Brazilian Journal of Development

Alternating Nile tilapia (*Oreochromis niloticus*) and silver catfish (*Rhamdia quelen*) farming in recirculation system: A possibility for aquaculture in Southern Brazil

Cultivo alternado de tilápia do Nilo (Oreochromis niloticus) e peixe-gato de prata (Rhamdia quelen) em sistema de recirculação: uma possibilidade para a aquicultura no sul do Brasil

DOI:10.34117/bjdv6n6-174

Recebimento dos originais: 04/05/2020
Aceitação para publicação: 07/06/2020

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ABSTRACT
The world aquaculture scenario has undergone several changes due to the deficit in natural fish reserves, which has led to the growth of aquaculture activities to the point of them being considered the leading sector in food production. In Brazil, this activity is increasing rapidly, and the most common commercially cultivated species is the Nile tilapia. Southern Brazil presents a more rigorous winter period than the other Brazilian regions, when aquaculture activities present several unoccupied tanks, generating low productivity and decreases in producer income. In search of an alternative to this problem, the present study aimed to evaluate the alternating production of Nile tilapia (*Oreochromis niloticus*) and silver catfish or silver catfish (*Rhamdia quelen*), a native fish that displays adequate growth during the cold period. Fish were divided into two phases, rearing and fattening, and the volume of water used for rearing was 3 times lower than that used for fattening. Tilapia fingerlings were bred in winter months and fattened during summer months, while silver catfish fingerlings were bred in summer months and fattened during winter months. Morphometric and performance parameters were analyzed. The experimental breeding of both Nile tilapia and silver catfish presented promising results. Extrapolating the data obtained herein for the occupation of a productive area close to the ideal, a productivity per species similar to that reached in commercial productions in the region would be obtained. Thus, alternating Nile tilapia and silver catfish farming is a viable alternative for Southern Brazilian aquaculture, as it maintains fish production year round, even during cold periods.

Keywords: aquaculture, aquatic system, breeding, fish production, jundiá, native fish.

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RESUMO
O cenário da aquicultura mundial sofreu várias mudanças devido ao déficit nas reservas naturais de peixes, o que levou ao crescimento das atividades da aquicultura a ponto de serem consideradas o setor líder na produção de alimentos. No Brasil, essa atividade está aumentando rapidamente, e as espécies cultivadas comercialmente mais comuns são as tilápias do Nilo. O sul do Brasil apresenta um período de inverno mais rigoroso que as demais regiões brasileiras, quando as atividades de aqüicultura apresentam vários tanques desocupados, gerando baixa produtividade e diminuindo a renda do produtor. Em busca de uma alternativa para esse problema, o presente estudo teve como objetivo avaliar a produção alternada de tilápia do Nilo (Oreochromis niloticus) e bagre prateado ou prateado (Rhamdia quelen), um peixe nativo que apresenta crescimento adequado durante o período frio. Os peixes foram divididos em duas fases, criação e engorda, e o volume de água usado para criação foi 3 vezes menor que o usado para engorda. Os alevinos de tilápia foram criados nos meses de inverno e engordados nos meses de verão, enquanto os alevinos de prata foram criados nos meses de verão e engordados durante os meses de inverno. Os parâmetros morfométricos e de desempenho foram analisados. O melhoramento experimental de tilápia do Nilo e bagre de prata apresentou resultados promissores. Extrapolando os dados aqui obtidos para a ocupação de uma área produtiva próxima ao ideal, seria obtida uma produtividade por espécie semelhante à alcançada em produções comerciais na região. Assim, alternar a criação de tilápia do Nilo e peixe-gato de prata é uma alternativa viável para a aquicultura no sul do Brasil, pois mantém a produção de peixes durante o ano todo, mesmo em períodos frios.

Palavras-chave: aquicultura, sistema aquático, melhoramento, produção de peixes, jundiá, peixes nativos

1 INTRODUCTION

Global aquaculture has underwent intense transformations in recent years, due to the depletion of natural fish stocks. Declines in fishing activities have resulted in the accelerated growth of fish farming in the last 30 years, with aquaculture activities being one of the fastest growing food production sectors in the world today (FAO 2016).

From a social point of view, fish farming can become an important source of income for local populations, both for formal workers in large enterprises, as well as small associations comprising producers or cooperatives. In this context, Nile tilapia has been presented as an important alternative, since this species comprises a technological cultivation package dominated by technicians and producers (Meurer et al. 2009).

Brazilian aquiculture activities reached the mark of 474 thousand tons cultivated in 2014, with 41.9% of the total production composed of tilapia, which, in turn, answered for 198 thousand tons. Nile tilapia production alone was 17% higher than that obtained for 2013 (IBGE 2014). However, this species decreases their feed intake and, consequently, their growth, at lower temperatures (Azaza, Dhraief, and Kraiem et al. 2008).

Fish production systems in southern Brazil (figure 01), based predominantly on fish farming in excavated tanks, present certain limitations related the cold during the winter period, between June to September, which is considered the off-season. During this period, many tanks are generally idle, which translates into a lack of income for the producer, as well as the whole associated production chain. Nobrega et al. (2017) states that there is an urgent need to develop technologies to improve Nile tilapia (*Oreochromis niloticus*) production in subtropical regions, where water presents a wide temperature variation between summer and winter.

Phased or alternating production increases the use of the production area, although this artifice may not be enough to ensure adequate production scheduling, due to production characteristics and fingerling availability during the coldest periods of the year. Seasonal year to year differences also make predicting fingerling availability difficult, with consequent idleness of productive structures.

One of the ways to mitigate this problem in production systems located in southern Brazil is the use of species that show good growth during the winter period, such as certain native fish species that have shown prominence in the national fish production scenario, such as the silver catfish (*Rhamdia quelen*). This species has been increasingly produced in the southern region of the country, since, in addition to presenting adaptable characteristics to cultivation systems, it also presents an excellent flavored meat, high resistance to cold periods, rapid growth, rusticity regarding handling and easy adaptation to artificial feeding (Luchini and Salas 1985; Feiden et al. 2010).

In this context, phased production of these two species, alternated at each time of the year, is an interesting option for fish farming in southern Brazil. Therefore, the present study aimed to evaluate the alternating production of Nile tilapia and silver catfish in a water recirculation system, evaluating their productive parameters.

2 MATERIALS AND METHODS

2.1 LOCATION AND EXPERIMENTAL PERIOD

Alternate breeding cycles between Nile tilapia and silver catfishs were maintained at the Laboratory of Fish Production Systems, Department of Animal Science, Federal University of Paraná, Palotina Sector, during 19 months, between October and April.

The cycles were divided into two phases, rearing and fattening (figure 2). Rearing was performed with 100 fingerlings for both species, and fattening with 75 juveniles. The breeding structure consisted of a system for rearing and one for fattening, at a 3 to 1 ratio, i.e. the fattening system used 3 times the water volume used for rearing. The stocking densities were maintained at 20 fish per m^3 for the rearing phase and 5 fish per m^3 for the fattening phase.

The first rearing accommodation was conducted with Nile tilapia fingerlings (5.06 ± 0.23g), for 34 days from 04/10 to 07/11. After the tilapia juveniles left the rearing structure, it was occupied by silver catfish fingerlings (8.93 ± 0.15g) for 126 days, from 11/01 to 05/17. Subsequently, a new tilapia fry (4.72 ± 0.23g) was housed for 49 days, from 08/22 to 10/10.

Fattening was initiated by the accommodation of Nile tilapia juveniles (50.26 ± 3.56g) from rearing for 183 days, between 07/11 and 05/05. Subsequently, silver catfish juveniles were housed for 109 days, from 05/15 to 03/10. Later, tilapia juveniles were housed again for 189 days, between 10/10 and 16/04.

2.2 STRUCTURE AND EXPERIMENTAL MANAGEMENT

For the rearing phase, the structure consisted of five circular 1,000L plastic boxes with water recirculation connected to a 5,000L circular tank for biofiltration. The structure for the fattening phase consisted of three circular 5,000L tanks, individually connected to a 2,000L tank for biofiltration, also maintaining water recirculation. Water recirculation was performed by an electric water pump with 3.000L hr-1 capacity and biofiltration was performed by macrophytes, *Eichhornia crassipes* and *Pistia stratiotes,* (Henry-Silva and Camargo 2008). Water exchange volumes of 600L hr-1 during rearing and of 3,000L h during fattening for each tank were maintained. Thus, for both phases, an exchange of about 14.4 times the total water volume per day was maintained.

Commercial fish feed (Anhambi Alimentos LTDA) was used for both species. Feeding was performed to apparent satiety, twice a day, at 9 AM and 2 PM. For silver catfishs, the rearing phase feed contained 400g kg-1 crude protein and 3,600kcal/kg crude energy and a mean diameter of 1.8 mm, while the fattening phase feed contained 32 g kg-1 crude protein and 3,400kcal/kg crude energy and mean diameter of 5mm. For tilapia, similar feed was used, only adding feed with guaranteed levels of 28g kg-1 of crude protein, 3,200kcal of crude energy and average diameter of 8mm towards the end of the fattening phase.

2.3 ENVIRONMENTAL PARAMETERS

Water quality parameters were analyzed weekly. Dissolved oxygen was measured using an oximeter (YSI PRO20) and pH by means of a pH meter (YSI F1010). Ammonia, nitrite, alkalinity and hardness were obtained using commercial water analysis kits (Alcon - Camboriú - SC), and temperature was measured by means of a mercury thermometer.

During the experimental period, dissolved oxygen in the tanks ranged from 4.5 to 8.5mg L-1; pH from 7.0 to 9.0; total ammonia from 0.12 and 0.80mg L-1; ammonia (N-NH 3) from 0.002 to 0.0167mg L-1; nitrite from 0.0 and 0.5 mg L-1; alkalinity from 40 and 60mg L-1 ($CaCO_3$) and hardness from 40 and 60mg L-1 ($CaCO_3$). Figure 3 displays the mean values of water temperature during the breeding cycle.

The water chemical parameters of the tanks were adequate for both silver catfish (Marchioro and Baldisserotto 1999; Lopes et al. 2006; Miron et al. 2008; Townsend and Baldisserotto 2001; Townsend, Silva, and Baldisserotto 2003) and Nile tilapia development (Hussain 2004; El-Shafai et l. 2004; Redner and Stickney 1979; Atwood et al. 2011; Yanbo et al. 2006).

As expected, water temperature during the winter months presented values below those recommended for best Nile tilapia growth. However, this is the reality that fish farmers go through.

Statistical analyses

Monthly, 10 fish from each replicate experiment was taken from each tank, weighed, measured and returned to the tank, in order to obtain performance parameter evaluations. At the end of each production cycle, whether the fish were reared or fattened, specimens were anesthetized in an eugenol solution (250mg L-1), counted, weighed and measured for evaluation of survival parameters, morphometry, weight gain and food conversion.

The morphometric parameters between the two tilapia fattening cycles were compared using the T (N <30) and the Z (N>30) tests. When significant differences were verified, they were compared by Tukey's test, using the BioEstat 5.3 software package.

3 RESULTS

The values of the initial and final parameters of the first (34 days) and second cycles (49 days) for tilapia rearing are presented in Table 1. Final weight, biomass, daily weight gain and specific growth rate were higher for the first rearing cycle (P <0.05). The other evaluated parameters did not differ between breeding cycles (P> 0.05). The values of the initial and final cycle parameters (126 days) for silver catfish rearing are displayed in Table 2.

The values of the initial and final parameters of the first (183 days) and second cycles (189 days) for tilapia fattening are presented in Table 3. During the fattening period, the second cycle presented lower initial weight and feed conversion (P <0.05) than the first cycle. All other parameters were similar (P> 0.05) between cycles. The initial weight parameter of the second fattening period was lower than the first. However, the variations in juvenile (or fingerling) sizes observed herein are adequate to what is offered in the Brazilian market, since fish range from 30 to 50g. The values of the initial and final silver catfish fattening parameters (139 days) are displayed in Table 4.

4 DISCUSSION

4.1 REARING

For Nile tilapia, the first rearing period presented higher performance in terms of daily weight gain and, consequently, specific growth rate, compared to the second. However, no difference was observed regarding survival and feed conversion values.

The difference in batch performance can be explained by the time the fish were housed and grown. Thus, depending on the accommodation period of the fry for rearing, one should anticipate a longer time for this stage, since it took almost 50% more time for the fish to begin rearing at a lower temperature.

The tilapia fingerlings of the second cycle were housed in early spring, and grown at an average temperature of 21.8° C. The fry from the first cycle were housed at the end of the same season and grown at an average temperature above 25.3ºC. At a lower temperature, fingerling metabolism decreases, reflecting in lower feed intake and, consequently, slower growth. Lui et al. (2012) in an experiment regarding juvenile Nile tilapia feeding observed a daily weight gain of approximately 0.3g per day for fish weighing between 5 and 20 g.

The survival parameters and specific growth rate of tilapia during the rearing phase reached in this study are in agreement with those reported for tilapia fingerlings in the literature (Teoh and Ng 2016; Boscolo et al. 2010). However, daily weight gain and apparent feed conversion were higher herein than those presented by the aforementioned authors. This may be related to different strains, cultivation system and applied nutritional strategy.

For silver catfish, growth, survival and feed conversion values during rearing were satisfactory and suitable for this phase, providing fish of appropriate size for the subsequent stage. Survival rates were close to the values presented by Maffezzolli and Nuñer (2006). The specific growth rate, however, was below that presented by Piedras, Moraes and Pouey (2004).

Feiden et al. (2010), when evaluating the performance of silver catfish grown in net tanks using an organic system, observed a daily weight gain of approximately 0.5g day-1 for fish weighing between 15 and 52g. Diemer et al. (2011) found similar values, ranging from 6 to 24g, for silver catfish reared in net-tanks. When evaluating the development and body composition of silver catfish fingerlings with initial weight of 21.58g during 26 days, Melo et al. (2002) observed an average daily weight gain between 0.65 and 0.89g.

4.2 FATTENING

The fattening phase of Nile tilapia was adequate according to that described by several authors. For example, Leonhardt et al. (2006), when comparing different tilapia strains, obtained final average weight at 180 days, of 650g, 534g and 360g, for each strain, respectively. Dan and Little (2000), also comparing Nile tilapia strains, obtained average final weights of 353g, 380g and 400g for each strain at the end of 184 days. Mercante et al. (2007), when monitoring the quality of the nursery water of tilapia was able to reach an average weight of 600g in about 5 months, starting with 130g juveniles.

The daily growth found herein for tilapia in fattening phase ranged from 2.72 to 3.03g per day for medium temperatures between 25 and 26°C. Lima, et al. (2015), when testing the production of tilapia in a biofloc system at different densities, reported daily weight gain between 2.16 and 2.36g, while Dan and Little (2000) obtained values between 1.6 and 2.1g for tilapia between 9 and 400g during 184 days of cultivation in excavated tanks. Leonhardt et al. (2006) obtained daily weight gain between 2 and 3.6g for three different tilapia strains with initial weight of 0.68g during 180 days in net-tanks installed in an excavated nursery.

Other studies include the report by Sampaio and Braga (2005), that achieved daily weight gain between 4.73 and 5.02g for fish reared in ponds in a hydroelectric plant lake during 130 days; Boscolo et al. (2010), which obtained daily gain values greater than 2.0g per day for fish weighing between 84 and 288g; and Pinto et al. (2011), that observed daily growth of 3.57g for fish weighing between 50 and 500g when comparing the performance of Thai tilapia and Florida red tilapia.

The apparent feed conversion rate for tilapia from the first and second fattening presented an adequate value for this stage, and better than values observed by Sampaio and Braga (2005) (1.53) and Marengoni (2006) (1.54 to 1.75), and similar to those reported by Lima et al. (2015) (1.38-1.62) and Moraes et al. (2009) (1.34-1.59). Regarding comparisons between the two fattening periods, the second period presented worse feed conversion than the first, but, nevertheless, presented a specific growth rate higher than the first. The differences in performance between these parameters, although significant, were small and may be due to difference between fish batches.

The performance parameters of Nile tilapia may vary according to the environmental cultivation conditions, as well as the development stage of the animal. In the present study, values were similar to those found in the literature, and also close to those achieved in commercial farms in excavated tanks in western Paraná (Brazil).

The survival rates observed herein during the tilapia fattening stage are in agreement with those reported by Lima et al. (2015) and higher to those reported by Leonhardt et al. (2006) (84-87%), Dan ans Little (2000) (70-82%) and Moraes et al. (2009) (76-88%).

There is still no consensus on the adequate size of silver catfish commercialization. However, due to the good fillet yield of this species of fish, demands exist for specimens weighing around 300 g, about 30 cm in length and presenting 12.0g of fillet. Fracalossi et al. (2004), when evaluating silver catfish growth in two localities of the state of Santa Catarina, verified that in the north region of the state it was possible to reach 728 g during 365 days of breeding while in the south this value was lower, of 365g.

Among the obstacles observed for silver catfish production is the heterogeneous growth and reduced growth rate of males, which are remarkable when compared to females. In males, the energy and nutrients spent in semen production delays their growth, since they reach sexual maturity much faster that females, which is an undesirable characteristic for their reproduction.

According to Fracalossi et al. (2004) the final commercial weight of females is greater than that of males, indicating that a monossex culture of females would be preferable. It is suggested that the higher initial growth of females is associated with an "investment" in egg production later on, since larger females produce a larger number of eggs when compared to smaller females (Suzuki and Agostinho, 1997).

Variability in silver catfish size was also observed herein, although feeding was carried out until the apparent satiety of the stocked fish. Specimens weighed between 145 and 426g, demonstrating a clear dominance behavior of some specimens over others.

The survival rates observed in the present study were lower than that reported by Pedron et al. (2008) (92-100%), but higher than that found by Fracalossi et al. (2004) (71%) and de Souza and Pouey (2005) (63%). Mortality in the present study can be attributed to the development of an ichthyophyte disease in one of the tanks, a common parasite observed during silver catfish production.

Rapid growth is an important factor in the selection of aquaculture species. The daily weight gain observed during the silver catfish fattening period was higher than those reported by de Souza and Pouey (2005) (0.8g) and Pedron et al. (2008) (0.95g). Fracalossi et al. (2004) was able to obtain values between 1.0 and 1.97g for silver catfish rearing at water temperatures above 20°C. In general, the growth results obtained herein can be considered very interesting for fish not fattened during the winter period.

Fracalossi et al. (2004), obtained feed conversion rates between 1.78 and 1.85 for 300 and 800g fish, respectively, lower than the values reported presented herein. Lazzari et al. (2006), when comparing different diets for silver catfish specimens with initial weight of 15g in a temperature-controlled system at 26.8°C found varied results after 90 days, with specific growth rates between 0.8 and 2.2% per day and apparent feed conversion between 1.3 (more efficient diet) and 4.5 (less efficient diet).

The feed conversion rates measured in the present study are in agreement with those reported by Fracalossi et al. (2004) (1.2-1.9), but significantly higher than that reported by de Souza and Pouey (2005) (3.09). These data indicate that silver catfish are efficient in converting food, even more so when considering the season of the year. Feed conversion is highly influenced by the nature of the diet, body composition of the animal and average daily weight gain (Rocha et al. 1999), that is, the higher the weight gain and the shorter the production cycle, the lower the energy expenditure with basal metabolism (also known as maintenance energy). Thus, fish grown during periods where the water is warmer tend to have present higher average daily weight gain and lower feed conversion rates during the productive cycle.

According to some authors, better results for the intensive commercial cultivation of silver catfish can be obtained by cultivating monosex animals. Amaral Júnior, Nunes and Garcia (2008), using monosex females feminized with 17 β-estradiol in a monoculture system in soil nurseries, with supplementary aeration and predator control, were able to reach the daily weight gain of 2.26g, survival of 90.37% and feed conversion of 1.30 during 25 weeks of culture.

Piaia and Baldisseroto (2000) observed a positive effect on the increase in stocking density on weight gain and survival rate of silver catfish fingerlings reared in a water recirculation system, while Hecht and Uys (1997) observed this same density effect in African catfish fingerlings *Clarias gariepinus*. However, Engle and Valderrama (2001) and Esquivel, Esquivel, and Zaniboni Filho (1997) observed the opposite effect on channel catfish.

4.3 THE ALTERNATING NILE TILAPIA AND SILVER CATFISH SYSTEM

A clear effect of water temperature on the performance of Nile tilapia was observed. A decrease in the growth rates of the first fattening cycle with a decrease in water temperature and an effect of temperature on rearing were verified. The effect of water temperature on the performance of Nile tilapia may vary according to strain (Rezk et al. 2002). For example, Wagner et al. (2004), when comparing four Nile tilapia strains, verified higher productive performance for the Chitralada (Thai) strain, but the fillet yield did not differ among the studied strains.

Nile tilapia show seasonal growth variations, closely linked to water temperature. Nile tilapia stop feeding about 16.0°C, and severe mortality occurs at 12.0°C, with optimum range 25.0 to 30.0°C (El-Sayed 2006). According to Popma and Masser (1999), the optimal temperature for Nile tilapia ranges from 29.44 and 31.11° C, and the growth observed during this temperature range is three times higher than at 22.2° C.

Silver catfish specimen showed almost constant growth between May and August, despite the gradual decreases in water temperature. Silver catfish can be considered a eurithermic species, resistant to high temperature variations, since its fry acclimated to 31ºC also supports temperatures between 15ºC to 34ºC. (Chippari-Gomes, Gomes, and Baldisserotto 1999). Its ideal thermal range is between 22 to 28ºC (Borges 2005). Silver catfish shows higher growth than Nile tilapia during the cold periods of the year (Piedras et al. 2004; Gomes et al. 2000; Garcia et al. 2008; Azaza, Dhraief, and Kraiem 2008).

Thus, alternating the breeding of these species, with Nile tilapia being fattened during the hot months of the year and silver catfish during the cold, provides a constant fish production during the year. In the same way, the rearing periods for both species can be considered adequate, since they provided fish in the amount and size appropriate to the next stage.

During the experimental period two complete breedings were obtained for Nile tilapia of the Nile and one for silver catfish. The tilapia farming (including rearing and fattening) lasted a total of 217 days for the first breeding and 238 days for the second breeding. On the other hand, silver catfish farming lasted a total of 265 days, significantly longer ($P < 0.05$) than the tilapia breeding cycles.

Taking into account the occupation of the production area, the area used for rearing there was occupied for 175 days, and the area used for fattening, for 328 days (in the case of the longest tilapia rearing period). Therefore, the rearing area was occupied during 47.9% of the time (year), while the fattening area was occupied during 89.8% of the time. The greater occupation of the farming system, the shorter its idle time and the greater the financial return it provides to the producer.

The ideal occupation would be close to 100%, however, this value may not be easy to reach for a commercial aquaculture property farming, given the difficulty in maintaining the adequacy of the system's cost and population, as well as the time required for tank preparation measures, as is normally the case for systems using excavated tanks.

With the use of an area destined exclusively for young rearing, corresponding to 25% of the total volume of the productive area, and the presence of silver catfish in fattening phase, less total property idleness was obtained, of 12.39% of the time, with 8.28% (121 days) corresponding to the rearing area and 4.11% (15 days) to the fattening area.

For an ideal occupation for each phase of practically 100% of the year (365 days) silver catfish rearing should begin in November and end in the end of April, which would be adequate for fingerling availability in the beginning in May and ending at the end of October, with consequent fattening beginning at the same time and ending at the end of April.

An interval between the harvest and stocking from about a week to a fortnight would not significantly impact the total output of the system's production system, providing a total occupancy of 351 to 358 days per year, or 96 to 98% of the time.

In a system of alternating tilapia farming with silver catfish in a rearing system with one week for stocking and settlement, with the stocking of the rearing system with tilapia fingerlings weighing about 1g, the harvest of fish weighing between 150 and 200g of average is expected. The fattening of these fish would probably provide fish with an average weight of between 800 and 900g. For silver catfish, fish around 180 and 200g at the end of the rearing beginning with fingerlings weighing about 1g are expected, and fattening would allow for a harvest of fish weighing between 500 and 600g.

Alternating Nile tilapia and silver catfish farming is, thus, a viable alternative for aquaculture in Southern Brazil, as this method allows for the maintenance of fish production throughout the year, even during cold periods.

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ANEXOS

Figure 1. Map of Brazil, with three states of South Region, Paraná, Santa Catarina, and Rio Grande do Sul (https://www.estadosecapitaisdobrasil.com/regiao/sul/).

Figure 2. Alternating Nile tilapia and silver catfish farming system.

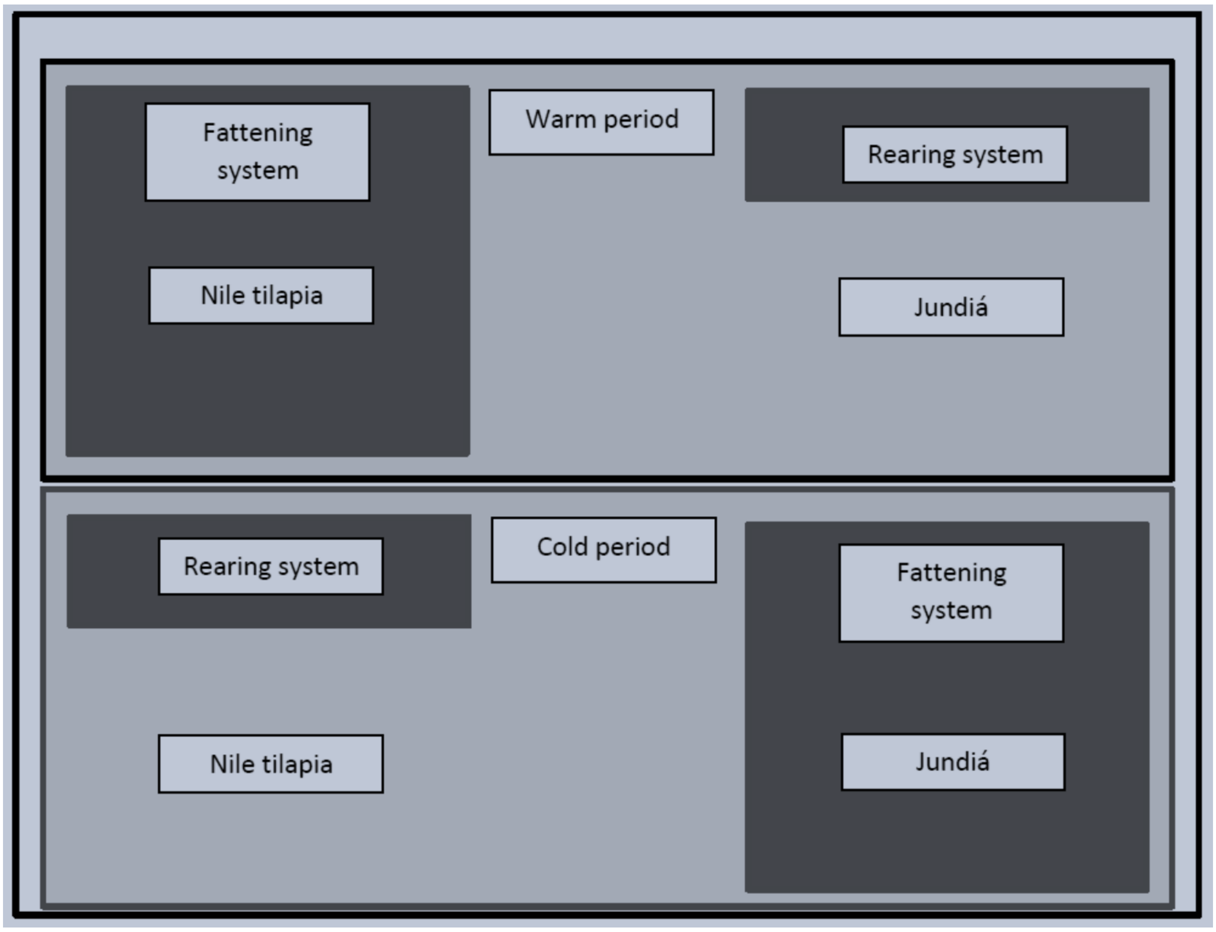

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Figure 3. Water temperature during experimental period (from October 2014 to April 2016).

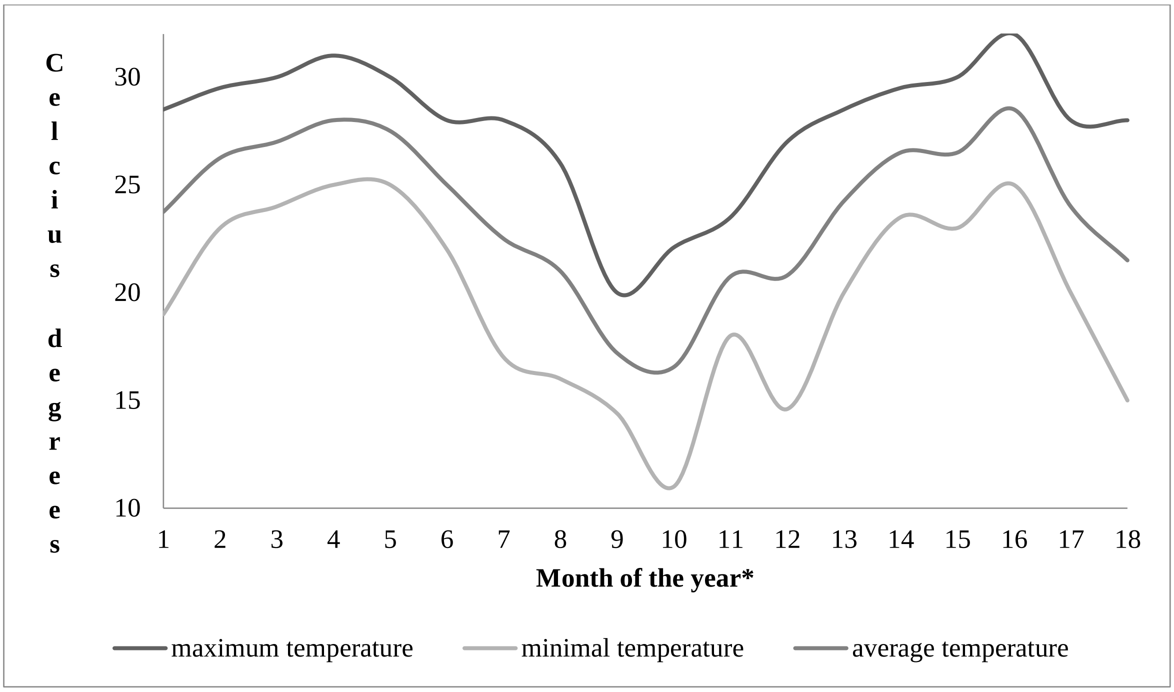

Table 1. Nile tilapia performance parameters during rearing phase.

Parameter	1st cycle	2st cycle
Initial weight (g)	5.06a	4.74a
Final weight (g)	49.86a	44.55b
Initial lenght (cm)	6.70a	6.54a
Final lenght (cm)	14.4a	13.78a
Survival (%)	97a	94a
Biomass/m^3 (kg)	0.99a	0.83b
DWG[1] (g)	1.32a	0.81b
AFC[2]	1.08a	1.03a
SGR[3] (%)	2.92a	1.98b

[1] Daily weight gain; [2] Apparent Feed Conversion; [3] Specific growth rate.

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Table 2. Silver catfish performance parameters during rearing phase.

Parameter	Value
Initial weight (g)	8.93
Final weight (g)	90.1
Initial lenght (cm)	9.59
Final lenght (cm)	21.28
Survival (%)	97
Biomass/m^3 (kg)	1.80
DWG[1] (g)	0.64
AFC[2]	1,34
SGR[3] (%)	0.80

[1] Daily weight gain; [2] Apparent Feed Conversion; [3] Specific growth rate.

Table 3. Parameters values of the first and second cycles for tilapia fattening.

Parameter	1st cycle	2st cycle
Initial weight (g)	50.26a	42.27b
Final weight (g)	578.33a	586.66a
Initial lenght (cm)	14.16a	13.62b
Final lenght (cm)	30.97a	29.51b
Survival (%)	96a	94.66a
Biomass/m^3 (kg)	2.77a	2.62a
DWG[1] (g)	2.88a	2.88a
AFC[2]	1.36b	1.40a
SGR[3] (%)	0.58b	0.60a

[1] Daily weight gain; [2] Apparent Feed Conversion; [3] Specific growth rate.

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Table 4. Parameters values of the silver catfish fattening phase.

Parameter	Value
Initial weight (g)	102.69
Final weight (g)	274.08
Initial lenght (cm)	22.23
Final lenght (cm)	30.18
Survival (%)	84
Biomass/m^3 (kg)	1.16
DWG[1] (g)	1.23
AFC[2]	1.76
SGR[3] (%)	0.31

[1] Daily weight gain; [2] Apparent Feed Conversion; [3] Specific growth rate.