Technical note: Growth performance evaluation of fingerlings from different lineages of *Oreochromis niloticus* farmed at sub-optimal temperature in earthen ponds

Nota técnica: Avaliação do desempenho de crescimento de alevinos de diferentes linhagens de *Oreochromis niloticus* cultivados em temperatura sub-ótima em viveiros escavados

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ABSTRACT
The study evaluated the productive performance of two lineages of *Oreochromis niloticus*, GIFT (Genetically Improved Farmed Tilapia) and Chitralada (Thai), farmed in earthen ponds under low temperatures. The ponds were populated with a density of two fish m⁻³ and three replicates for each group. The fish were fed with commercial feed (40% crude protein). After 30 days, it was replaced by a diet with a content of 32% crude protein until the end of the study. After 127 days no significant difference in productive indexes was observed between the lineages.

**Keywords:** Aquaculture; GIFT; chitralada; fish farm; pisciculture.

RESUMO
O estudo avaliou o desempenho produtivo de duas linhagens de *Oreochromis niloticus*, GIFT (Genetically Improved Farmed Tilapia) e Chitralada (Thai), cultivadas em viveiros escavados com temperaturas sub-ótimas. Os viveiros foram povoados com densidade de dois peixes m⁻³ e três repetições para cada grupo. Inicialmente, os peixes foram alimentados com ração comercial (40% de proteína bruta). Após 30 dias, uma ração comercial com teor de 32% de proteína bruta foi utilizada até o final do estudo. Após 127 dias de cultivo, não foi observada diferença significativa nos índices produtivos entre as linhagens.

**Palavras-chave:** Aquaculture; GIFT; chitralada; fazenda de peixe; piscicultura.

1 INTRODUCTION
In Brazil, Nile tilapia is farmed from the Amazon River Basin to Rio Grande de Sul (Ribeiro, 2001) and has great potential for growth, as it survives and grows under varying environmental conditions. It is a species with excellent growth between 26 to 28 °C (Castagnolli, 1992), dissolved oxygen concentration in water between 3.5 and 4.0 mgL⁻¹ and pH between 6.0 to 8.5 (Boyd, 1990). Brazil is an agricultural nation (Schuh and Alves, 1970) and emerges on the world stage as one of the great aquaculture powers. Only in 2019 did Brazilian fish farming increase its production by 4.9% (highest rate among all proteins of animal origin) and reached the mark of 758,006 tons, reinforcing the position of the 4th largest tilapia producer in the world (PeixeBR, 2020).

The State of Santa Catarina is located in the South Region of Brazil, corresponding to 1.12% of the Brazilian area and 16.61% of the South Region (Pandolfo et al., 2002). In Santa Catarina, fish farming is characterized by producers that can be classified as Amateur and Commercial, that is, they cultivate fish as a hobby and eventual commercialization or by the systematic and regular commercialization of production (Silva et al., 2017). Another important issue for fish farming in Santa Catarina is the climate issue. The predominant climate in Santa Catarina is subtropical and temperate, thus, it presents mild temperatures, which can vary between 13º and 25ºC. Unlike the other Brazilian states in which two seasons are perceived basically, in Santa Catarina it is possible to distinguish the four seasons, consisting of hot summers and severe winters.
and, at the highest plateaus where the altitudes reach up to 1,810 meters, snowfall occurs in winter (Epagri-Ciram, 2014).

The regions with temperate climate, exclusively observed in the southern region of Brazil, can have very low temperatures at certain times of the year (Pandolfo et al., 2002; Epagri-Ciram, 2014) and, consequently, can reduce the productive increase of fish from fresh water, making the cultivation of many species unfeasible under conditions exposed to the climate (Pankhurst, 1997). In this way the productive performance of certain fish lineages can be affected when farmed in some locations in Santa Catarina.

2 MATERIAL AND METHODS

The present study evaluated in real conditions, the production indexes that could indicate the best performance of the GIFT and Chitralada lineages (Figure 1) in the Vale do Itajaí region, responsible for almost 35% (Souza Filho et al., 2002; Epagri-Cepa, 2018) of the total tilapia produced throughout the state of Santa Catarina. The research was carried out at Sabiá Farm (27 ° 06' 14" S and 49 ° 41' 45" W) located in the rural municipality of Presidente Getúlio, Vale do Itajaí (Santa Catarina, Brazil), at an altitude of 230 m above the sea, in earthen ponds exposed to the weather.

Figure 1: GIFT and Chitralada lineages used in the experiment. It is possible to observe a distinct morphological difference between the two specimens.
Two lineages of tilapia were used in the experiment. The GIFT lineage came from the Agricultural Research and Rural Extension Company of Santa Catarina (Epagri) and the Chitralada was donated by the Hintemann fish farming laboratory. The different lineages were randomly distributed in 180 m³ (18 x 10 x 1m) earthen ponds in 3 replicates each. The ponds were fertilized only once, at the beginning of the experiment with 45 kg ha⁻¹ of urea and 10 kg ha⁻¹ of triple superphosphate, according to Kubitza and Kubitza (2000). The stocking densities commonly used in the region were used, 2 tilapia m⁻³ in each pond.

GIFT tilapia fingerlings were obtained from natural spawning stock at Epagri Research Station in Itajaí (SC) and were fed eight times a day at 1.5 hour intervals with 50% Crude protein (CP) feed containing 60 mg of 17 α–Methyltestosterone hormone for 45 days, when they reached an average weight of 2.65 ± 0.03g. Likewise, the Chitralada lineage went through the sexual reversion process, previously described, when they reached an average weight of 3.08 ± 0.16g. After the sexual reversion process, the fry of the two lineages at 45 days old were distributed in the experimental units.

Daily at 9 am and 3 pm the water quality parameters, temperature and dissolved oxygen were monitored with an oximeter (HANNA, model F-HI 9147). The pH was measured weekly with GULTON equipment (model pH master) and the concentrations of nitrite, ammonia and alkalinity with the ALFAKIT analysis kit. To fed the juveniles a commercial feed containing 40% CP with 2.0 mm in diameter was used until the animals reached 50 g. Then commercial feed containing 32% CP 4.0 mm in diameter was used until the end of the experiment, fed until the animals were satisfied. Feed was offered twice a day (morning and afternoon). Biometrics were performed every two weeks using 40 specimens from each experimental unit. At the end of the experiment, the weight gain of each lineage in each pond was evaluated, the average total length, fillet yield (36 animals were slaughtered from each repetition, a skinless fillet with spines removed was used as a measure), feed conversion and survival. The student t test (Spiegel, 1985), at the 5% level of significance, was used to analyze the data of this study.

3 RESULTS

In the evaluation of productive performance comparing the two lineages of Nile tilapia in a temperate climate region, no significant difference was observed between the lineages (Table 1).

During the experimental period the average water temperature of the earthen ponds was 22.52 ± 2.19 °C. Dissolved oxygen had an average of 7.30 ± 2.85 mg L⁻¹. The pH remained close to neutrality and the average was recorded at 7.19 ± 0.33. Total ammonia concentrations registered a final average of 0.25 ± 0.32mg L⁻¹.
4 DISCUSSION

Water temperature is one of the most determining factors for the growth of tropical fish (Ostrensky & Boeger, 1998). In the present study, the water temperature remained close to or below 20 °C during most of the experimental period, therefore outside the comfort range for the species (Boyd, 1995). The southern region of Brazil, especially in the region of the present study, Santa Catarina, encompasses two climatic types with very hot summers and very rigid winters, with intense frosts and even snow in some places. This is due to the location close to the tropic of capricorn, between 25º and 29º south latitude. This can be a determining factor for the production of tilapia in the region, since Nile tilapia maintains its ideal performance at temperatures between 27 and 30 °C (Beamish, 1970; El-Sayed and Kawanna, 2008; El-Sherif and El-Feky, 2009).

Table 1: Means (± standard deviation) of the performance indexes of the Chitralada and GIFT lineages farmed in earthen ponds. Results obtained during the 127 days of cultivation. FW: final weight; FL: final length; DWG: Daily weight gain; IB: Initial biomass; FB: final biomass; AFC: Apparent feed conversion.

<table>
<thead>
<tr>
<th>Productive indexes</th>
<th>GIFT</th>
<th>Chitralada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial fish population</td>
<td>1080</td>
<td>1080</td>
</tr>
<tr>
<td>Final fish population</td>
<td>939</td>
<td>896</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>87</td>
<td>83</td>
</tr>
<tr>
<td>Farming days</td>
<td>127</td>
<td>127</td>
</tr>
<tr>
<td>FW (g)</td>
<td>186.88 ± 19.05</td>
<td>183.44 ± 17.87</td>
</tr>
<tr>
<td>FL (cm)</td>
<td>20.25 ± 1.10</td>
<td>20.45 ± 1.27</td>
</tr>
<tr>
<td>DWG (g / day)</td>
<td>1.47 ± 0.15</td>
<td>1.44 ± 0.14</td>
</tr>
<tr>
<td>IB (kg m⁻³)</td>
<td>0.0053</td>
<td>0.0062</td>
</tr>
<tr>
<td>FB (kg m⁻³)</td>
<td>0.326</td>
<td>0.301</td>
</tr>
<tr>
<td>AFC</td>
<td>1.36 ± 0.09</td>
<td>1.48 ± 0.10</td>
</tr>
<tr>
<td>Fillet yield (%)</td>
<td>39.70 ± 0.57</td>
<td>41.85 ± 1.06</td>
</tr>
</tbody>
</table>

According to Macaranas et al. (1997) a selected lineage that is optimal for one environment, may present different performance in other environments. In this way, the definition of the best lineage, according to regional characteristics, starts to play an important role in crops, since it can generate savings in feed consumption, labor and cultivation time. Although we did not observe a significant difference between the lineages, we can notice that from the third sampling, the GIFT lineage showed a higher average in weight compared to the Chitralada lineage. From April, 90 days after the beginning of the experiment, the Chitralada lineage seemed to recover its growth, ending the experimental period with practically the same productive indexes as the GIFT lineage.
According to Kubitza (2006) the growth rate of the GIFT tilapia seems to be more accelerated at the beginning of the cultivation and decreases when the fish reaches the weight of 200g. Afterwards, there appears to be a recovery of the Chitralada lineage in terms of weight gain, comparing its growth to the GIFT lineage until the end of cultivation. The fact that the Thai lineage (Chitralada) shows similar growth to that of the GIFT lineage in the present study, may be related to the cultivation environment (earthen ponds), since the GIFT lineage showed the best performance in floating cages when compared to the Chitralada and Supreme lineages in winter period in the north of the state of Paraná - Brazil (Galo et al., 2008). However, the GIFT lineage showed a higher growth rate at 30 ° C when compared to the Red lineage. Furthermore, the productive performance can be optimized at temperatures close to 30 ° C (Santos et al., 2013), when compared to the present study.

As for the fillet yield, Souza (2002) observed a fillet yield of approximately 40% in tilapia weighing between 500 and 800g. Leonhardt (2006) comparing three lineages of tilapia in western Paraná (Chitralada, Local and Hybrid of Chitralada x local), observed yields of 36.51%, 38% and 39.05% respectively. In general, the work carried out with different tilapia lineages has not shown a significant difference regarding fillet yield. Similarly, when we compare survival rates, we see similar results found by Galo et al. (2008), Marengoni et al. (2008) and Massago et al. (2010).

In general, it is clear that the sub-optimal conditions in terms of low temperature can result in different responses to each specific condition and the productive increases of the fish can be directly affected due to the maintenance of the ideal temperature (Zhang and Runham, 1992; Boyd, 1995). The restriction of fish growth under low temperature conditions may explain the similar growth of fish during the present study.

Nile tilapia has contributed to the development of aquaculture worldwide since ancient times in Egypt and remains an important cultivated freshwater species, as it is considered a fish that is very resistant to environmental variations and diseases when compared to other cultivated fish species (Amal and Zamri-Saad, 2011; Tavares-Dias and Martins, 2017). Although we conducted the experiment for a relatively short period and ended before the fish reached the commercial size for slaughter, we understand that any information that can clarify doubts in the productive sector related to the species will always be well welcome. In addition, there is little information on the growth rates of Nile tilapia at low temperatures.
5 CONCLUSIONS

The GIFT and Chitralada lineages of *O. niloticus* showed no significant difference in productive performance when farmed in earthen ponds under sub-optimal temperature. This fact represents an elucidation for producers in temperate climatic regions of the world, since they will be able to choose the use of both lineages, with no apparent production losses, although low temperatures can cause reduced growth compared to tropical regions of higher temperatures.

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Compliance with ethical standards

The present study evaluated in real conditions the production indexes of the GIFT and Chitralada tilapia lineages in accordance with the Brazilian law nº 11.794/2008 and following requirements of Ethics Committee of Animal Use (CEUA/UFSC).

Conflict of interest

The authors declare that they have no conflict of interest.
REFERENCES


