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GROWTH AND SURVIVAL RATE OF STURGEON HYBRID BESTER ♀ × BELUGA ♂ JUVENILES REARED IN A RECIRCULATING AQUACULTURE SYSTEM

**Cristian RÎMNICEANU[1, 2], Mirela CREȚU[1, 2], Marian Tiberiu COADĂ[1, 2]
Angelica DOCAN[1, 2], Lorena DEDIU[1, 2]**

[1]"Dunărea de Jos" University, 47 Domnească Street, 800 008, Galați, Romania
[2]Romanian Center for Modelling Recirculating Aquaculture Systems, "Dunărea de Jos" University of Galați, 800008, Galați, Romania

Corresponding author email: lorena.dediu@ugal.ro

Abstract

Growth performance and survival rates of backcrossed hybrids of bester females × beluga males were assessed after 28 days of rearing. Hybrid larvae were obtained in the conditions of the reproduction station from the Horia branch of Danube Research Consulting SRL. Three experimental groups were created, corresponding to three classes of sizes: V1- the initial weight of 3.2-5.2 g, V2-initial weight of 1.4-2.5 g, and V3- the initial weight of 0.7-1.4 g. To minimize the effects induced by the increase of the degree of heterogeneity among the fish, after 20 days the fish biomass was divided into two classes of sizes: VA: 25.8 - 32.8 g, respectively VB: 7.3 - 16.8 g. The obtained results showed better values of the individual weight gain in V1 compared to V2 and V3, while at the second stage of the experimental period, the values of the individual growth gain for each of the two experimental variants (VA, VB) were almost similar. Due to the high growth performance, as well as the good survival rate obtained in the two stages of the hybrid rearing, the crossing of these two species can be recommended for commercial fish producers for maximum yield and higher profit.

Key words*: aquaculture, growth, hybridization, sturgeons.*

INTRODUCTION

Sturgeons are one of the oldest groups of fish, with a high economic value (Agh et al., 2012; Havelka & Arai 2018; Williot et al., 2018). Unfortunately, due to the destruction of their natural habitat and to intensive international trade of caviar and meat, sturgeon populations around the world are declining (Williot et al., 2002; FAO, 2018) being classified as critically endangered by the IUCN (2013) Red List (International Union for Conservation of Nature). Lately, the sturgeon aquaculture industry is growing worldwide (Chebanov and Billard, 2001; Vasilyeva et al., 2019), being conditioned by the increasing demand of consumers for meat and caviar (Bronzi et al., 2019).

Generally, sturgeon aquaculture is divided into two main directions such as restoking of the wild population and maximizing the efficiency of production, by obtaining valuable products in a short period. To be profitable sturgeon aquaculture strategy is oriented towards obtaining intraspecific hybrids sturgeon lines (Shivaramu et al., 2019), which have higher disease resistance, and increase environmental tolerances and a better food conversion ratio (Williot et al., 2001; Shivaramu, 2019; Nikolova and Bonev, 2020). For example, bester hybrid (a cross between *Huso huso* and *Acipenser ruthenus*) proved to have a faster growth performance than its parental species (Arefjev, 1999; Baradaran, 2009). Also, Dediu et al., 2021, in a study that compares growth performance of bester hybrid and the hybrid obtained by crossing of bester ♀ × beluga ♂ (best beluga), reported a better performance for best beluga.

Over the past years, recirculating aquaculture systems (RAS) become popular for growing fish species with high commercial value, such as catfish, tilapia, rainbow trout, striped bass, sturgeons, etc (Vasilean et al., 2009; Crețu et al., 2019; Amin et al., 2020; Ekawati et al., 2021). RAS systems have the advantage of raising fish in controlled environmental conditions thus obtaining the highest production per unit area (Timmons & Ebeling, 2013). To be profitable the main goal of RAS systems is to obtain maximum weight gain by all individuals and to increase their survival rate which results in obtaining the maximum biomass. In this context, an important technological aspect is to size-grading fish periodically. Sorting separates small and big fish fingerlings, contributing to the reduction in cannibalism (Ugwem et al., 2016), decrease in size variability among harvested fish and increased growth among small fish (Saoud et al., 2005; Chebanov et al., 2011).

In this context, this study aimed to compare the growth performance of different size classes of the best beluga hybrids, obtained by crossing of Bester ♀ × Beluga ♂, reared in a recirculating aquaculture system.

MATERIALS AND METHODS

Study animals and experimental design. Hybrid sturgeon were obtained after artificial reproduction at the hatchery of a commercial farm belonging to Danube Research Consulting (DRC), Tulcea County, Romania. Healthy Bester females and Beluga males, well developed and without any trauma, were used for artificial reproduction. After 7 days of hatching, about 50 % of the larvae began to swim actively. At this point, the administration of food began. For adaptation to pre-starter feed, with high protein content, a progressive feeding protocol was applied which aimed at the gradual transition from feeding exclusively with zooplankton (in the first 5 days when 40% BW was administered/day to the formulated diet) to mixed feeding of zooplankton and benthic organisms - tubifex (in the next 4 days) and exclusively tubifex up to 12 days. From the 13th day, the feed was gradually introduced, initially in a proportion of 3%, every 3 days doubling the proportion to the detriment of natural food. Thus, after 45 days of hatching, the hybrids were fed exclusively with extruded pellets. In this context, 219 fish with an individual weight between 0.7-5.2 g/fish were randomly distributed in a recirculating aquaculture system to create three experimental variants: V_1 (3.2-5.2 g), V_2 (1.4-2.5 g), and V_3 (0.7-1.4 g), respectively. Each size class was divided into two homogeneous experimental batches ($p>0.05$), thus ensuring an experimental design in duplicate V_1 ($V_{1.1.}$, $V_{1.2}$), V_2 ($V_{2.1}$, $V_{2.2}$), and V_3 ($V_{3.1}$, $V_{3.2}$).

To minimize the effects induced by the increase of the degree of heterogeneity among the sturgeon hybrids, after 20 days from the beginning of the experiment, the fish biomass was regrouped in two classes of sizes. In this context, 183 best beluga specimens are redistributed in two experimental variants, in triplicate VA (VA_1, VA_2, VA_3): 25.8-32.8 g, respectively VB (VB_1, VB_2, VB_3): 7.3-16.8 g.

During the 28 days of the experimental period, the fish were fed *ad libitum*, with a feed of 0.5 mm granulation, 56% crude protein, 15% lipids (first 20 days), respectively 1 mm, 54% crude protein, 20% lipids (last 8 days). Water quality was monitored daily for temperature (20.46 ±1.06°C), pH (7.36±0.16), dissolved oxygen (7.51±0.23 mg L^{-1}), weekly for nitrogen compounds (total ammoniacal nitrogen 0.20±0.09 mg L^{-1}, un-ionized ammonia was 0.012±0.006 mg L^{-1}) and was kept in the optimal range for specie and stage of development.

Calculations. At the end of each trial growth performance and feed utilization parameters were calculated according to the following equations:

- Survival rate (SR, %) = $(N_t/N_0)\times 100$, where N_t represents the fish number at the end of the experiment and N_0 -number of fish at the initialization of the experiment;
- Weight gain (WG, %) = [(BWf−BWi)/BWi] ×100, where BWi and BWf are the initial and final average body weight (g) of fish sampled from each tank, and t is the experimental period in each trial (days);
- Relative growth rate (RGR, g/g/day) = (BWf-BWi)/ t /BW) (g/ g/day);
- Specific growth rate (SGR, %/day) = [(lnBWf−lnBWi)/t] ×100;
- Feed conversion ratio (FCR) = FI (g)/BG (g), where FI stands for food consumption (food provided – uneaten food) and BG is biomass gain per tank;
- Protein efficiency ratio (PER) = BG/protein consumed;
- The coefficient of variability (CV) = CvBW (%) = 100 (SD/mean BW), and was calculated for the body weight on the initial (CvBWi) and final (CvBWf) days of the experiment.

Statistical analysis. All data were analyzed using SPSS for Windows, Version 21.0 (SPSS Inc., Chicago, United States). Growth parameters were presented as means ± SD of the replicates. Before statistical analyses, both normality and homogeneity of variance were confirmed by Levene's tests. In the first trial if significant effects (ANOVA, $p<0.05$) were detected, treatment means were compared by the Duncan test ($p<0.05$). In the second trial, significant effects between treatments mean were tested using T-test

RESULTS AND DISCUSSIONS

The growth performance of the hybrids during the first 20 days is briefly presented through the technological indicators summarized in Table 1. At the beginning of the experiment and after redistribution of the biological material there were no significant differences ($p>0.05$) between the duplicates/triplicates of each experimental variant (V1, V2, V3) / (VA, VB).

Table 1. Growth performance of fish at the end of the first experimental stage and second experimental stage

Technological indicators	Experimental variants				
	Stage I			Stage II	
	V1	V2	V3	V1	V2
Experimental period (days)	20	20	20	8	8
Crude protein from feed (%)	56	56	56	54	54
Survival (%)	100	98.34±2.35	98.36	100	90
Initial average weight (g/ex)	3.93±0.19	1.88±0.12	1.09±0.02	30.51±2.56	10.90±0.15
Initial stocking density (g/m^2)	205.50±2.01	160.45±10.02	188.49±6.01	868.06±648.83	617.91±8.51
Individual weight gain (g/ex)	21.84±0.73	9.67±0.26	5.36±0.11	10.43±0.41	10.73±0.47
DGR - (g/day/fish)	1.09±0.04	0.48±0.01	0.27±0.01	1.30±0.05	1.34±0.06
RGR - (g/g/day)	0.28±0.004	0.25±0.02	0.25±0.01	0.04±0	0.12±0.01
CV initial - weight (%)	14.63±1.54	18.435±1.22	19.22±0.01	5.51±0.45	23.94±1.03
CV final - weight (%)	7.42±0.37	11.55±0.31	14.94±0.30	17.96±2.76	26.38±1.51
SGR (% BW/day)	9.42±0.06	9.075±0.37	8.89±0.22	3.79±0.18	8.57±0.29
FCR	0.60±0.02	0.48±0.03	0.25±0.03	0.72±0.05	0.58±0.4
PER (g/g)	3.01±0.13	3.69±0.29	7.17±0.81	2.57±0.17	3.29±0.22

Note: The values are presented as mean±standard deviation of the duplicates (Stage I), triplicates (Stage II), respectively.

In terms of body mass, the homogeneity of the lots was statistically verified with the Levene test ($p>0.05$). Also, the checking of the representativeness of the average was performed using the coefficient of variation (CV). The coefficient of variation of body mass (CV-weight) has a significant degree of significance in the analysis of the degree of homogeneity/heterogeneity for the fish population. Thus, taking into account the first stage of the experimental period, a downward evolution of CVM was observed in each of the three variants (V1, V2, V3). This aspect highlights an increase in the homogeneity of the experimental groups, as a result of the high nutritional recovery capacity of individuals with body biomass below the group average.

Also, at the end of the first 20 days of the experimental period, there is an inverse relationship between the average individual biomass of the biological material within the tested variants and the heterogeneity of the group of hybrids. As a result, as hybrids grow in biomass, there is an increase in competition for food consumption between the individuals from the same experimental variant. This aspect is also confirmed in the second stage of the experiment (last 8 days), where a significant increase of CV-weight values was observed in the case of the variant with the highest average of the individual biomass (VA).

From Table 1 it can be observed that the best individual weight gain was registered in the variant V1 compared to V2 and V3. Given the fact that differences between the values of the relative growth rate (RGR) associated with each of the three experimental variants are very close, the higher values of the individual weight gain from V1 can be justified by the higher individual biomass of the fish from this variant at the initial moment. At the second stage of the experimental period, the values of the individual weight gain recorded for each of the two experimental variants (VA and VB, respectively) were close, but the higher RGR values for VB show a higher growth performance for specimens from this variant, justified by their higher metabolic activity, induced by the need for nutritional recovery.

The feed efficiency, expressed as the feed conversion factor (FCR), is better in the experimental variant V3, followed by V2 and V1. The same higher trend of feed utilization is observed, with lower individual biomass variants, and in the second stage of the experimental period, where higher FCR values are recorded for VA, compared to VB.

To evaluate the fish condition, we calculate the allometric condition factor F ($F=W/L^b$), where “b” is an allometric exponent experimentally determined. From Figure 1 and Figure 2 it can be observed that the allometric exponent "b" recorded values lower than 3, which indicate a negative allometric increase, higher in length compared to body weight.

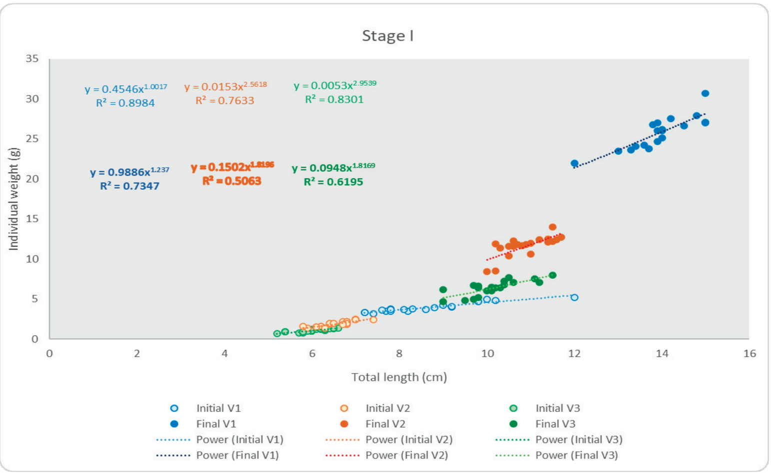

Figure 1. Length-weight regressions for different size classes at the first experimental stage (initial and final moment)

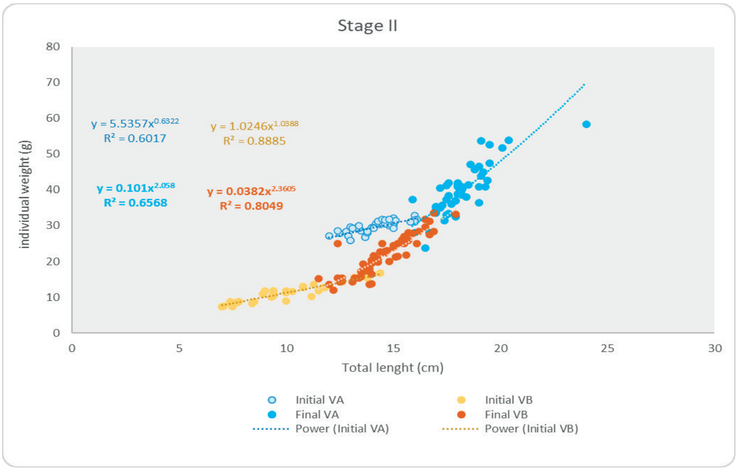

Figure 2. Length-weight regressions for different size classes at the second experimental stage (initial and final moment)

Following the comparative analysis of the experimental variants, it can be observed a higher value of the allometric condition factor, higher in VB compared to VA, suggesting an isometric increase in VB and a negative allometric increase in VA. The better initial condition recorded in the VB variant, in conjunction with the smaller initial size of fish can be an argument for the better results obtained for all the technological indicators (Table 1). Therefore, appreciable robustness can be reported in the case of VB variants, compared to VA, which confirms the positive influence of sorting and redistribution of biological material, respectively, the ability to recover the biomass deficit. At the same time, it was observed that, at larger sizes, food competition is more pronounced, an aspect that induces a more pronounced intra-group heterogeneity.

CONCLUSIONS

The results from this study indicated that the periodically sorting of fish and dividing in less competitive subclasses can be a condition of recovering as many individuals as possible. That`s why periodically sorting of sturgeon larvae by size classes is extremely important because it increases the efficiency of the subsequent processing stages and thus the ultimate yield. This, therefore, helps most fish farmers, especially the fish hatchery operators, to achieve a high survival rate and a better efficiency of food, at early fingerlings production.

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