OPTIMIZATION OF FOOD RATIONS USED FOR THE PRE-DEVELOPMENT OF THE SPECIES ACIPENSER BAERII (J.F. BRANDT, 1869) IN RECYCLATING AQUACULTURE SYSTEM.

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Abstract. Sturgeon farming is practiced in rearing systems with different types of fresh water, such as surface water, depth water (including geothermal water) and industrial water. At the beginning of the twentieth century, sturgeon farming was successfully applied in ponds, nowadays, with the need for quantitative and qualitative productions imposed by the principles of economic viability in the context of ensuring the norms of the European Union, high intensity recirculating rearing systems have been developed. Nutrition plays a central role in sustainable aquaculture and, as a result, research on food resources as well as production costs continues to dominate aquaculture worldwide. According to literature, sturgeon fingerlings with a length of 2.5 – 12.5 cm require a daily ration of 3 – 7% of body weight per day. The optimization of feeding rations for Acipenser baerii related to the pre-development stage in a recirculating aquaculture system was carried out accordingly by following the biotechnological indicators (especially the growth increase) which indicate a favorable growth rate of the biomass.

Keywords: Siberian sturgeon, feeding ratio, RAS.

INTRODUCTION

Sturgeons are a primitive stock of teleost fish with highly valued meat and caviar which their cultivation have continuously grown during the recent two decades as an economic development tool to meet the market demands for products from these species as well as to reduce the pressure on their natural populations (BRONZI et al., 2019; SICURO, 2019; WEI et al., 2011). Several sturgeon species are now considered for whole-cycle production under captive conditions, among which, Siberian sturgeon is one of the best freshwater candidates due to its rapid growth rate and early sexual maturity (GISBERT and WILLIOT, 2002).

Sturgeons are important aquatic products, not only for preserving genetic resources and extending biological diversity, but also for breeding and consumption. They are particularly important as freshwater aquaculture species with high nutritional value (CFSY, 2018).

Optimal growth and fish health directly associated with feed and feeding condition (PERES, SANTOS, & OLIVA-TELES, 2014). Feed deprivation or restricted feeding may apply in sturgeon rearing regarding costly and long rearing period. Particular effects of feed deprivation are associated with some factors such as species, and the energy stored in tissues (Navarro & Gutierrez, 1995) and these play an important role in their resistance to this condition. Fish size and inappropriate temperature in summer or winter seasons can limit sturgeon growth because fish could not be able to consume more feed (Falahatkar, 2012). The existing conditions have encouraged us to investigate the effect of body size under different nutritional status on physiological responses and growth performance of sturgeon.

In order to counteract the decline of wild populations, the optimal alternative is to rear them in specially designed culture systems, including Recirculating Aquaculture Systems (RAS) (OPREA et al., 2012). The most suitable sturgeon species for culture in artificial systems are freshwater and nonmigratory species: sterlet (A. ruthenus) and Siberian sturgeon (A. baerii), recently introduced in Romania (Nita V. N. et al., 2018).

The development of sturgeon breeding is conditioned, on the one hand, by the delicacy harvested production and, on the other, by the global critical status of natural populations of sturgeon species, which is why their catch in many countries is prohibited (Bloesch et al., 2005; Vasileva, 2015). Stacking density is an important environmental factor that has a significant impact on fish rearing. Many studies indicate that high rearing density increases stress and, at the same time, induces the inhibition of growth in fish (Barton, B.A.; Iwama, G.K., 1991, Weidemeyer, G. et al. 1990, Kebus, M.J. et al. 1992). Some authors suggest that the negative influence of high stacking densities on growth is due to a deterioration of water conditions (Kebus, M.J. et al. 1992).
Life Science and Sustainable Development

In an intensive fish farm, feeding cost can achieve 50-80% of total production costs that’s why determining the best feed rate for sturgeons is an important concept in aquaculture, mainly for economically considerations. Choosing a good feeding rate depends on environmental conditions, such as water temperature. Given the economic importance of the cost in terms of feeding, a good understanding of how effective assimilation feeding is very important. In this experiment on the optimization of feed rations administered to Acipenser baerii fingerling in the pre-development phase, it is proposed to adapt to the recirculating aquaculture system, establish the initial ration, monitor growth and update the feeding ration according to it. At the same time, these approaches are made taking into account the load-bearing capacity of the intensive rearing system and the application of different population densities.

MATERIAL AND METHODS

The biological material is represented by sturgeon brood Acipenser baerii (J.F. Brandt, 1869) aged 1 month, from the artificial reproduction station of the Institute for Research and Development in Aquatic Ecology, Fishing and Aquaculture Galați. In order to populate the rearing system, the biological material was adapted in the two experimental variants. Thus, in variant V1, a number of 2850 specimens with an average initial weight of 1,2 g/ex were introduced, and in variant V2 there were 2270 specimens with an average weight of 1,4 g/ex. At the time of establishing the feeding ration (after the first 15 days) the number of specimens remained the same, but the average weight was 3,3 g/ex in V1 and population density 18 kg/m³, and in V2 the average weight was 3,8 g / ex and population density 17 kg/m³.

The recirculating technological system of aquaculture consists in:

- system for collecting the supply water from the urban network provided with a supply tap;
- tank for dechlorination and refreshment of technological water in a percentage of 20% in 24 h to replace losses resulting from the removal of residual solids from the settling tank as well as the one used for washing the filters;
- settling tank with mechanical and biological filtration mode, by gravitational separation of sediments and the action of biological filter with bactobolts in order to pre-filter the technological water with the load of organic substances from the system;
- pumping group;
- mechanism for water conditioning composed of mechanical filter with sand bed, filter with activated carbon bed and UV sterilization structure;
- buffer tank that feeds the rearing units;
- technological water evacuation system with the role of transporting, through pipes, the wastewater to the settling tank and the separation of sedimented solids, digestive metabolic residues and unconsumed food.

The used recirculating aquaculture system scheme can be found in the figure 1:

Figure 1. Scheme of the recirculating aquaculture system.
The experimental rearing basins are represented by 2 circular rearing units and 6 square rearing units. The circular rearing units have a diameter of Ø 4400 mm and the optimal volume of water – 12,1 m³ and Ø 3600 mm respectively with the optimal volume of water – 8,1 m³ while the other 6 units each have a side of 1,4 m and the maximum volume of water – 0,6 m³.

During the 30-day experimental period, the fish were fed ad libitum for the first 15 days after beginning the experiment. The frequency of food administration was at 3 hours with 8 meals/day, the food was administered manually. In the next 15 experimental days, the feeding was performed by updating the ration administered at an interval of 5 days. Thus, 5 days was administered a ration of 5% of biomass (BW)/day, then 3% of biomass (BW)/day, reducing to 2% of BW/day in the last 5 experimental days of the period. The frequency of food administration was at 4 hours with 6 meal/day, the food was administered manually.

During the first 15 days of the experimental period, the fish were fed a complete feed specific to the larval stage PERLA LARVA, with a protein content of 62% and 11% lipids, and the diameter of the granules being 0,6 mm. The biochemical composition of the feed is shown in the following table:

<table>
<thead>
<tr>
<th>Composition</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein %</td>
<td>62,0</td>
</tr>
<tr>
<td>Crude lipid %</td>
<td>11,0</td>
</tr>
<tr>
<td>Crude cellulose %</td>
<td>0,8</td>
</tr>
<tr>
<td>Crude ash %</td>
<td>9,5</td>
</tr>
<tr>
<td>Phosphorus %</td>
<td>1,7</td>
</tr>
<tr>
<td>Calcium %</td>
<td>2,2</td>
</tr>
<tr>
<td>Vitamin A (UI)</td>
<td>6,000</td>
</tr>
<tr>
<td>Vitamin D3 (UI)</td>
<td>1,125</td>
</tr>
<tr>
<td>Mg sulphate monohydrate (mg)</td>
<td>15</td>
</tr>
<tr>
<td>Fe sulphate monohydrate (mg)</td>
<td>40</td>
</tr>
<tr>
<td>Zn sulphate monohydrate (mg)</td>
<td>90</td>
</tr>
<tr>
<td>Sulphate pentahydrate (mg)</td>
<td>5</td>
</tr>
<tr>
<td>Anhydrous Ca iodate (mg)</td>
<td>2</td>
</tr>
<tr>
<td>Citric acid (mg)</td>
<td>7,9</td>
</tr>
</tbody>
</table>

During the last 15 experimental days, the Siberian sturgeon brood was fed with AQUA START extruded feed, with a content of 60% crude protein and 15% lipids, with a grain diameter between 0,6-1 mm. During this period, control weightings were performed at an interval of 5 days, in order to update and optimize the feeding ration administered according to the growth increase achieved and the load-bearing capacity of the recirculating aquaculture system. The biochemical composition of the feed is presented in table 2.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein %</td>
<td>60,0</td>
</tr>
<tr>
<td>Crude lipid %</td>
<td>15,0</td>
</tr>
<tr>
<td>Crude cellulose %</td>
<td>1,5</td>
</tr>
<tr>
<td>Phosphorus %</td>
<td>2,30</td>
</tr>
<tr>
<td>Vitamin A (UI)</td>
<td>25,000</td>
</tr>
<tr>
<td>Vitamin D3 (UI)</td>
<td>2,000</td>
</tr>
<tr>
<td>Vitamin E (mg)</td>
<td>25</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>750</td>
</tr>
<tr>
<td>Digestible energy (MJ/kg)</td>
<td>18,1</td>
</tr>
</tbody>
</table>

During the experimental period, special attention was paid to the daily monitoring of water quality parameters, as well as their maintenance within optimal physiological limits for the species Acipenser baerii. The assessment of water quality in the culture system was performed by daily monitoring of temperature, oxygen and pH using portable oxygen meter HACH HQD Field Case 58258-00, respectively by periodic determination of nitrates, nitrites, ammonium, chlorine and dissolved organic matter by the method colorimetric with the help of the DR 2800 spectrophotometer, the values thus determined were compared with those optimally admissible for the crop species.

Table 1

Table 2
RESULTS AND DISCUSSIONS

Feeding intensity, food composition, level of metabolic activity and the amount of uneaten food change the quality of water in growth pools. Most of the food administered is eaten by fish, while uneaten food, if not eliminated, breaks down in the system. Products resulting from fish metabolism (metabolites) include carbon dioxide, ammoniacal nitrogen and faecal solids. If the unconsumed food and the mentioned metabolites remain in the system, the concentrations in carbon dioxide and ammonia nitrogen of the culture water can reach values that exceed the optimal gap from a technological point of view (CRISTEA et al., 2002). The quality of water in a recirculating aquaculture system is given mainly by the concentration of dissolved oxygen, ammonia nitrogen, concentration in nitrites, nitrates, pH, alkalinity and temperature (depending on the eco-technological requirement of the species reared in the recirculating system). The values of the physico-chemical parameters of the culture water were within the optimal gap for sturgeon growth. The water temperature recorded average values of 19,28 ± 0,32° C and variations in the range 17,78 – 20,40° C, and the dissolved oxygen (7,22 ± 0,30 mg/l) and the pH (8,44 ± 0,10 pH units) recorded constant values (figure 2).

![Figure 2. Evolution of the physico-chemical parameters in water (RAS).](image)

Also, nitrogen compounds were maintained in the optimal range for sturgeon growth, the minimum and maximum values of nitrites, ammonium and nitrates being 0,01 – 0,043 mg / l; 0,12 – 0,16 mg / l; 7,5 – 21,3 mg / l (figure no 3), where there is an increase in nitrates during the experimental period.

![Figure 3. Nitrogen compounds in water from RAS.](image)

Sturgeons are a species of fish with high protein requirements. However, an excess increase in the protein level in feed can lead to deterioration of the culture water due to high concentrations of excretion
products with high ammonia content (TIBBETTS et al., 2000). Nutrition plays a central role in sustainable aquaculture and, therefore, research on food resources as well as production costs continues to dominate aquaculture worldwide (MOCANU E., 2011). To calculate the feed rations, it is necessary to know the relationships between the nutritional requirements of the fish and the environmental conditions. It is recommended that the determination of food quantities and their correction be based not only on the data of the feeding calendar charts, but also on real information and observations obtained during the growing period (OPREA and GEORGESCU, 2000).

Regarding the optimization of the feeding rations, initial (average weight 3.5 g/ex), intermediate (average weight 7.3 g/ex) and final (average weight 10.23 g/ex) weightings were performed during the last 15 experimental days, aimed at monitoring the growth increase and, respectively, updating the administered rations. The growth increase recorded in the two experimental variants is shown in the following figure 4:

![Figure 4. Biomass gain in the experimental period.](image)

From the analysis of the biotechnological indicator on the growth rate of _Acipenser baerii_ fingerlings, significant differences are found in the first experimental variant, where a marked increase is observed in the first 5 days, then a stagnation of growth, followed by a return at the end of the experimental period. In the experimental version V2, the growth rate registered a permanent intensification, which indicates an ascending growth rate. Therefore, the feeding rations administered proved to be efficient and optimized accordingly in the case of experimental variants, a fact also recommended by the specialized literature which claims that the sturgeon fingerlings with a length of 2.5–12.5 cm requires a daily ration of 5–7% of body weight per day. This percentage decreases to 3.5% for fish with a length of 15-30 cm and to 1.25% for fish larger than 680 g or 48 cm (MIMS et al., 2002).

In this experimental trial, fish growth was positively influenced by decreasing feeding ratio. A linear increasing trend was observed in the experimental variant with lower stocking density (V2). Increasing biotechnological indicators is also reported by Rad et al (2003), for Siberian sturgeon (mean body weight of 1736±37 g) at a feeding rate of 1 and 1.25 % BW day⁻¹. Also, Cristea et al (2012) reported for five months old _Acipenser stellatus_ with an average mass of 46 g/fish an increase of SGR and WG with the increasing of feeding ratio. It is well known that at higher feeding ratio fish can easily increase the chance to access food and use the provided energy for growth (Sun et al 2006), while in lower feeding rate fish do not have enough energy to sustain their normal growth or the dietary nutrients are used for maintenance (Hung et al 1989). On the other side, according to some authors (Brett 1979; Cacho et al 1990) fish maximum growth occurs at the limit of voluntary food intake (satiation), while maximum feed efficiency occurs at some level below satiation. Our results are supported by the statements of these authors, being observed that in the experimental variant V2.

The success and optimization of production in a recirculating system can be achieved in certain special circumstances, namely: maintaining a good water quality, maintaining an appropriate level of feeding intensity, and applying a well-developed technological management based on deep knowledge of the metabolism of the
selected species and factors that influence this process (CRISTEA, V. et al., 2002; OREA, L., R. GEORGESCU, 2000).

Research on sturgeon nutrition has established that fingerlings and breeders must have a diet of at least 40% protein and 8-10% fat. Sturgeons efficiently capitalize on feed, the feed conversion coefficient (FCR) being 1,0-1,4 for brood and maximum 1,6-2,0 for adults (SION, 2012). The literature indicates that the minimum protein level in sturgeon feed should not be less than 40%.

Rearing of Siberian sturgeon Acipenser baerii in intensively recirculating aquaculture system is dependent on the administration of artificial food. This sturgeon fingerlings feeding is considered to be a critical period during the growing technology. Thus, there are numerous studies and researches that have highlighted the determining role of feeding as being one of the most representative factors with major impact on growth rate, survival rate, maintaining the quality of culture water, reducing stress, etc. In this respect, proper feeding is an essential and necessary condition for obtaining higher sturgeon production.

CONCLUSIONS

Sturgeon farming is practiced in rearing systems with different types of fresh water, such as surface water, depth water (including geothermal water) and industrial water. If at the beginning of the twentieth century sturgeoniculture was successfully applied in ponds, nowadays, with the need for quantitative and qualitative productions imposed by the principles of economic viability in the context of ensuring the norms of the European Union, high intensity recirculating growth systems have been developed. The optimization of the feeding rations of the Acipenser baerii species related to the pre-development stage in the recirculating aquaculture system was carried out accordingly by following the biotechnological indicators (especially the growth rate) which indicate a favourable growth rate of the biomass. Overall, for the optimization period, the feeding ratio calculated at the end of the experimental period was around 2% BW day\(^{-1}\) and it seems to be the optimal feeding rate for Siberian sturgeon juveniles in our culture condition (\(T = 19.28\pm0.68 \, ^\circ\mathrm{C}\)), but since obtained values of food conversion ratio are very close to each other a feeding rate at 2% BW day\(^{-1}\) seems be more suitable as far as economic considerations are concerned. In conclusion, the results of this study suggest that a feeding rate of 2% BW day\(^{-1}\) is the more efficient feeding strategy for Siberian sturgeon juveniles in experimental variant with lower stocking density (V2), because it provides greater growth and production, with a low cost for feeding.

BIBLIOGRAPHY


