *Polyodon spathula* in different development stages and in juvenile of Russian sturgeon (*Acipenser güeldenstaedti*) raised in recirculating system respectively. According to the values obtained by us for this index, we can consider the juvenile sterlets as having an elongated body and a straight back.

Thickness index found in the specimens of the 5 growth pools, has similar values to those reported for Russian sturgeon by Szelei et al., [10].

In terms of *Fulton's Condition Index* ($I_î$), individuals from all 5 pools having the same conditions regarding environment and feed, they harness in a similar way the available resources, as data in table show. Our results exceed those obtained by Simeanu et al., [9] and Szeley et al., [10] in padeel fish and Russian sturgeon, this higher value corresponding to a superior maintenance state and feeding [11]. As the fattening index values are higher, the fish is well developed [9, 10].

Quality index (Kiselev) helps to determine fish quality, without making any other measurements or weightings. The higher the quality index is lower, both the fish is better developed. Low values of this index recorded in the present paper, recommend the individuals from the five pools for selection activity (Table 8).

Meat indices were higher for all growth pools considered when we take into account the length of the caudal peduncle than head length (Table 8) and better than thouse reported by other authors [10]. And it is desirable to provide low values.

Table 8. Body indices of juvenile sterlet at 431 days of age

Body indices	Pool I	Pool II	Pool III	Pool IV	Pool V
	X± SD	X±SD	X±SD	X±SD	X±SD
Profile index (I_p)	6.50±0.13	6.49±0.09	6.51±0.08	6.53±0.14	6.53±0.08
Thickness index (I_g)	280.18±0.04	277.27±0.05	280.98±0.01	279.82±0.12	279.70±0.0
Fulton's Condition Index ($I_î$)	0.94±0.04	0.98±0.01	0.97±0.06	0.95±0.01	0.99.±0.10
Quality index (I_c)	2.08±0.02	2.28±0.19	2.26±0.17	3.03±0.02	2.24±0.03
Meat index (I_{m1})	26.82±0.12	26.96±0.04	24.55±0.03	25.10±0.10	25.97±0.04
Meat index (I_{m2})	8.50±0.02	8.48±0.01	8.59±0.17	8.43±0.04	8.46±0.03

4. Conclusions

The obtained results led to the conclusion that analyzed specimens had:

- good maintenance and feeding,
- an adequate development,
- a high proportion of meat,
- an elongated body and a straight back, and they are eligible for selection.

References

1.http://www.coppens.eu/gallery/Engelse_brochures/2013/enstecoleaflet2013.pdf), Sturgeon leaflet, 2013.

2. Bro Bronzi, P., Rosenthal, H. and Gessner, J., Global sturgeon aquaculture production: an overview, J. Appl. Ichthyol., 20011, 27, 169-175.

3. Simeanu, C., Păsărin, B., Importanţa speciei de sturioni dulcicoli *Polyodon spathula,* pentru acvacultura românească, Revista de Zootehnie, 2009, Iaşi, Anul VI, 4, 44-46.

4. Damon-Randall, K., Bohl, R., Bolden, S., Fox, D., Hager, C., Hickson, B., Hilton, E., Jerre Mohler, Robbins, E., Savoy, T. and Spells, A., Atlantic Sturgeon Research Techniques, National Oceanic and atmospheric administration (NOAA), 2010.

5.http://www.seagrant.wisc.edu/home/Default.aspx?tabid=607&TermID=10, Fish glossary

6. Brian G. Blackwell, Michael L. Brown, and David W. Willis, Relative Weight (Wr) Status and Current Use in Fisheries Assessment and Management, Reviews in Fisheries Science, 2000, 8(l), l-44.

7. Fortin, R., Dumont, P., and Guénette, S., Determinants of growth and body condition of lake sturgeon (*Acipenser fulvescens*), Can. J. Fish. Aquat. Sci., 1996, 53, 1150-1156.

8. Mireşan, V., Cocan, D., Constantinescu, R., Răducu, C., Feştilă, I., Sărmas, I., Using body size indices for selection of future rainbow trout breeding (*Oncorhynchus mykiss*, Wallbaum 1792), Bulletin of UASVM Animal Science and Biotehnologies, Cluj-Napoca, 2010, 67(1-2), 60-65

9. Simeanu, C., Păsărin, B., Simeanu, D., The study of some morphological characteristics of the sturgeon species of *Polyodon spathula* in different development stages, U.S.A.M.V. Iaşi, 2010, 54(15)244-247
10. Szelei, Z., Bura, M., Grozea, A., Muscalu-Nagy, C., Bănăţean-Dunea, I., Study about corporal indicators in juvenile of Russian sturgeon (*Acipenser güeldenstaedti*) raised in recirculating system, Lucrări ştiinţifice Zootehnie şi Biotehnologii, 2009, 42 (2), 123-129
11. Măgdici, E., Pagu I. B., Nistor C. E., Iordache, M. I., Hoha G. V., Păsărin, B., Study on the evolution of some morphological characteristics of *Silurus glanis* species in different development stages, farmed in Iasi county, Lucrări Ştiinţifice-Seria Zootehnie, 2014, 62, 79-84.