THE INFLUENCE OF FEEDING INTENSITY ON GROWTH PERFORMANCE OF *ACIPENSER STELLATUS* (PALLAS 1771) JUVENILS

V. Cristea[1*], Maria Desimira Dicu[1], Lorena Dediu[1], Marilena Măereanu[2], M.T. Coadă[1]

[1] Aquaculture, Environmental Science and Cadastre Department, Universitatea „Dunărea de Jos" Galati, Romania
[2] Kaviar House, Bucharest, Romania

Abstract

This paper presents a experiment regarding the influence of feeding intensity over intensive growth performance of juvenile sturgeon (Acipenser stellatus, Pallas 1771), 5 months old. The experiment was held in a recirculating aquaculture pilot system (RAS). Experimental period was 30 days. The material was stored in four growing units with a volume of 300 liters each. Two variants were compared V1 (B1, B3) and V2 (B2, B4), with repetition. Same type of feed, (Nutra Pro MP-T) -1.7 mm was given, with 50% protein content. The stocking density was identical in B1, B3, B4 -15 fish/tank (46g/fish) and 14 fish/tank in B2 (47 g/fish). Based on an algorithm derived from species growth equation, the daily amount of feed was calculated as follows: V1-1.1% feed from total biomass (6g/kg metabolic weight) and a double amount of feed in V2-2.2% from total biomass (12g/kg metabolic weight). At the end of the experiment, the increased growth rate and daily growth rate (DGR) recorded in V2 is 2.79 times higher than the ones recorded in V1, by administrating only a two times higher quantity of feed. SGR indicates a ratio, 1.2 higher, between the experimental variants. In conclusion, the main growth performance indicators (total growth rate, DGR, SGR, FCR) are superior to this stage of evolution for this species, at higher intensities feeding rates.

Key words: Stellate sturgeon, feeding intensity, RAS

INTRODUCTION

The most reasonable and logical mitigation strategy to reduce the fishing pressure on natural stocks would be a massive development of sturgeon aquaculture production that would help to not only compensate for the decline of fishery production, but also satisfy the market demand to the extent that price come drastically down, thereby making illegal trade less attractive [1]. Worldwide, sturgeon production increased slowly in the last decades, the most reared species being represented by Siberian sturgeon (*Acipenser baerii*), Russian sturgeons (*Acipenser gueldenstaedtii*), sterlet (*Acipenser ruthenus*) and bester [11]. Although, in terms of production, is not found among the top species, stellate sturgeon (*Acipenser stellatus*) occupy the forth popularity place, presently being cultured in 12 countries. Growth in the early life stages has a great importance because stellate sturgeon is a sensitive specie due to its high nutritional requirements. Therefore meeting physiological needs, both quantitatively and qualitatively, is particularly important. For sturgeons, a proper nutritional program (feeding frequency and intensity) correlates with a high technological efficiency, especially in early stages of development. Also, the economics behind feeding is important, feeding efficiency enhancing production and operational benefits. In aquaculture farms, feed costs are the greatest operating expense [4] and, therefore, it is critical to optimize feeding strategy in order to maximize growth, avoiding overfeeding which is an important source for water quality deterioration, disease proliferation, fish mortality, etc. For sturgeons in general, little information is available on feed requirements and data are mostly related to other species than stellate sturgeons. Hence, several studies have been reported on the effects of feeding rate on the growth performance of juveniles and sub-yearlings of white sturgeon, Atlantic sturgeon, short nose sturgeon and Persian

*Corresponding author: desimira_84@yahoo.com
The manuscript was received: 25.05.2012
Accepted for publication: 20.09.2012

sturgeon [12]. Considering the above arguments, the main objective of the present study was to assess the growth performance and feeding efficiency for stellate sturgeon juveniles at different feeding intensities.

MATERIAL AND METHODS

The experiment was conducted from December 2011 to January 2012 at the pilot station from Aquaculture, Environmental Science and Cadastre Department of Food Science and Engineering Faculty, Galati. The pilot recirculating grow system used for these experiments has been described, constructively speaking, also in other studies [3] reason for which this paper no longer contains its description. The main physical-chemical parameters (temperature and dissolved oxygen) were monitored daily with a Hanna HI 9147 Portable Multiparameter. Nitrogen compounds ($N\text{-}NO_3$-, NO_2-N-, $N\text{-}NH_4$-) and also pH were monitored once a week. The pH was measured with a WTW 340 pH meter. Nitrogen compounds were determined with Spectroquant Nova 400 Spectophotometer and compatible Merck kits. The statistical analysis performed for determining the homogeneity of the experimental group were made using Windows software package, Excel and SPSS 20. Statistical differences between the two variants were determined by using T-test. The biological material used in the current experiment was 5 months old *Acipenser stellatus* juveniles with an average mass of 46 g / fish. The juveniles were provided from SC Kaviar House sturgeon station - Horia, Tulcea County, representing first generation obtained from aquaculture breeders. This event is a premiere in aquaculture domain from Romania where, until now, the breeders were represented by wild sturgeons. Before starting the experiment, the biological material, represented by 59 sturgeon fry with a total mass of 2.7 kg, was maintained for 5 days under optimum conditions in a fiber glass tank to accommodate them with the new environmental conditions.

Two variants V1 (in B1 and B3 tanks) and V2 (in B2 and B4 tanks) were tested. In each experimental unit, 14-15 sevruga fry were introduced randomly creating homogenous groups. Regarding the biometric characteristics of the initial group, they are summarized in Table 1. Statistically, between the experimental groups were not observed significant differences in mass variability (T test, $p \geq 0.05$).

Table 1 Somatic characteristics' at the start of the experiment

Parameter/ Variant		W (g)	H (cm)	TL (cm)	FL (cm)
V_1	B_1	46.13± 29.20	2.36± 0.61	25.38 ±4.14	19.78 ±3.18
	B_3	45.73± 12.67	2.08± 0.43	25.90 ±3.02	20.38 ±2.57
V_2	B_2	46.71± 15.51	2.35± 0.52	25.71 ±3.14	20.06 ±2.41
	B_4	46.40± 14.20	2.20± 0.45	25.61 ±2.65	20.06 ±1.94

where: W-average individual weight; H-height; Lt-total length; Lf-length to fork.

Daily, throughout the experimental period (30 days), commercial trout extruded pellets (Nutra Pro MP-T), with 1.7 mm diameter, was distributed. The biochemical composition of feed is shown in Table 2, the protein content (50%) corresponding to nutritional requirements of sevruga. Feeding intensity in those two versions was different: 1.1% of the biomass weight (BW) at V1, representing 6 g feed/kg metabolic weight and 2.2% of the biomass weight (BW) in V2 case, representing 12 g feed/kg metabolic weight.

At the end of the experiment, from biometric measurements performed over the culture biomass, the main growth performance parameters were determined: daily growth rate, feed conversion ratio, specific growth rate, and protein efficiency. Those were calculated using the following equations.

Increase of biomass growth (W) = final biomass (Wt) - initial biomass (W0) (g);

Feed conversion ratio (FCR) = total amount of feed distributed (F)/g biomass grow rate (W) (g/g);

Specific growth rate (SGR) = 100 x (lnWt - ln W0) / t (% BW/day);

Table 2 Biochemical composition of feed

Components	Quantity
Protein	50%
Lipids	20%
Ash	9%
Cellulose	0.7%
Phosphorus	0.9%
Digestible energy	19.7 MJ/kg
Vitamin A	12000 UI
Vitamin D_3	1800 UI
Vitamin E	180mg
Vitamin C	500 mg

Protein retention efficiency (PER) = increased growth biomass (W)/protein feed (P) (g);

Also in graph it was shown the correlation between length and weight determining the exponent "b" from the growth equation W = a * W-Lb where W = fish mass (g), L - total length (cm) and a – length coefficient.

RESULTS AND DISCUSSIONS

Water quality

Feeding intensity, among other important factors (feeding frequency, metabolism intensity, feed waste and feed composition), directly influences the water quality from rearing tanks [2]. The average value of tanks water temperature is 21.5 ± 0.95°C with a minimum of 18.4ºC in B_3 and a maximum of 22.7ºC in B_1. The 4.3°C difference is justified by the impossibility of maintaining a constant thermal condition in winter season. Average value of dissolved oxygen (DO) recorded in the experimental rearing tanks was 6.57 ± 0.27 mg/l, with a minimum of 5.6 mg/l in B_4 tank.

Regarding the nitrogen compounds (NO3-N, N-NO2, N-NH4), the average values recorded during the experiment are summarized in table 3.

Table 3. Synthetic table with the average values (± SD) of nitrogen compounds

Parameter (mg/l)	Experimental rearing units			
	B_1	B_2	B_3	B_4
NO_3-N	95.36 ±3.52	94.67 ±2.16	95.57 ±2.99	138 ±55.23
NO_2-N	0.007 ±0.009	0.007 ±0.009	0.007 ±0.009	0.002 ±0.005
NH_4-N	0.12 ±0.05	0.10 ±0.12	0.10 ±0.15	0.004 ±0.02

The maximum concentration of nitrogen compounds was recorded as follows: N-NH4 - 0.33 mg/l N-NO2-0, 0.2mg/l NO3-N, 208 mg/l. While for ammonium, respectively nitrite, were recorded normal values, found in optimal range of *Acipenser stellatus* species, showing a correct functioning of the biological filter, nitrate concentrations exceeded the normal limits in all rearing units as result of water renewal rate insufficiency (table 3).

Growth performance

Different aspects regarding nutritional requirements of sturgeon are not quite known. The studies aiming the influence of feeding intensity on juvenile sturgeon growth performance are scarce.

Among these, the most relevant are those on *Acipenser transmontanus* species (20-40g) [5]; *A. transmontanus* - 60g-[6]; *Huso huso*-35.5g [13]; *Acipenser oxyrinchus* [9]; *Acipenser persicus* (19.5-90g) - [14] and more recently on *A. oxyrinchus* species (28g) – [8]. In Romania, the first study on growing juvenile sturgeons in recirculating system (RAS) was performed in 2002 [3], where daily feeding rate optimization was monitored in an adaptive manner. The current experiment aim is to develop the scientific knowledge regarding how feeding intensity influences the performance of juvenile sturgeon grown in recirculating system conditions. The main conclusions are presented below.

At the end of the experiment, the material was weighed and measured and the recorded values were statistically analyzed. The biometric parameters statistical analysis: W (weight), H (maximum height), TL (total length) and FL (fork length) shows insignificant differences ($p > 0.05$) between the control groups of the same variant and significant differences ($p \leq 0.05$) between the two experimental variants, the biometric measurements mean values are presented in table 4.

Table 4 - Somatic measurements at the end of the experiment

Parameter	W (g)	H (cm)	Lt (cm)	Lf(cm)
B1	69.78± 33.83 $^{\alpha}$	2.28 ±0.72$^{\alpha}$	30.66±4.34$^{\alpha}$	23.89±3.68$^{\alpha}$
B3	68±41.14 $^{\alpha.}$	1.84±0.72$^{\alpha}$	30.16±5.40$^{\alpha}$	23.54±4.45$^{\alpha}$
B2	103.42±30.43 $^{\beta}$	2.22±058$^{\beta}$	34.04±3.46$^{\beta}$	26.37±2.39$^{\beta}$
B4	108.73±21.81$^{\beta}$	2.88±0.59$^{\beta}$	35.07±2.59$^{\beta}$	26.92±1.30$^{\beta}$

Notes: The variables with the same letter indicates non-existence of statistical differences ($p > 0.05$)

In order to characterize the intra and intergroup variation the coefficient of variation was calculated.

Before experiment, the variation coefficient (CV) registered 33.21% in V1 respectively 31.91% in V2, while, at the end of the experiment, they increased up to 54.49% in V1 and decreased to 24.74% at V2. This is also highlighted by the histograms (Figure 1) which reveals pronounced heterogeneity at the end of the experiment in the case of group fed with 1.1% BW. Thus, the results obtained in this study align to other researches considering that feeding under an optimal level, at any stage of growth, has a negative influence over the satiety, leading to a higher competition for feed, competition which requires high energy consumption, this being ended with lower weight gain and higher biomass heterogeneity [10, 7].

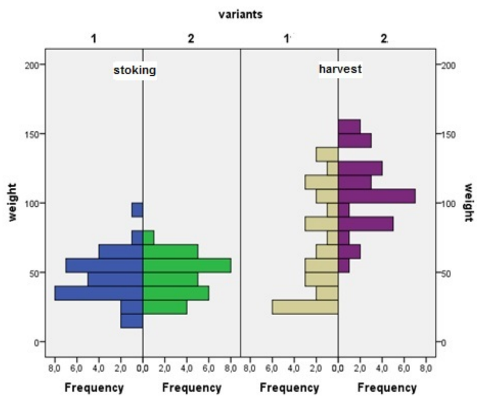

Figure 1 - Mass classes' histogram

A very important conclusion of the present experiment is that the recorded growth rate from variant V2 (2.88 kg/m^3) was 2.79 times higher than the one from variant V1 (1.03 kg/m^3), although the quantity of given feed was only twice higher. The emerged idea, from the interpretation of these data, is that a high feeding intensity led to an increase of metabolic activity. In terms of daily growth rate (DGR), it ranged from 10.31 g/day in V1 case, to 28.82 g/day at V2. Average specific growth rate (SGR) for the two variants was 1.24%/day (V1) and 2.74%/day (V2), indicating a ratio of 2.2 between the two variants. Thus, SGR indicates a direct proportionality relation between biomass gain and feeding intensity. Daily individual growth rate is also 2.2 times higher at V2, compared with V1, ranging from 1.24 g/fish (V1) and 2.74 g/fish (V2)- figure 2. At a feeding intensity of 5% with 54% feed protein, in a similar study [3] was achieved a lower growth rate (0.91 g/day) comparing to the one from the current experiment. A possible explanation could be the greater adaptability of biological material with higher genetic potential.

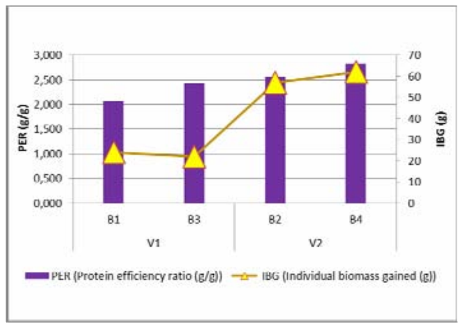

Figure 2 Variation of protein retention ratio (PER) and individual growth rate

Regarding food utilization efficiency, expressed as feed conversion ratio (FCR), in V1 have been registered 0.89 g feed/g biomass gain while, in V2, FCR was as low as 0.74 g feed/g biomass gain.

An interesting conclusion is that feed-utilization efficiency, expressed by FCR, is higher at variant V2 where feeding intensity was double, compared to V1, which means a 1.2 ratio between the conversion factors reported in both variants (figure 3). A possible explanation for this phenomenon could be that a larger amount of available food determines, implicitly, a metabolism intensification and so an increase in its efficiency. Since feed conversion efficiency was directly proportional correlated with feeding intensity, it can be said that an intensity of 2.2% BW/day does not represent the upper limit for the nutritional needs of *A. stellatus* species, those most likely, being capable to efficiently use additional amounts of feed with tested protein level. In context of present experiment, FCR values for both experimental variants are sub-unitary, this aspect expressing the ability of sevruga to efficiently use the given feed. Similar values for feed conversion coefficient (around 0.8 g feed/g gain biomass), for sevruga juveniles, were reported in previous studies, where given feed had 54% protein content [3].

It is known that L - W relationship for different growth stages is linear/isometric or exponential/allometric.

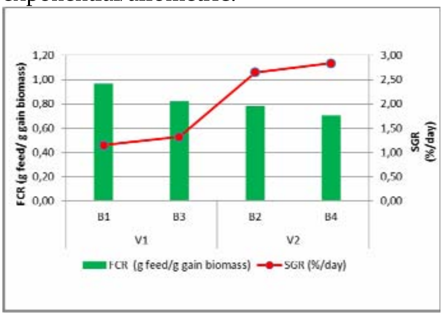

Figure 3-The variation of feed conversion ratio (FCR) and specific growth rate

Alometric characterization of culture biomass.

The condition of the biomass is usually expressed by a number of biometric indicators, namely: allometric factor, Fulton coefficient, Kiselev coefficient, profile index, etc. In our experiment, the condition of sevruga juveniles (fish condition) was assessed using allometric/condition factor F ($F = W/L^b$, where b is an allometric exponent, experimentally determined). Therefore, for each group, the value of this factor was determined, assuming an allometric growth.

In this direction, in figure 4 were represented the length (TL) - mass (W) regressions, which revealed the exponent "b"as allometric coefficient (table 5).

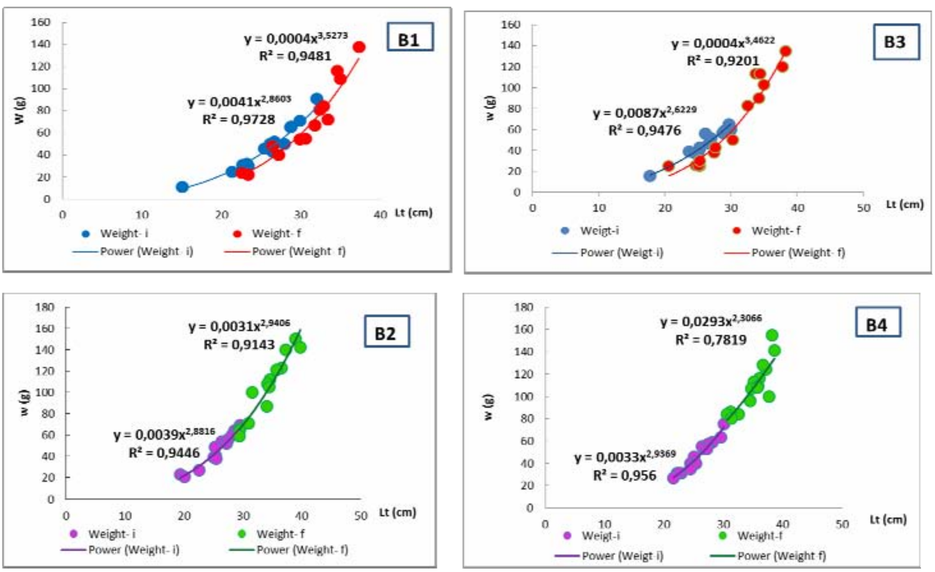

Figure 4: L-W regression for each growing unit

Table 5: F'' alometric coeficients and ,,b'' exponent

		STOCKING		HARVEST	
		„b"	F	„b"	F
V_1	B1	2.8603	0.38	3.5273	0.037
	B3	2.6229	0.88	3.4622	0.045
V_2	B2	2.8816	0.47	2.9406	0.27
	B4	2.9369	0.68	2.3066	0.55

From allometric coefficients analysis it can be observed that for all stocks, in the beginning of the experiment, there was a negative allometry (b<3) and weaker condition at the end of the experiment comparing with the initial evaluation. The lowest value of „b'' and highest of condition factor - F, at the end of the experiment, was encountered in V2 variant, B4 rearing unit, reflecting the higher degree of well-being or relative robustness of the fish under higher feeding intensity treatment.

CONCLUSIONS

The general objective of current experiment consists on technological management optimization of sevruga juveniles, from the perspective of feeding intensity influence over intensive rearing performances, in a recirculating system. The well known growth performance evaluation indicators (SGR, FCR) and their statistical processing results showed considerable influence of feeding intensity over growth performances and feed-use efficiency. The obtained experimental results have a special practical value, the condition state importance being well known, also the one of vigorously of juveniles in their further grow, up to marketable size, in terms of ensuring economic efficiency.

High survival, combined with superior grow performance indicators, reflects a bio-productive potential, respectively high technological plasticity, of juvenile sevruga obtained by artificial propagation, with a group of breeding obtain by aquaculture activity, not by capturing from natural environment.

To conclude, feeding under optimal level revealed pronounced heterogeneity of the group due to inner-group competition and to poorer technological performance.

ACKNOWLEDGEMENTS

The work of Desimira Maria DICU was supported by Project SOP HRD – TOP ACADEMIC 76822/2010 and the work of Marian Tiberiu COADA was supported by Project SOP HRD – EFICIENT 61445/2009.

REFERENCES

[1] Bronzi P., Rosenthal H., Gessner J.: Global sturgeon aquaculture production: an overview, Journal of Applied Ichthyology 27, 2011, p.169-175.

[2] Cristea Victor, Grecu Iulia, Ceapă Cornel: Engineering of recirculating systems, Didactic and Pedagogical Publishing, Bucharest, 2002, p 15-17

[3] Cristea V., Grecu I., Ceapă C., Cristea V., Talpeş M., Roşu A.: Research about *Acipenser stellatus* growth in super intensive system with aquarium units, International Symposium „Euro-food", 2003, p.815-834.

[4] De Silva S.S., Anderson T. A.: Fish nutrition in aquaculture, Chapman and Hall, London, UK, 1995, p 334.

[5] Hung S.S.O., Lutes, B.P:Optimum feeding rate of hatchery-produced juvenile white sturgeon (*Acipenser transmontanus*) at 20ºC, Aquaculture 65, 1987, p.307-317.

[6] Hung, S.S.O., Conte F. S., Lutes B.P.: Optimum feeding rate of white sturgeon (*Acipenser transmontanus*) yearlings under commercial production conditions, Journal of Applied Aquaculture 5, 1995, p.45-51.

[7] Jobling M., Arnesen A.M., Baardvik, B.M., Christiansen, J.S., Jorgensen E.H.: Monitoring feeding behavior and food intake: Methods and applications. Aquaculture Nutrition 1, 1995, p.131-143.

[8] Jordun, W.A. :Growth and feed conversion of sub-yearling Atlantic sturgeon, *Acipenser oxyrinchus*, at three feeding rates, Journal of Applied Aquaculture 15, 2004 p 141-150.

[9] Kelly J.L., Arnold D.E.: Effects of ration and temperature on growth of age-0 Atlantic sturgeon, North American Journal of Aquaculture 61, 1999, p. 51-57.

[10] McCarthy I.D., Carter C.G., Houlihan D.F.: The effect of feeding hierarchy on individual variability in daily feeding of rainbow trout *Oncorhynchus mykiss* (Walbaum), Journal of Fish Biology 41,1992, p 257-253.

[11] Mims S. D. A., Lazur W. L, Shelton B., Gomelsky, Frank Chapman. Species profile: Production of Sturgeon. Southern Regional Aquaculture Center, Publication 7200, 2002.

[12] Mohseni M., Pourkazemi M., Bahmani M., Falahatkar B., Pourali H.R., Salehpour M.: Effects of feeding rate and frequency on growth performance of yearling great sturgeon, *Huso huso*, Journal of Applied Ichthyology 22, 2006,p 278

[13] Pourali H., Mohseni M., Aghtouman V., Tavakoli M.: Rearing juvenile *Huso huso* with different percentage of concentrated feed. First national symposium on sturgeons, 15-16 dec, 1998.

[14] Yousefpour H., Aghtouman V., Mohseni M.: Determination of best feeding percentage relative to the live weight in Persian sturgeon, First national symposium on sturgeons, 15-16 dec, 1998.