THE INFLUENCE OF FEEDING FREQUENCY ON GROWTH PERFORMANCE AND MEAT QUALITY OF *A. STELLATUS* (PALLAS, 1771) SPECIES, REARED IN A RECIRCULATING AQUACULTURE SYSTEM

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Abstract

Achieving noteworthy technological performance in terms of growth, largely depends by using an appropriate nutritional program. Therefore, as a support, the purpose of this paper is to evaluate the effects of two feeding frequencies (2 meals / day - A1 and 4 meals / day -A2), on growth performance and meat biochemistry of stellate sturgeons juvenils. The experiment was initiated using a total of 52 stellate sturgeon juvenils, with a initial average weight of 97 ± 1.8 g. The biological material was divided randomized, into four rearing units, corresponding to each feeding frequency tested, with replicate. At the final of 30 days experiment, the individual average weight was 204 ± 8g/ex. The well-known growth performance parameters (FCR, SGR, PER) recorded values with a slight upward trend for the variant fed with 4 meals / day, the differences being statistically insignificant $p \geq 0.05$. Also, the biochemical composition of meat remained generally unchanged in both variants of feeding frequencies; though, the difference was observed only in case of lipids, 0.76% at A1 compared with 0.41% at A2. As a conclusion, the analyze of growth indicators strengthened with the relative robustness (expressed as length-weight factor) of biological material, obtained in experimental conditions, indicates a better efficiency in terms of growth at stellate sturgeon juvenils fed with 4 meals / day, comparing to those fed with 2 meals / day.

Key words: stellate sturgeon, feeding frequency, technological parameters

INTRODUCTION

Given the fact that, for a fish farm, feed cost occupies the largest share of its total costs [8], a feeding strategy optimization is critical for the potentiation of fish growth and feed conversion, reducing fish stock heterogeneity and limiting the biological material mortality rate [18]. Feeding frequency is an important aspect because it directly affects growth, survival and biochemical composition of fish meat [1]. The optimization of feeding frequency is made after the age of fish, the cultured species, environmental factors and also feed quality [10].

Thus, better results in terms of growth performance were obtained at some species, such as rainbow trout (*Onchorhynchus mykiss)*, when fed 4 times / day, compared to 2 times / day [2]. However, [17] and [7] reported a better growth performance and nutrient retention efficiency for a 2 times / day feeding frequency. At other species, such as Epinephelus tauvina, better results were obtained when feeding only once a day [4]. Regarding sturgeons, given their slower feeding behavior, applying a continuous feeding program could be the most effective nutritional regimen. [3, 24] Regarding age and feeding frequency correlation, at both sturgeon and other species, the idea that feeding frequency decrease with increasing the age, was highlighted. A good example of feeding frequency decrease by passing from an individual weight of 8.5g to one of 34.3g, was reported at *Clarias gariepinus* species [1].

In the literature, there is little information regarding the nutritional requirements of sturgeons and even less concerning the relationship between feeding frequency, growth performance and meat biochemistry. Thus, studies on optimizing feeding frequency management were made on

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The manuscript was received: 18.02.2013
Accepted for publication: 09.10.2013

juvenile beluga [20], beluga 900 g [14], juvenile stellate sturgeon [5, 16] *Acipenser sturio, Acipenser brevirostrum* [9] and *Acipenser transmontanus* [6].

Therefore, this paper aims to develop the knowledge regarding the optimization of nutritional strategy and more specific, to evaluate the effects of different feeding frequencies on growth performance and meat quality of stellate sturgeon.

MATERIAL AND METHOD

The current experiment took place at the recirculating aquaculture system pilot station, of Aquaculture, Environmental Science and Cadastre Department, from "Dunarea de Jos" University of Galati, between January-February 2012. The biological material used in this experiment consist of a number of 52 stellate sturgeon, 6 months old, with an initial average individual weight of 97 ± 1.8 g / fish, purchased from Horia sturgeon station, Tulcea - Kaviar House Company. The biological material in question is the result of artificial breeding of captive breeders, first time made in Romanian aquaculture.

The recirculating aquaculture system design includes the following components: 4 rearing units with a volume of 0.336 m^3 (0.35x0.8x0.120 m) each and a series of water quality conditioning units (mechanical filter, biological trickling filter, UV lamp - Quiet Tetra UV-C 35000, power 36 W and oxygenation units compressor type RESUN Quiet 100W LP-100, 0045 Mpa). The technical description of pilot recirculating aquaculture system is presented in detail in other specialized studies [5, 22]

The following experimental variants were established: A1 (B1 and B3) and A2 (B2 and B4). Each experimental rearing unit was populated, randomized, with a total number of 13 fish, in order to create homogeneous groups - table 1. The only variable that differentiates the two experimental variants is given by the feeding frequency. Thus, the fish from the first experimental variant - V1 received 2 meals/day (at 8:00 and 20:00)-A1 while those from the second variant - V2 received 4 meals/day (8:00, 12:00, 16:00, 20:00)-A2. The main physico-chemical parameters (temperature and dissolved oxygen) were monitored daily with Hanna HI 9147 portable multi-parameter. Nitrogen compounds ($N\text{-}NO_3^-$, $N\text{-}NO_2^-$, $N\text{-}NH_4^+$) - by using spectrophotometer Spectroquant Nova 400 and Merk compatible kits and pH – by using pH meter - model WTW 340, were monitored weekly. The dissolved organic compounds (COD) was determined at the beginning and at the end of the experiment.

Table 1 Initial technological indicators

Experimental variant	**Variant 1**		**Variant 2**	
Initial technological indicators / *Rearing units*	B_1	B_3	B_2	B_4
Initial biomass (g)	1265	1284	1229	1259
Stocking density (kg/m^3)	4,21	4,28	4,09	4,19
Initial number of fish	13	13	13	13
Mean individual weight (g)	97	99	95	97

Diet

Throughout the experimental period, commercial trout feed (Nutra Pro MP-T) with a diameter of 1.7 mm, was administrated. Biochemical composition of feed is shown in Table 2. The feeding intensity applied was 2% BW.

Table 2 Chemical composition offeed

Components	Quantity
Protein	50%
Fat	20%
Ash	9%
Cellulose	0,7%
Total P	0,9%
Digestible energy	19,7 MJ/kg
Vitamin A	12000 UI
Vitamin D_3	1800 UI
Vitamin E	180mg
Vitamin C	500 mg

Growth performance indicators

At the end of the experiment, a series of technological indicators (daily growth rate, feed conversion ratio, specific growth rate, protein efficiency) were calculated using the following formula:

Weight gain (WG) = Final weight (Wt)– Initial weight (W_0) (g);

- Food conversion ratio (FCR) = Total feed (F) / Total weight gain (W) (g/g);
- Specific growth rate (SGR) = 100x(ln Wt –ln W0)/t(% BW/day);
- Protein efficiency ratio (PER) = Total weight gain (W)/amount of protein fed;
- Retained protein (RP) = Total feed (F)x Crude protein (PB%)/100.

Also, the correlation between length and weight has been shown graphically, by Power curve, determining the growth coefficient "b", from the equation

$$W=a\cdot L^{b},$$

where W- fish weight (g), L-total length (cm).

Meat biochemistry analysis

In order to determine the biochemical composition of stellate sturgeon meat, at the end of the experiment tissue samples were collected. During sampling process,ensuring the uniformity was one of the main objectives, so that errors due to mass differences can be eliminated. Biochemical determinations were performed on samples of homogenized muscle tissue and average samples were extracted from the obtained mixture.

Lipids were determined using Soxhlet (extraction with petroleum ether) with Raypa extraction apparatus, dry matter was determined by heating at a temperature of 105±2ºC using oven-type Esac Sterilizer, ash was measured by calcination at a temperature of 550±20°C in Nabertherm furnace and proteins were determined by the Kjeldahl method with Gerhardt standard equipment.

Statistical analysis

Tehnological indicators were analyzed using statistical computer program – Microsoft Excel 2010, from which we used the following statistical tests: descriptive statistics, parametrict-Student test.

RESULTS AND DISCUSSIONS

Water quality

Environmental factors play an important role in fish biomass growth and development. In closed systems, water quality and feeding management are two interrelated factors. During the experiment, water temperature (20.71 ± 0.75°C) and dissolved oxygen (6.59±0.34 mg L^{-1}), pH (7.71±0.37 pH units) remained approximately constant, no significant differences being registered ($p\geq0.05$). The chemical parameters, measured throughout the experiment, recorded the following values: Nitrates - 129.97±85.44 mg L^{-1}, nitrite 0.03±0.04 mg·L^{-1}, ammonium - 0.05±0.04 mg·L^{-1} and organic substance - 7.18±3.62 mg·L^{-1}. Generally, the values of chemical parameters are situated in the optimal range for sturgeon grow [12, 21] . Higher values of nitrates were recorded at the end of the experimental period and were due to low water exchange rate from the recirculating system, reported to cultured biomass, that has doubled since the beginning of the experiment.

Growth performance

At the end of the experiment, the biomass weight increased by 51.3% at A1 variant respectively 53.1% at A2 and a very low mortality rate of 1.92% was registered. In terms of biomass growth, it had similar values for both treatments (A1- 1342 g and A2 - 1409 g). Also, daily growth rate (DGR) showed similar values in both variants, slightly higher in variant A2 (Figure 1).

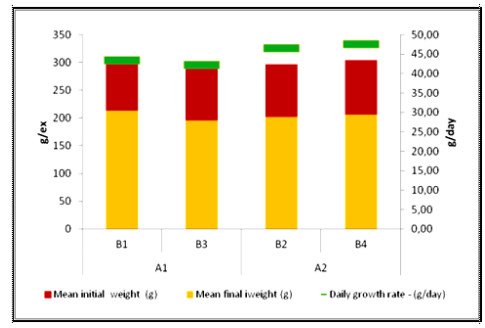

Fig. 1 The variationof average individual weightandspecific growthrate

The values of specific growth rate (SGR), the most relevant parameter in terms of growth dynamics, have growth trends in A2 variant (2.52%g/day), comparing with A1 variant (2.32% g/day), but the differences are statistically insignificant, $p \geq 0.05$. Also, feed utilization efficiency, expressed as feed conversion ratio, show almost equal values for both variants (Figure 2).

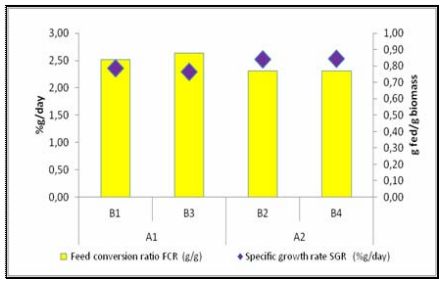

Fig. 2 The variation of feed conversion ratio (FCR) and specific growth rate (SGR)

Protein retention efficiency showed higher values at the variant with four meals per day - 2.6 g/g, compared with the one with two meals per day - 2.33 g/g. Results respects the trends in evolution as other growth performance indicators do, differences not being statistically significant ($p \geq 0.05$).

Therefore, according to data related to growth performance parameters, it can be said that between a feeding program with two meals / day (A1) and one with four meals / day (A2), no significant differences can be observed in terms of growth, although the results obtained for the second variant are slightly better. Comparable results were obtained for beluga 900 g, for an increase of feeding frequency from 3 to 5 meals/day (Mohseni, 2006).

Fish condition

The L-W correlation, at various growth stages, is linear/isometric or exponential/allometric and expresses the biological material condition. Biological material relative robustness or condition is expressed by the condition coefficient (also known as condition factor or length–weight factor). Fish condition was assessed using F allometric/condition factor ($F = W \cdot L^b$, where "b" is an allometric exponent that has been determined experimentally). This indicator reflects, in our case, the biological material feeding level [23]. For this purpose, we determined for each treatment separately, the value of this factor assuming an allometric growth. Thus, if the condition coefficient decreases at the end of the experimental period, in case of A1 variant, even showing an negative allometry ($b < 3$), at variant A2, this coefficient increased at the end of the experiment showing, at the same time, a good condition of the biological material (Fig. 4 A1, A2).

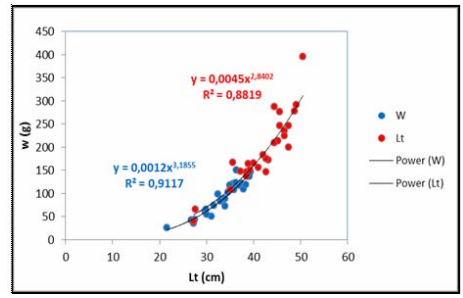

Fig. 4 (A1)L-Wregressionsfrom the first experimental variant

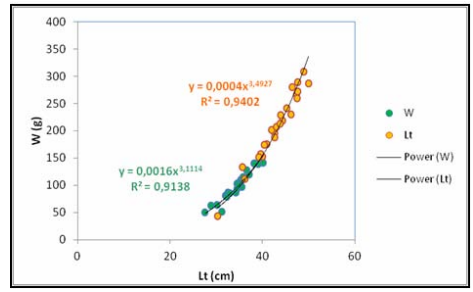

Fig. 4 (A2)L-Wregressionsfrom the second experimental variant

Meat quality

Feeding management along with fish size, age and environmental conditions directly influence the biochemical composition of fish meat [13]. Both feed quality and its distribution, were assessed by analysing the key biochemical parameters: crude protein, fat, moisture and ash (Figure 5).

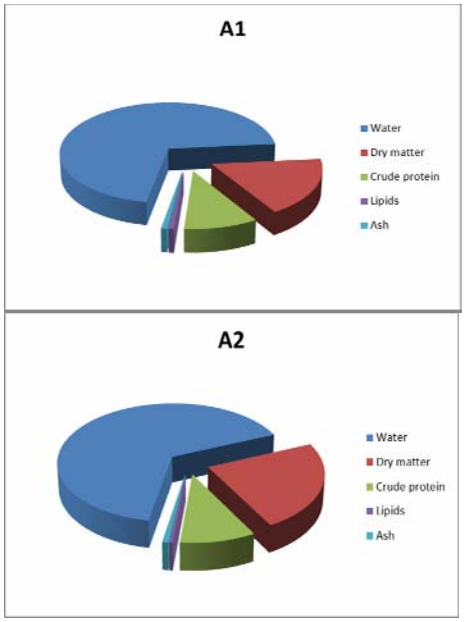

Fig. 5 Comparative graphical representation (A1/A2) of stellate sturgeon meat biochemistry

The protein content of fish meat can be situated within the range of 12.3-28% from total weight of the sample [11]. By fish meat protein level, [19] - classified fish into four categories as follows: under 10%, 10-15%, 15-20% and over 20% protein. The nutritional value of fish meat and the maintenance of biological material can be characterized by the ratio of water versus protein. Thus, a lower value of this ratio indicates a better maintenance of the biological material and a high nutritional value. In the current experiment, the water versus protein ratio is lower at A2 variant, with an average of 6.51±0.57g and higher in case of A1 variant, with an average of 7.12±0.3 g, but those differences between the variants are statistically insignificant ($p \geq 0.05$).

The percentage of fat in fish flesh varies widely, from 0.1% to 28%. In the literature, [11, 22, 15] have reported for fat values below 4%, at sturgeon, fact that includes them into the low fat fish group. Fat values were lower at variant A2, with an average of 0.41±0.06%, compared to A1 variant - 0.76±0.22%.

After the biochemical meat analyzes, we observe that for both experimental variants the biochemical profile remains largely unchanged, which demonstrates that feeding frequency does not affect meat quality of stellate sturgeon.

CONCLUSIONS

After this experiment we can conclude that feeding frequency did not affect the technological growth indicators. Also, the specific grow rate has similar values for both variants, but the biomass structure differ according to length-weight factor.

Finally, the evaluation of growth indicators, combined with the relative robustness (measured as length-weight factor) of the biological material, obtained under experimental conditions and also the biochemical profile of juvenile stellate sturgeon, indicates a better efficiency in terms of juvenile stellate sturgeon grow, fed with 4 meals/day, compared with the one fed with 2 meals/day.

ACKNOWLEDGEMENTS

The work of Desimira Maria DICU was supported by Project SOP HRD – TOP ACADEMIC 76822/2010

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