Compensatory growth of tilapias (*Oreochromis niloticus*) reared in earthen ponds in Southern Brazil

Crescimento compensatório de tilápias (*Oreochromis niloticus*) cultivadas em viveiros escavados no Sul do Brasil

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ABSTRACT
Tilapia fingerlings (0.5 ± 0.08g) were reared during the nursery phase in two different stocking densities (0.5 fish/m² for control in a pond of 600m² and 75 fish/m² for compensatory group in a cage of 4m²) for a period of 100 days. After this period, a 50-day trial study was performed with 43 juveniles of tilapia (Oreochromis niloticus) for each group (control 294 ± 24.43g and compensatory 99.33 ± 16.99g) stocked at the same density (0.28 fish/m²) in order to evaluate the compensatory growth in eathern ponds of 160m² for each treatment. Throughout the experimental period the water quality was monitored and biometrics were performed to evaluate the zootechnical performance. The results revealed that the fishes of compensatory group presented higher specific growth rate compared to control, demonstrating a compensatory growth. At the end of the trial both treatments presented weight loss strongly influenced by temperature decrease. These results showed the compensatory growth of O. niloticus and the possibility to use this strategy (nursery in high density) contributing to ensure a successful production of O. niloticus in this region of the country.

Keywords: pisciculture, cold, thermal tolerance, fish

RESUMO
Os alevinos (0.5 ± 0.08g) foram cultivados durante a etapa de berçário em duas diferentes densidades de estocagem (0,5 peixe/m² para o controle em viveiro de 600 m² e 75 peixes/m² para o grupo compensatório em gaiola de 4m²) por um período de 100 dias. Depois desse período, um estudo de 50 dias foi realizado com 43 juvenis de tilápia (Oreochromis niloticus) em cada grupo (controle 294 ± 24.43g e compensatório 99,33 ± 16,99g) estocados com a mesma densidade (0,28 peixe/m²) para avaliar o crescimento compensatório em viveiros excavados de 160m² para cada tratamento. Ao longo do período experimental a qualidade da água foi monitorada e biometrias foram realizadas para avaliar o desempenho zootécnico. Os resultados revelaram que os peixes do grupo compensatório apresentaram maior taxa de crescimento especifico comparados com o controle, demonstrando o crescimento compensatório dos animais. No final do experimento, os peixes de ambos tratamentos apresentaram perda de peso fortemente influenciado pela queda na temperatura. Esses resultados mostraram o crescimento compensatório das tilápias e abre a possibilidade de usar essa estratégia (berçário em alta densidade) contribuindo para assegurar o sucesso da produção de O. niloticus nesta região do país.

Palavras-chave: piscicultura, frio, tolerância térmica, peixe
1 INTRODUCTION

Aquaculture, defined as the culture of aquatic organisms, is the fastest growing food-producing sector in the world providing almost a half of all fish intended for human consumption (FAO, 2014). The world population has increased substantially and projections indicate that by the year 2050 the world population could reach 9 billion people. This activity became extremely important to the supply of the global demand for food as the capture is stagnant due to overexploitation of fish stocks (FAO, 2014; 2018).

Brazil presents an area of 8,547,404 km², holds 12 percent of the planet's freshwater reserve, with more than two million hectares of natural resources suitable for aquaculture, as well as 25,000 rivers across the country. Brazil has a coastline that stretches for 8,400 kilometers, bordering the Atlantic Ocean coast (Saint-Paul, 2017). The species Oreochromis niloticus (tilapia) is the second most farmed fish world-wide and Brazil is the fourth-largest producer (357 mil tons) (Associação Brasileira de Piscicultura, 2018). Therefore O. niloticus can contribute to develop the pisciculture, consequently increasing the aquaculture indexes in the country.

Tilapia is a tropical species that cannot tolerate cold weather (Yuan et al., 2017). At the Southern Brazil, there is a seasonal wide range of water temperature from 10°C (winter) to 30°C (summer) (Garcia et al., 2003; Garcia et al., 2008). Thus, the challenge in the South of Brazil and in other countries that face cold weather is to found strategies to rear this species throughout the year. The RS state is only the twelve-largest producer in the country but there is a great potential to increase significantly the production due to the natural resources existing in this region (Saint-Paul, 2017). However there is the possibility of rearing in closed systems with high stocking densities and controlled temperature.

Besides the cold season, another problem in aquaculture is the feed that accounts for over 70 percent of the production cost (Yuan et al., 2017). One strategy used to improve the zootechnical performance and reduce feeding costs is compensatory growth. Compensatory growth is defined as a physiological process by which an organism accelerates its growth after a period of restricted development, generally due to the reduced consumption of feed, in order to reach the weight of the animals whose feeding was not interrupted (Hornick et al., 2000). Therefore, the aim of this work was to develop a strategy of rearing the nursery stage in high stocking density and the growout stage in lower density which minimize the problematic period of cold weather contributing to ensure a successful production in this region of the country.
2 MATERIAL AND METHODS

The experiment was conducted at Pisciculture Laboratory of the Chasqueiro (LabChasq) at the Universidade Federal de Pelotas (UFPel) in Southern Brazil. Prior to the experiment, a group of 600 fingerlings (0.5 ± 0.08g) were divided and reared in two different densities (0.5 fish/m² for control in a pond and 75 fish/m² for compensatory group in a cage) for 100 days. After this period 43 juveniles from each treatment were randomly transferred to earthen ponds of 160m² for a 50 days trial. As the fingerlings were reared in two different stocking densities, their initial weight were different (control group 146,09 ± 11,57g and the compensatory group 99,33 ± 5,49g) in order to test the compensatory growth.

Prior to the growout experiment (during the nursery stage), the fishes were fed with a commercial diet Supra alevino inicial® containing 56% crude protein, followed by Supra Juvenil® 46% crude protein twice daily, ad libitum, and during the growout experiment, the tilapias were fed twice daily, five days a week (Monday to Friday) with a commercial diet Supra tilápia® containing 36% crude protein, adjusted according to fish consumption and periodic biometrics. Four biometrics were done during the experimental period. In the begging of the experiment, the control group was fed with 2,7% of total biomass and the compensatory group with 3,3% daily. In the two subsequent intervals of biometrics the indexes were 2,4 and 6,3% for both treatments, respectively. These feed rates were followed by Furuya (2010) according to animals weight. Therefore, the animals were deprived of feed twice a week (weekends). The water quality analysis was performed weekly. Temperature and dissolved oxygen (Lutron DO-5519®), pH, ammonia and hardness were measured by a colorimeter kit (LabconTest®). At the end of the experiment all the animals were, weighed and measured to obtain the final results. The specific growth rate (SGR) was calculated as:

\[
SGR = \frac{(\ln(W_f) - \ln(W_i)) \times 100}{t}
\]

Where: \(W_f\) = final weight; \(W_i\) = initial weight; \(t\) = time.

According to the statistical analysis, data are given as the mean±standard error and were analyzed by the one-way analysis of variance, followed by the Tukey post-hoc mean comparison. Assumptions of normality and of homogeneity of variances were previously checked by the Kolmogorov-Smirnov and Levene tests, respectively. In all cases, results were considered to be significant at 5% probability.

3 RESULTS AND DISCUSSION

The water quality parameters remained at concentrations suitable for tilapia culture in both treatments (Table 1).
Table 1. Water quality parameters in the experimental tanks of rearing tilapia to evaluate the compensatory growth. Data are reported as the mean ± SEM. No significant differences were found between treatments.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>Compensatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>23.33 ± 1.02</td>
<td>22.48 ± 1.36</td>
</tr>
<tr>
<td>pH</td>
<td>6.93±0.32</td>
<td>6.97±0.15</td>
</tr>
<tr>
<td>Dissolved oxygen (mg/L)</td>
<td>5.70±2.25</td>
<td>4.46±1.46</td>
</tr>
<tr>
<td>Total ammonia (mg/L)</td>
<td>0.14±0.12</td>
<td>0.26±0.22</td>
</tr>
<tr>
<td>Hardness (mg/L)</td>
<td>94.67±21.9</td>
<td>93.67±38.25</td>
</tr>
<tr>
<td>Transparency (cm)</td>
<td>45±16.59</td>
<td>50.5±10.08</td>
</tr>
</tbody>
</table>

The animals started this study with different weights because of the system of culture adopted before the experiment. On figure (1) can be observed a higher SGR rate in compensatory group compared to control. These results were observed in the second and third interval between biometrics. On the last one the results did not follow the same pattern because the temperature decreased significantly. The negative results for SGR on the graph reflect the weight loss due to the thermal stress suffered by the animals.

Figure 1. Specific growth rate, initial and final weight in each sampling point and the temperature during the experimental period of rearing tilapia to evaluate the compensatory growth.
The tilapia is a warm water fish with a greater aquaculture potential (Sun et al., 1992; FAO, 2012; Lim & Webster, 2006), but they are sensitive to cold stress (Abdel-Ghany et al., 2019). By this reason the weight loss was observed (figure 1). When the temperature dropped below 22 °C the fishes reduced the food intake and consequently lost weight in accordance with Abdel-Ghany et al. (2019) who observed that at 16°C *O. niloticus* stopped eating due to cold stress. Corrêa et al. (2017) evaluated the growth performance of tilapias at 22 and 28°C and observed a significantly lower growth of fishes reared at 22°C. These authors tested enriched diets including unsaturated fatty acid sources that demonstrated benefits to animal growth in suboptimal temperatures.

In this study the animals of compensatoty group were reared in high stocking density prior to the experiment. When the trial started fishes from both treatments were privad of feed twice a week. Moreover a reduction in food intake represents a decrease in general costs as a result higher profit to the farmer. Another result is the capacity of culture in higher densities. In this work almost 300 fingerlings were reared in a tank of 4 m² for almost four months reaching a weight of aproximately 100g.

It opens another possibility for cold season in Southern Brazil and in other places that faces with this problem. The farmer can obtain the fingerling on winter, rear the fingerlings in warm temperature in high stocking density in small indoor tanks and when spring comes the fishes will be transfered to eatern ponds to reach the commercial weight. In this way the fishes will grow faster ensuring an annual cycle and the perspective to achieve two cycles per year.

4 CONCLUSION

In conclusion, the SGR of compensatory treatment were higher compared to control in fishes reared during the nursery stage in high stocking density, demonstrating the compensatory growth. In the Southernf Brazil, this strategy of rearing the nursery in closed systems as RAS in winter and the growout outdoor in eatern ponds (starting on spring) is a possibility to ensure sucess and improve the production of this species.
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