GROWTH DYNAMIC OF THE MAIN MORPHOLOGICAL TRAITS IN A STERLET (*ACIPENSER RUTHENUS*) POPULATION REARED INTO RECIRCULATING AQUACULTURE SYSTEM, FROM 2 TO 6 MONTHS OLD

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Abstract. *The Danube sturgeons are fishes with high economic value, and their intensive aquaculture shown a wide interest from the Romanian investors. The sterlet (Acipenser ruthenus) is the smallest sturgeon which could be found in the Danube basin, being a fresh water species with many useful characteristics which recommend it as a very good candidate for intensive aquaculture, in recirculating aquaculture systems (RAS). This species can be found at this time in many Romanian farms, which are rearing sturgeons in RAS. The aim of this study is to emphasize the growth dynamic of the main morphological traits and the body indices in a population of sterlet fingerlings, during 4 months, between 2 to 6-month-old, reared into a RAS. The juveniles of sterlet (Acipenser ruthenus) used in this study were obtained using artificial reproduction of the broodfish reared exclusively in RAS in the spring of the year 2016. The juveniles were reared in RAS until the age of 2 months, when the biometrical study started. The RAS used for trials had 3 tanks, with one cubic meter of water each, and the water exchange rate was about once per hour. One hundred and fifty sterlet, 2 months old, were introduced into the 3 tanks of the RAS, 50 fish per tank, in triplication. The main body traits were measured twice per month, from the age of 60 days to the end of 6^{th} month of fish life. The following measurements were carried out: total length (TL), standard length (SL), head length (HL), head width (HW), snout length (SnL), maximum body depth (MBD), mouth width (MW) and body weight (BW). During the experimental period, the fish were fed with sturgeon feed produced by Coppens International (Nederland), with different sizes, from 1.2-1.5 mm to 3 mm according to fish sizes. The amount of feed per day was calculated as a percent of the total fish biomass established at each measurement made at every two weeks. The growth dynamic of the sterlet in the 4 months of study was very fast, with significant differences ($p \geq 0.05$) between measurements at every 2 weeks, in almost all cases. The TL of the fish increased from 134.37±11.92 mm to 359.53±22.04 mm and the BW greatly increased, from 10.2±2.27 g to 180.53±45.28 g. The other traits registered also good dynamics with certain patens emphasized in the paper. All of these allowed the drafting of growth curves for different traits, very useful for sturgeon farmers but not only.*

Keywords*: sterlet, Acipenser ruthenus, fingerlings, growth dynamic, RAS*

INTRODUCTION

The sturgeons are fishes with high economic value, being considered flagship species for the Danube River basin and a real indicator for water quality and health of the ecosystem (MAIR & MANDL, 2013). In the last decades, the six species of sturgeons regarded as native in Danube River have declined drastically. Only four species are still present in the river being considered critically endangered (Russian sturgeon – *Acipenser gueldenstaedtii*; beluga sturgeon – *Huso huso*), endangered (stellate sturgeon – *Acipenser stellatus*) or vulnerable (sterlet – *Acipenser ruthenus*), according with IUCN Red List of Threatened Species (GESSNER et al., 2010; 2010a; 2010b; QIWEI, 2010). Anyway, these fish started in the last years to have an important role in the sturgeon aquaculture in Romania and many investors starts the rearing of these species into farms. The sterlet (*Acipenser ruthenus*) is the smallest sturgeon which could be found in the Danube basin, being a fresh water species with many useful characteristics which recommend it as a very good candidate for intensive aquaculture, in recirculating aquaculture systems (RAS). So far, there were made some studies regarding the growth dynamic of the sterlet (BURA & SZELEI, 2009) and other sturgeons into RAS (BURA et al., 2009; SZELEI et al., 2009), but for short period, and generally the information are sparse.

The aim of this study is to emphasize the growth dynamic of the main morphological traits and the body indices in a population of sterlet fingerlings, during 4 months, between 2 to 6-month-old, reared into a RAS.

MATERIAL AND METHODS

The juveniles of sterlet (*Acipenser ruthenus*) used in this study were obtained in the spring of the year 2016, into a recirculating aquaculture system (RAS) at Banat's University of Agricultural Sciences and Veterinary Medicine „King Michael I of Romania" from Timisoara. The artificial propagation started when the temperature in the RAS where the broodfish were kept reached 15°C. They were stimulated with an analog of LHRH: des-Gly10 [D-Ala6]-LHRH ethylamide acetate salt (LHRH-A) (L4513, SIGMA-ALDRICH), using a single dose according with the method described by RONYAI (2008). The juveniles were raised the first month of life into elongated rectangular tanks (330 x 40 x 30 cm) connected to a RAS, after that being moved into square tanks with rounded corners (150 x 150 x 90 cm) with one cubic meter of water in each tank. These tanks were part of a RAS as well. The fish were maintained and accommodated with these tanks for one month until they had 2 months old.

The RAS used for trials had 3 tanks, with one cubic meter of water each, and the water exchange rate was about once per hour. One hundred and fifty sterlet fingerlings, 2 months old, were introduced into the 3 tanks of the RAS, 50 fish per tank, in triplication.

During the experimental period, the fish were fed with sturgeon feed produced by Coppens International (Nederland), with different sizes, from 1.2-1.5 mm (ADVANCE, 56% crude protein - CP) to 2 mm (STAR ALEVIN, 54% CP) and 3 mm (SUPREME-10, 49% CP), corresponding to fish sizes. The amount of feed per day was calculated as a percent of the total fish biomass established at each measurement made at every two weeks. The amount of feed was adjusted at 5% of fish biomass per day for the fish with the age of 2-3 months, and gradually decreased to 4% and 3% of fish biomass per day at the fish with the age of 4 months-old and 5-6 months-old, respectively. The feeding was made using 24 hours belt feeders (FIAP, Germany).

The main body traits were measured twice per month, from the age of 60 days to the end of 6^{th} month of fish life. Each time, 30 specimens were measured, 10 from each tank. The following measurements were carried out: total length (TL), body weight (BW), standard length (SL), maximum body depth (MBD), head length (HL), head width (HW), snout length (SnL) and mouth width (MW) according with the methods described by BURA & GROZEA (1997) and GROZEA (2007). The results were statistically processed using STATISTICA 10 package. For each trait, there were calculated the mean, standard deviation, standard error, coefficient of variation and logarithmic regressions. The data statistically processed are written into the paper as Mean ± SD.

Based on the obtained data, some indices have been calculated using the following formulae:

Profile index; Pi = SL (cm) / MBD (cm)

Condition factor; $K = (BW\ (g) \times 100) / TL^3\ (cm)$

Specific growth rate; $SGR_{BW} = [(\ln \text{final BW} - \ln \text{initial BW}) / \Delta T] \times 100$

$SGR_{TL} = [(\ln \text{final TL} - \ln \text{initial TL}) / \Delta T] \times 100$

Daily growth rate; $DGR = (\text{final BW} - \text{initial BW}) / \Delta T$

where: ΔT is the duration of the experiment, the other being described above.

RESULTS AND DISCUSSIONS

The data from the table 1-8 reveal the mean, standard deviation, standard error and coefficient of variation of the traits measured in the sterlet fingerlings during the experimental period. The trends of the total length (TL), body weight (BW), standard length (SL), head length (HL), head width (HW), snout length (SnL), maximum body depth (MBD) and mouth wide (MW) were mathematically adjusted with the second-degree polynomial regression, being revealed in the figures 1-4.

Table 1

The dynamic of the total length (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	134.37	191.23	226.03	262.17	296.78	317.93	333.63	345.30	359.53
SD	11.92	25.50	8.21	9.12	10.85	17.40	19.52	17.23	22.04
SE	3.77	4.66	1.50	1.67	1.98	3.18	3.56	3.15	4.02
CV	8.87	13.34	3.63	3.48	3.66	5.47	5.85	4.99	6.13

SD – standard deviation; SE – standard error; CV – coefficient of variation

Table 2

The dynamic of the body weight (g) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (g)	10.20	23.96	41.94	65.21	104.97	120.93	133.77	157.93	180.53
SD	2.27	5.30	4.85	7.36	15.64	23.96	31.60	33.05	45.28
SE	0.72	0.97	0.89	1.34	2.86	4.38	5.77	6.03	8.27
CV	22.27	22.12	11.58	11.28	14.90	19.82	23.63	20.93	25.08

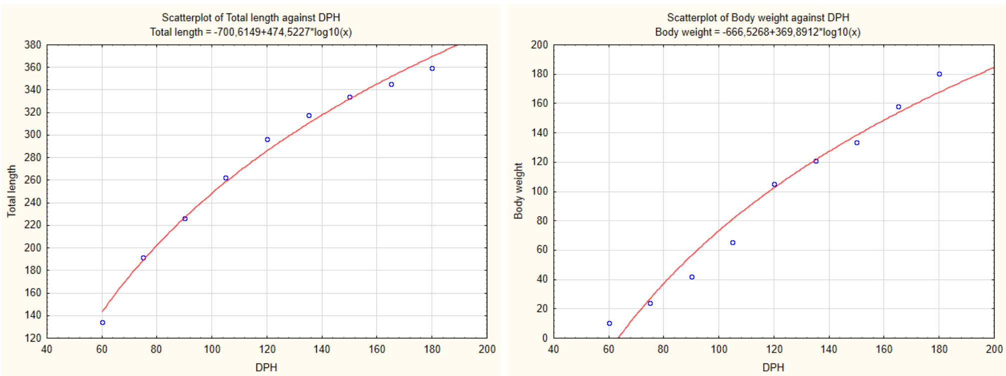

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Figure 1. The trend of the total length (a) and body weight (b) in the sterlet fingerlings between 60 and 180 DPH, mathematically adjusted with the logarithmic regression

The TL of the fish increased during the four months of study from 134.37±11.92 mm to 359.53±22.04 mm, this meaning that sterlet fingerlings increased their length 2.68 times in this period. Therefore, between 60 and 180 days post-hatching (DPH), the sterlet fingerlings elongate a lot their bodies, especially in the first half from this period when the total length of a fingerling could grow 2.21 times, that's meaning 82% from the total period. Specific growth rate for total length, SGR_{TL} calculated for entire period was equal with 0.82% day^{-1}.

The BW spectacularly increased, from 10.2±2.27 g to 180.53±45.28 g, that's meaning 17.70 times in 120 days. The trend is very well emphasized in the figure 1b. Specific growth rate for body weight, SGR_{BW} calculated for entire period was equal with 2.39% day^{-1}, very high comparing with the same index expressed for TL. DGR was calculated for the sterlet fingerlings in the experimental period, being equal with 1.42 g.

Table 3

The dynamic of the standard length (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	104.43	146.29	183.47	208.87	237.57	255.80	267.17	277.80	291.50
SD	8.62	12.53	7.39	6.93	9.44	14.91	15.13	13.84	17.85
SE	2.72	2.29	1.35	1.26	1.72	2.72	2.76	2.53	3.26
CV	8.25	8.57	4.03	3.32	3.97	5.83	5.66	4.98	6.12

Table 4

The dynamic of the maximum body depth (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	18.30	22.19	25.61	30.19	35.70	36.20	36.83	38.70	40.63
SD	1.23	1.85	1.38	1.87	2.51	3.04	3.62	3.83	4.44
SE	0.39	0.34	0.25	0.34	0.46	0.56	0.66	0.70	0.81
CV	6.74	8.34	5.38	6.20	7.03	8.40	9.82	9.88	10.92

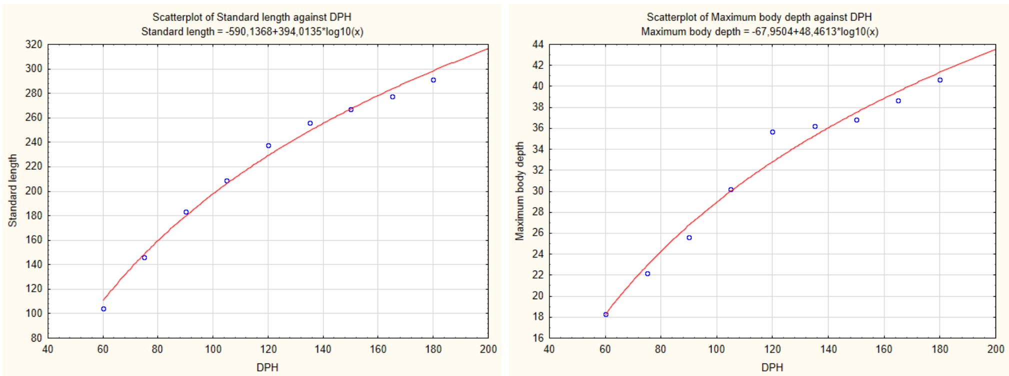

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Figure 2. The trend of the standard length (a) and maximum body depth (b) in the sterlet fingerlings between 60 and 180 DPH, mathematically adjusted with the logarithmic regression

The SL of the fingerlings shown a quite similar trend like the TL, but with a higher dynamic. Therefore, between 60 and 180 DPH, the SL of the sterlet fingerlings grown 2.68 times, which means that the tail grown slower in length than the rest of the body included in TL.

The MBD of the fish increased 2.22 times in the study period. The trend of MBD during the four months shown a specific paten, with a very high curve in the first half, growing 1.95 times (that's meaning 87.8% from total period).

Based on the above data, two indices (profile index and condition factor) have been calculated. The results are shown in table 5.

Table 5

The dynamic of profile index and condition factor (K) in sterlet fingerlings during experimental period

Indices	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Profile index	5.71±0.31	6.60±0.32	7.17±0.28	6.93±0.31	6.67±0.35	7.09±0.45	7.29±0.51	7.22±0.55	7.23±0.63
Condition factor K	0.41±0.02	0.35±0.06	0.36±0.03	0.36±0.02	0.40±0.04	0.37±0.03	0.35±0.04	0.38±0.04	0.38±0.05

Profile index; P_i = SL (cm) / MBD (cm)
Condition factor; K = (BW (g) x 100) / TL^3 (cm)

The condition factor (K) had very small values (from 0.35 to 0.41), this showing that the sterlet fingerlings have been very elongated and thin between 60 and 180 DPH without any important changes from this point of view.

Table 6

The dynamic of the head length (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	31.92	45.54	53.66	62.43	68.97	72.63	74.90	77.93	81.20
SD	2.78	5.96	2.22	1.87	1.99	3.15	4.14	3.28	4.26
SE	0.88	1.09	0.41	0.34	0.36	0.57	0.76	0.60	0.78
CV	8.71	13.09	4.14	2.99	2.89	4.33	5.53	4.21	5.25

Table 7

The dynamic of the head width (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	15.57	20.85	23.92	26.93	31.34	30.87	32.54	34.10	35.93
SD	1.41	1.89	1.06	1.01	11.22	1.67	2.43	2.71	2.36
SE	0.45	0.35	0.19	0.19	2.05	0.31	0.44	0.49	0.43
CV	9.07	9.07	4.42	3.77	35.81	5.41	7.48	7.94	6.57

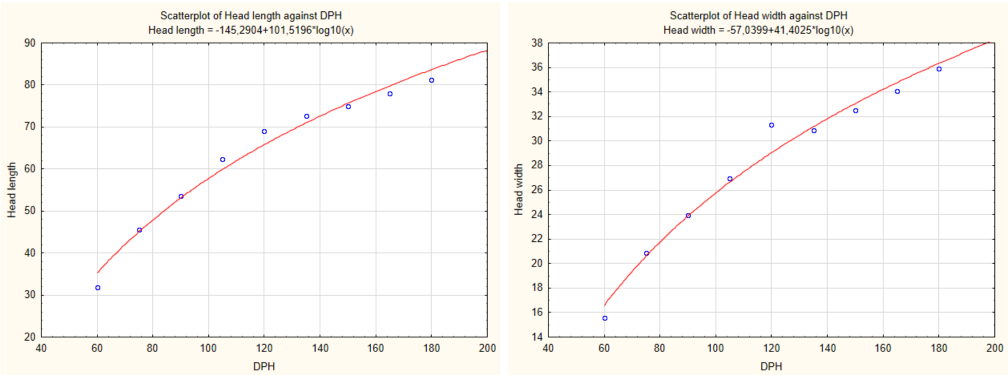

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Figure 3. The trend of the head length (a) and head width (b) in the sterlet fingerlings between 60 and 180 DPH, mathematically adjusted with the logarithmic regression

Table 8

The dynamic of the snout length (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	21.30	26.21	31.06	34.16	39.79	42.05	42.94	44.30	46.00
SD	1.55	1.93	1.52	6.67	2.00	2.07	2.18	2.37	2.51
SE	0.49	0.35	0.28	1.22	0.37	0.38	0.40	0.43	0.46
CV	7.30	7.37	4.90	19.52	5.03	4.92	5.08	5.34	5.45

Table 9

The dynamic of the mouth width (mm) in sterlet fingerlings (n = 30) during experimental period

Specification	Days post-hatching								
	60	75	90	105	120	135	150	165	180
Mean (mm)	6.39	7.03	7.68	8.40	8.81	9.52	9.52	9.57	9.70
SD	0.57	0.76	0.44	0.50	0.47	0.38	0.61	0.50	0.65
SE	0.18	0.14	0.08	0.09	0.09	0.07	0.11	0.09	0.12
CV	8.92	10.79	5.78	5.98	5.34	4.01	6.43	5.27	6.71

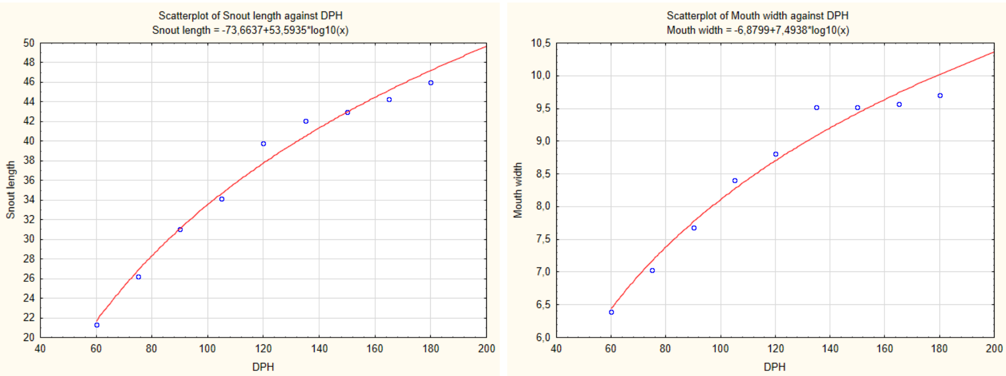

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Figure 4. The trend of the snout length (a) and mouth width (b) in the sterlet fingerlings between 60 and 180 DPH, mathematically adjusted with the logarithmic regression

The growth dynamics of the HL, HW, SnL and MW, have shown a quite similar paten, increasing very fast in the first half of experimental period.

CONCLUSIONS

1. Sterlet fingerlings increased their length 2.68 times between 60 and 180 days post-hatching, up to 359.53±22.04 mm. In the first half from this period the total length of a fingerling grown 2.21 times, that's meaning 82% from the total period.

2. The BW grown 17.70 times in 120 days, from 10.2±2.27 g to 180.53±45.28 g.

3. Specific growth rate for body weight, SGR_{BW} calculated for entire period was equal with 2.39% day^{-1}, very high comparing with the same index expressed for TL (0.82% day^{-1}).

4. The SL of the fingerlings shown a quite similar trend like the TL, but with a higher dynamic, growing 2.68 times.

5. The MBD of the fish increased 2.22 times in the study period, growing very fast in the first half (87.8% from total period).

6. The condition factor (K) had very small values, this showing that the sterlet fingerlings have been very elongated and thin throughout the experimental period.

7. The growth dynamics of the HL, HW, SnL and MW, have shown a quite similar paten, increasing very fast in the first half of experimental period.

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