FIRST ATTEMPT OF REARING THE SIBERIAN STURGEON  
(Acipenser baerii Brandt, 1869) IN BLACK SEA WATER

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Abstract

The most suitable sturgeon species for culture in artificial systems are freshwater and non-migratory species: sterlet - Acipenser ruthenus - and Siberian sturgeon - Acipenser baerii, recently introduced in Romania. The experiment aimed at establishing the age and salinity thresholds to be taken into account in attempting to rear (Siberian sturgeon - Acipenser baerii) in a recirculating system using Black Sea water. From the point of view of adaptability in general, in about a week the individuals adapted to the captive breeding conditions of NIMRD’s recirculating system. The specimens also easily adapted to manipulation during measurements, showing calm handling behavior. The food used was very easily accepted, the active feeding behavior being observed even in the presence of the staff. Throughout the experiment, the fish were active. The survival rate was 100%. However, adaptability to the brackish environment has posed problems. The experimental batch became more sedentary and ingested significantly less food compared to the control group, when salinity exceeded 3%. Upon reaching the 7% threshold, all individuals were already completely refusing food, which is why it was decided to stop sea water input. The return to freshwater caused the resumption of feeding behavior in just a week, calling for further research on the osmoregulatory mechanisms of A. baerii.

Key words: adaptation, marine water, recirculating aquaculture systems (RAS), Siberian sturgeon.

INTRODUCTION

Although not ranked first in aquaculture statistics worldwide, sturgeons are extremely valuable fish species, given the quality of their meat and eggs (caviar). Being favored by the existence of 1,075 km of the Danube, Romania has a privileged position, as there are still living natural populations of wild sturgeons: beluga (Huso huso), Danube sturgeon (Acipenser gueldenstaedtii), starry sturgeon (Acipenser stellatus) and sterlet (Acipenser ruthenus), which can provide spawners captured from the natural environment. Also, in recent years, two new sturgeon species have been introduced into freshwater aquaculture, namely American paddlefish (Polyodon spathula) and Siberian sturgeon (Acipenser baerii), highly adaptable species, prone to aquaculture. Wild sturgeon populations are facing a decline and the most important legal instruments for the protection of wild sturgeons are legislative protection acts (Habitats Directive 92/43, Annex II, 1992) and national fishing bans (prohibition orders). In Romania and Bulgaria a moratorium banning sturgeon fishing is in force until 2021 (DSTF, 2016).

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 non-migratory species: sterlet (A. ruthenus) and Siberian sturgeon (A. baerii), recently introduced in Romania. The Siberian sturgeon inhabits rivers flowing northwards from Siberia. It is usually an anadromous species. The migratory form of the Siberian sturgeon spends most of its life in the middle and lower part of Siberian Rivers, and when migrating into the Arctic Ocean bays, it enters a brackish
environment (Sokolov and Vasilev, 1989; Krayushkina, 1995; Ruban, 1997).
The physiological mechanisms involved in maintaining the hydromineral plasma balance under brackish conditions are not yet elucidated. Euryhaline fish exposed to a hyper-osmotic environment compensate for the loss of water through the permeable surfaces of the body by drinking water and excreting excess sodium and chloride (Na\(^+\) and Cl\(^-\)) through the gills. The bivalent ions, except Mg\(^{2+}\), which are absorbed and subsequently secreted in the urine, are excreted through the rectum (Boeuf, 1987; McCormick et al., 1996).

Body tissues in saltwater fish contain less salt than the water in which they live. The saltier environment draws water from their body tissues, resulting in constant water loss through the skin and gills. To compensate and prevent dehydration, saltwater fish drink large amounts of saltwater, produce small amounts of concentrated (salty) urine, and secrete salt through their gills. In contrast, body tissues in freshwater fish contain more salt than the water they live in. As such, the body continually draws in water through its skin and gills. Due to this constant water intake, freshwater fish drink very little water and produce copious amounts of diluted urine to avoid excessive water in body tissues.

At present, there are not enough information about the osmoregulatory physiology of the Siberian sturgeon, but these data are needed for a better understanding of the vital cycle of this species, designing restocking programs, and exploiting its potential for aquaculture in brackish environments.

**MATERIALS AND METHODS**

The rearing of marine living resources in controlled environments is one of NIMRD’s (National Institute for Marine Research and Development “Grigore Antipa”) constant concerns. NIMRD’s team of engineers and biologists has designed and built a relatively simple marine Recirculating Aquaculture System (RAS), but incorporating all the modern filtering steps required and widely used worldwide (Figure 1).

The system is based on four rectangular fiberglass tanks, each of which has an approximate capacity of 1 m\(^3\) (800 liters of real use water, controlled by sensors monitored by an industrial computer).

![Figure 1. Schematic representation of NIMRD’s RAS system](image)
From each of the four tanks, water is drained by computerized action of electrovalves to a central collector tank. Here water is strongly aerated, which is the primary foaming step, the foamed residues being drained out of the circuit. From the collector tank, water is pumped into the self-cleaning mechanical filter, and then through the sand and quartz filters (Figure 2).

After the three mechanical filtration steps described above, the effluent enters the biological filter (design and construction carried out within NIMRD), and the water, after washing the bio-balls, is pumped to the denitrifier. The last step is UV sterilization, made by passing water through a high-power lamp. Then, through a distribution and pre-aeration system, it is pumped back to the four pools at optimum parameters. The system has been previously used for experimental rearing of turbot (*Psetta maxima*) (Nita and Nenciu, 2017) and golden gray mullet (*Liza aurata*) (Nita et al., 2018), with encouraging results. Moreover, the possibility of rearing other sturgeon species (*Huso huso* and *Acipenser gueldenstaedti*) in Black Sea marine water has been investigated (Zaharia et al., 2008; Zaharia et al., 2011; Zaharia et al., 2017).

Our current experiment aimed at establishing the age and salinity thresholds to be taken into account in attempting to rear *A. baerii* in NIMRD’s RAS using Black Sea water. The biological material used for the experiment consisted of 75 juveniles, aged 5 months, purchased from S.C. Quality Fish S.R.L. Timisoara, Romania, the origin of the embryos being Germany.

The acquisition of the biological material was made at just 5 months of age, precisely to capture the minimum tolerance threshold for the brackish environment in terms of fish age. Although apparently the very young age of Siberian sturgeons specimens (Boeuff, 1987; McKenzie et al., 1992; McKenzie et al., 1999, 2001) for a good adaptation to high salinity, we considered it necessary to check lower age thresholds, knowing the differences in the ionic balance between Pontic waters and other seas of the world. Thus, the 75 *A. baerii* individuals were kept for 10 days from the time of their acquisition in fresh water, in order to overcome the stressful period caused by the transport between Timisoara and Constanta and to generally adapt to the new conditions (brightness, color, environment) (Figure 3).

After the acclimation period, the fish were divided into two lots, one witness (control) batch (37 specimens) and one experimental batch (38 specimens), as balanced as possible in terms of size and biomass of fish. Each of the batches was placed in a rectangular tank with a surface area of 2 m² and the water column of 50 cm. The control batch was kept constantly in fresh water, while for the experimental batch salinity was gradually increased, at a rate of about 1‰ per week, by mixing sea water with fresh water (Figure 4, Figure 5). Feeding was dosed according to the regulations in force, based on the biomass of each batch.
The feed used was ALTERNA STURGEON 2 P (Table 1).

<table>
<thead>
<tr>
<th>Composition %</th>
<th>2P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw protein</td>
<td>48.0</td>
</tr>
<tr>
<td>Raw fat</td>
<td>16.0</td>
</tr>
<tr>
<td>Raw fiber</td>
<td>3.0</td>
</tr>
<tr>
<td>Raw ash</td>
<td>11.0</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.0</td>
</tr>
<tr>
<td>Digestible energy (MJ/kg)</td>
<td>16.0</td>
</tr>
</tbody>
</table>

At one month interval, between February and May, length and biomass measurements of each individual in the two batches were performed (Figure 6, Figure 7).

All data were registered in tables and analyzed.

RESULTS AND DISCUSSIONS

From the point of view of adaptability in general, we can appreciate that in about a week the individuals had adapted to the conditions offered by rearing in the tanks of the NIMRD’s recirculating system. The specimens have also easily adapted to manipulation during measurements, showing calm behavior during handling.

The food used (ALTERNA STURGEON 2 P) was very easily accepted, the active feeding behavior being observed even in the presence of the staff. Throughout the experiment, the fish were active (in the normal species, which is moderately active).

During the experiment, the health status of the fish was good, with no infection or parasitosis recorded.

The survival rate at the end of the two months of monitoring was 100% (all of the 75 individuals entered into the experiment survived).
Adaptability to brackish environment has, however, posed problems. Although it would have been expected, no behavioral and metabolic changes could be observed at least up to the 8‰ salinity threshold (Boeuff, 1987; Franklin et al., 1992; McKenzie et al., 1999, 2001).

The experimental lot became more sedentary and ingested significantly less food compared to the control group, as long as salinity exceeded 3‰, length between 4-6‰ salinity, after stagnation between 2-4‰ salinity (Figure 8).

The measurements performed indicated that specimens both in the experimental and the control tank recorded a steady linear growth in As far as weight is concerned, however, while Siberian sturgeons in the control group showed a positive increasing trend, the specimens in the study group recorded a slight decrease in biomass along the gradual passage from 2‰ to 6‰ salinity.

Upon reaching the 7‰ threshold, all experimenting individuals were already completely refusing food, which is why it was decided to stop the sea water supply. The return to 100% freshwater caused the resumption of feeding behavior in just one week.

The ability of a fish to adapt to different salinity levels depends on its ability to regulate intake and excretion of ions and maintain its hydromineral balance. In the study conducted by Rodríguez et al., 2002, only minor changes in osmolarity and electrolyte concentrations were reported in *A. baerii* juveniles, however they were statistically significant. These results can be considered as proof of adapting fish of these ages-sizes to low salinity levels (Boeuff,
1987; Franklin et al., 1992; McKenzie et al., 1999, 2001).

However, Siberian sturgeon juveniles (7 months old) did not tolerate exposure to hyperosmotic environments (14‰) for 45 days. Osmolarity and electrolyte levels increased compared to freshwater fish, indicating that the specimens were unable to excrete enough ions to maintain constant electrolyte values (Rodriguez et al., 2002).

Other authors (Williot et al., 1988) reported that *A. baerii* can adapt to salinity up to 12‰, while retaining their hydromineral balance and comfortable osmotic levels, but salinity higher than 17‰ is fatal. However, the size and age of the fish were not mentioned in the latter case.

We can identify two possible causes of differences between our results and those reported in the literature. On the one hand, we can suspect the origin of the fish from which the sexual elements were sampled. There are naturally living sturgeon populations living in exclusively in lakes, carrying a fresh water life, and populations living in rivers, making migrations in salty/brackish estuarine waters. Although they belong to the same species, migratory species may have a genetically and evolutionary modified baggage in the sense of a better tolerance to salinity exposure. This is important to be investigated in the future.

A second cause could be the young age at which we exposed Siberian sturgeon specimens to the stress caused by osmoregulation. In this sense, the investigations are to be resumed and deepened after the fish have passed the age of one year, during which time they will be kept in freshwater.

After the experiment was stopped and all fish were returned to the combined fresh water tank, fish length (Figure 10) and biomass (Figure 11) showed a positive linear growth, and an overall healthy behavior (Figure 12).

![Figure 10. Evolution of mean length (combined tank)](image1)

![Figure 11. Evolution of mean biomass (combined tank)](image2)
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Concluding, the results we have obtained suggest that while juvenile Siberian sturgeons (5-7 months old) presented some of the morpho-physiological mechanisms needed to adapt to hyperosmotic environments, as has been described in other sturgeon species (Krayushkina et al., 1995; McKenzie et al., 1999; Rodriguez et al., 2002), they cannot be considered hyper osmotic regulators as they were unable to maintain their plasma osmolality and electrolyte balance in salinities higher than 7%.

Further research in this respect will be pursued, extending the adaptation experiment to adult A. baerii specimens. The final objective is to reduce the pressure on wild sturgeon stocks by introducing a new species to marine aquaculture, which can be successfully reared along the Romanian and Bulgarian Black Sea coast.

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