GROWTH OF NON SEX-REVERTED TILAPIA *Oreochromis niloticus* (CHITRALADA STRAIN), REARED IN CONCRETE TANKS AND NET-CAGES IN NORTHEAST BRAZIL

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ABSTRACT

This work investigated the growth of sex-reverted and non sex-reverted tilapia fish *Oreochromis niloticus* (chitralada strain), reared in concrete tanks and net-cages at Paulo Afonso City, Northeast Brazil. The initial stock density in the concrete tank was 2 ind.m^{-2}, for a 90-day rearing period. In the net-cage, the density was of 250 ind.m^{-2}, and reared during 155 and 130 days for the sex-reverted and non sex-reverted fish, respectively. The non sex-reverted fish showed rapid growth performance, with a narrow statistical difference when compared to the sex-reverted ones; the final body weights were in average 308.0 and 363.0 grams, respectively. The water temperature was 24-27°C. Non sex-reverted fish reared under higher temperatures (29-31°C) grew much faster (411.2 g) than sex-reverted and non sex-reverted fish reared under lower temperatures. The number of phenotypic males was bigger even among the non-reverted fish, indicating that water temperature could have influenced their growth rate and sex-ratio. It was concluded that the use of steroid hormones in tilapia culture in Northeast Brazil should be of great concern, at least during the hottest periods of the year. Furthermore, besides the water temperature and the number of phenotypic males inside the populations, the origin of the offspring can determine whether the culture of non-reverted fish will succeed or not.
Key words: non sex-reverted tilapia, growth, steroid hormones.

RESUMO

Crescimento da tilápia, *Oreochromis niloticus* (linhagem Chitralada), sem reversão de sexo, cultivada em viveiros e tanques-rede no Nordeste do Brasil

O presente trabalho investigou o crescimento da tilápia *Oreochromis niloticus* (linhagem Chitralada), em peixes revertidos e não-revertidos sexualmente, criados em tanques de alvenaria e tanques-rede, em Paulo Afonso, Nordeste do Brasil. Nos tanques de alvenaria foram estocados 2 peixes/m^2, por um período de 90 dias. Nos tanques-rede, a densidade foi de 250 peixes/m^2 e a duração do cultivo, de 155 e 133 dias, para os peixes revertidos e os não-revertidos, respectivamente. Os peixes não-revertidos apresentaram um bom desempenho de crescimento, com pequena diferença estatística quando comparados com o dos peixes revertidos sexualmente; os ganhos de peso médios finais foram de 308,0 e 363 g, respectivamente. A temperatura variou entre 24-27°C. Peixes não-revertidos criados sob temperaturas elevadas (29-31°C) obtiveram maior peso médio (411,2 g) do que peixes revertidos e não-revertidos criados sob temperaturas mais baixas. Machos fenotípicos foram encontrados em grande quantidade mesmo entre os peixes não-revertidos, indicando que a temperatura pode ter influenciado tanto a taxa de crescimento quanto a proporção sexual. Conclui-se que o uso de hormônios esteróides na reversão sexual da tilápia deve ser reavaliado, pelo menos nas épocas mais quentes do ano. Pôde-se concluir que, além da temperatura da água e do número de machos fenotípicos dentro da população, a origem dos alevinos pode influenciar no sucesso da criação de tilápias não-revertidas.
Palavras-chave: tilápia não-revertidas, hormônios esteróides, crescimento.

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INTRODUCTION

Although commercial tilapia culture in Brazil started during early 1970s, only after the 1990 decade it has been practiced in a large scale, especially in its northeastern region. Initially, the tilapias were cultivated in a polyculture system of earthen ponds (SILVA, 1996). Afterwards, the culturing techniques changed into a semi-intensive and intensive culture in net-cages, having nowadays the male sex-reverted tilapia *Oreochromis niloticus,* chitralada strains, as the main reared species (taxon). Monosex male tilapia is desirable in a wide variety of aquaculture production systems, and in Brazil it is obtained by administering synthetic sex steroids hormones in food or water. However, manipulations of sexual phenotype designed to produce monosex populations are not straightforward and the results are unpredictable (BEARDMORE *et al*., 2001). Also, the biodegradation of synthetic sex steroids hormones in water is very slow and it can cause environmental impacts, if used frequently in a large scale. This subject is still of great concern among scientists, which have been called for a substitutive technique of sex reversal with synthetic steroids hormones in tilapia fish, as it was recurrently addressed during the last International Symposium on Tilapia Aquaculture held in Brazil in 2000.

It is already known that wild Nile tilapia males grow faster than females (RIBEIRO, 2001), but there is little information concerning the growth performance of the *non sex-reverted* tilapia, chitralada strain, when they are cultivated under tropical water temperatures (SANTOS, 2003 a,b). This investigation aimed to show a comparative study on the growing performances between non sex-reverted and sex-reverted tilapia fish *Oreochromis niloticus*, Chitralada strain, reared in concrete/earthen-bottom tanks and net-cages, located in the Northeastern region of Brazil.

MATERIAL E METHODS

The experiments were carried out from April to December at the Fish Farming Station which belongs to the public hydroelectric company-CHESF and inside of the 'Xingozinho', meander of the Xingó reservoir, both located at Paulo Afonso, Bahia State, Brazil.

Growth of sex-reverted and non sex-reverted fish

All seedlings were obtained at the CHESF Fish Culture Station. One part of them was submitted to the sex-reversal procedures, which consisted of 60 mg of 17α-Methiltestosterone per kilogram of food, and given to the fish during the period of 28 days. The other part of the seedlings did not receive any hormone treatment.

After that, a total of 400 fish was divided into two groups, named sex-reverted and non sex-reverted groups (group 1 and 2, respectively). Each group consisted of two replications. They were cultivated in a 50 m^2 concrete/earthen-bottom tank at a stock density of 2 ind. m^{-2}. All the fish were fed daily with a 32% gross protein food, at a daily rate of 3% of the total biomass. Samplings were taken almost every thirty days, in order to record the growth performance (body weight and length), and adjustments of food supply. At the end of the experiment, all fishes of each group were measured individually and counted for the survival ratio. This experiment lasted 90 days and was carried out between April and July, 2001.

Growth and sex ratio of non sex-reverted fish

The methodology applied in this experiment was the same of the first one, except for the absence of the sex-reverted fish group and the execution period, which occurred during the dry season, between September and December, 2001. The water temperature was also taken, in order to compare with the non-reverted group of the former experiment.

Growth performance of sex-reverted and non-reverted fish

The experiment was done in net-cages located at the fishculture ground 'Xingozinho', meander of Xingó reservoir in Paulo Afonso, from May to November, 2001.

Non sex-reverted fish were obtained from the CHESF Fish Farming Station, while the sex- reverted males were bought from a private fish farm located near the experimental area. Twelve 4.0 m^2-cages were used in this experiment: nine of them were ascribed to the sex-reverted fish groups and the remaining three cages for the non sex-reverted ones. The initial stock density was 250 ind.m^{-2}.

The feeding protocol consisted of four meals a day, with a 42% gross protein feed during the first thirty days and 32%, afterwards. Samplings (around 10% of total number of fish) were approximately taken every 15 days, for measurements and food supply adjustments.

Statistical analyses

For the relationship between body length and period of culture, the equation $W = \beta_0 e^{\beta 1T} + e_i$ was applied, where β_0 and β_1 means parameters used in the model, T means culture period and e_i is an associate error for each observation.

In order to compare the growth between the sex-reverted and non sex-reverted fish, there was applied the statistic W, based on the likelihood process (MENDES, 1999), as follows:

$$W = (n_1 + n_2)\,Ln\left(\frac{SQres_{(1,2)}}{n_1 + n_2}\right) - n_1 Ln\left(\frac{SQres_{(1)}}{n_1}\right) - n_2 Ln\left(\frac{SQres_{(2)}}{n_2}\right)$$

The body length daily growth rate was obtained from the estimative parameter "β_1" of the growth model

(DBLGR=β_1(cm.day^{-1}), while daily growth rate of the body weight was obtained from the "$e^{\beta 1}$" value of the exponential model: **DBWGR = $e^{\beta 1}$** (% weight.day^{-1})**.**

RESULTS AND DISCUSSION

In experiment I, the initial average body length of the non-reverted and reverted fish was 7.0 and 7.4 cm, while the bodyweight was 6.7 and 8.2 g, for each respective group. At the end of the experiment, they reached 22.5 and 25.00 cm, and 308.0 and 363.4 g. The survival rate was 78.0 % for the non-reverted fish group and 91.0% for the reverted one, in average values (Table 1). The daily body weight growth rate was calculated as 4.11% ($e^{0.0403}$) for the reverted fish and 4.08% ($e^{0.04}$) for the non-reverted fish, showing small statistical difference (P < 0,05) between groups (Table 2, Figure 1).

The water temperature in the beginning of experiment I was 30° C (maximum value) during the month of May, but decreased afterwards down to 28°C in August, near the end of the raining season. The minimum value recorded at this time was 26°C (Figure 2).

Here, an eventual observation on the sex ratio and the non sex-reverted fish indicated that the number of male fish was much bigger than the female's. This information was reconfirmed by the following experiment.

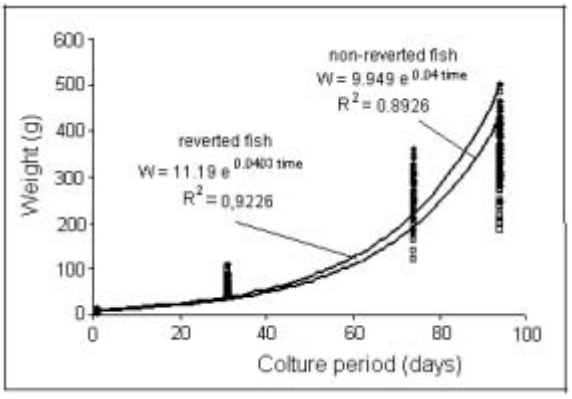

Figure 1 – Growth of sex-reverted and non sex-reverted tilapia fish raised in concrete tanks at CHESF Fish Farming Station from April to July, 2001 (Experiment I)

In experiment II, where only non sex-reverted fish were used, the sexual examination showed the

Table 1 – Data obtained from the rearing of sex reverted and non sex-reverted tilapia, Chitralada strain, in concrete/bottom earthen tanks at CHESF Fish Farming Station in 2001.

Parameters	Experiment I						Experiment II			
	non-reverted fish			reverted fish			non-reverted fish			
	R*$_1$	R$_2$	mean	R$_1$	R$_2$	mean	R$_1$	R$_2$	R$_3$	mean
Density (ind/m^2)	2	2	2	2	2	2	2	2	2	2
Initial fish number	100	100	100	100	100	100	100	100	100	100
Initial body length average (cm)	7.0	7.0	7.0	7.4	7.4	7.4	8.8	8.9	9.2	8.9
Initial bodyweight average (g)	6.7	6.7	6.7	8.2	8.2	8.2	13.5	14.7	17.5	15.2
Final body length average (cm)	22.6	22.4	22.5	25.3	24.8	25.0	25.4	26.5	25.4	25.7
Final bodyweight average (g)	229.9	316.1	308.0	375.2	351.6	363.4	388.0	451.7	394.0	411.2
Culture days	90	90	90	90	90	90	90	90	90	90
Survival rate (%)	75	81	78	96	86	91	88	85	80	84
Sexual ratios (%) male	-	-	-	-	-	-	66	73	78	72.3
Sexual ratios (%) female	-	-	-	-	-	-	34	27	22	27.7

R* means replication

Table 2 – Comparative statistical analyses between sex reverted and non sex-reverted tilapia fish raised in concrete tanks at CHESF Fish Farming Station, from April to July, 2001.

Fish group	Models	R^2	CS*
sex-reverted	$W = 11.19e^{0.0403time}$	0.9226	a
son-sex reverted	$W = 9.949e^{0.04time}$	0.8926	b

*CS = comparative statistics: different letters means statistic difference between the models

number of phenotypic males to be much bigger than the females; among 253 examined fish only 27.7% were females, against 72.3% of males (Table 1).

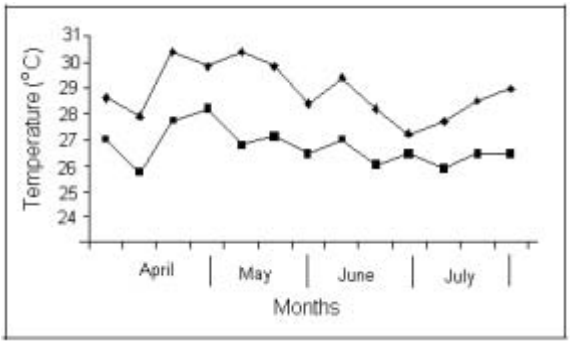

Figure 2 – Water temperature variation in the non sex-reverted tilapia fish from April to July, 2001. Triangular and square marks mean maximum and minimum water temperatures, respectively.

For the growth performance, the initial average in body length was 8.9 cm and 15.2 g in body weight. They reached 25.7 cm and 411.2 g, after the 90 days culture period. These non sex-everted fish grew more significantly when compared with those of experiment I (Table 3, Figure 3).

The water temperature at the end of the experiment was about 31.0° and 29.0° C, as for the maximum and minimum values, respectively (Figure 4). The average survival rate was 84.0 %.

The results from the fish reared in net-cages (experiment III) showed that the non-reverted fish grew from 34.0 g up to 790 g in only 130 days of culture, while the sexual reverted fishes grew from 25.0 g to 841 g, but in 155 days. Bigger values of body weight gain were observed in the class interval from 201-600 grams (Table 4, Figure 5). There was no statistic difference ($P > 0.05$) in daily body weight gain between the groups throughout the experiment. The water temperatures varied from 24 to 27° C, between May and October, 2001.

Tilapia has become one of the most important reared fish in Brazil and although commercial tilapia

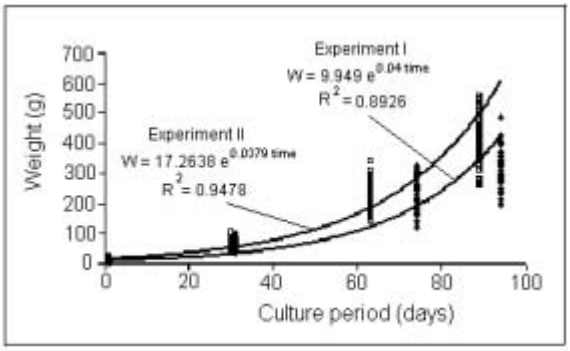

Figure 3 – Comparative growth of the non sex-reverted tilapia fish raised in concrete tanks at CHESF Fish Farming Station, in different rearing periods: April to July, 2001 (Experiment I) and September to December, 2001 (Experiment II)

the 1990s that it has been practiced in a large scale, especially in its northeastern region of the country, such as in Paulo Afonso City. In spite of the many investigations on the biology and farming of tilapia (PULLIN, 1982), a specific study on the comparative growth between the sex-reverted and non sex-reverted tilapia fish, Chitralada strain, reared in that region, was still unknown

It goes with saying that male tilapia fish grow much faster than female, and when fish are given sex steroid hormones during post-larval stages, sex can be changed into monosex populations, as it is desirable. However, the sex reversal technique with synthetic steroid hormones recently became questionable among scientists, since its intensive usage can cause some impact to the environment and native species (PANDIAN; SHEELA, 1995; BEARDMORE *et al*., 2001). Efforts must be made in order to avoid the use of sex-reversal by steroid hormones process in the tilapia culture.

According to the results obtained in the present work, reverted and non-reverted tilapia fish showed almost the same growth when reared in the concrete tanks. Although the growth of the two fish groups differed statistically, the daily body weight gain ratio between them was very small, so indicating a strong

Table 3 – Comparative statistical analyses between non sex-reverted fish groups raised in concrete tanks at CHESF Fish Farming Station from September to December, 2001

Non- reverted Fish group	Models	R2	CS*
experiment I	$W = 9.949e^{0.04time}$	0.8926	a
experiment II	$W = 17.2638e^{0.0379time}$	0.9478	b

*CS = comparative statistic: different letters means statistic difference between the models

Table 4 – Daily gain and mean body weights of reverted and non-reverted tilapia, Chitralada strain, raised in cages at Xingozinho fish farming ground from May to October, 2001.

Sampling (date/culture period)	Reverted fish weight (g)*	Sampling (date/culture period)	Non-reverted fish weight (g)*	Daily gain weight (g) (reverted fish)	Daily gain weight (g) (non-reverted fish)
May/29/2001	25.0	-	-	-	-
Jun/07/2001	40.0	Jun/23/2001	34.0	1.6	-
Jun/22/2001	67.0	Jul/17/2001	79.0	1.8	1.9
Jul/17/2001	160.0	Aug/01/2001	150.0	3.7	4.7
Aug/01/2001	248.0	Aug/18/2001	250.0	5.8	5.9
Aug/18/2001	394.0	Sep/05/2001	386.0	8.6	7.5
Sep/05/2001	536.0	Sep/21/2001	519.0	7.9	8.3
Oct/02/2001	740.0	Oct/02/2001	600.0	7.5	7.4
Oct/16/2001	790.0	Oct/16/2001	648.0	3.6	3.42
Oct/31/2001	841.0	Oct/31/2001	790.0	3.4	9.5
Culture days	155 days	Culture days	130 days	-	-

* Average velour's

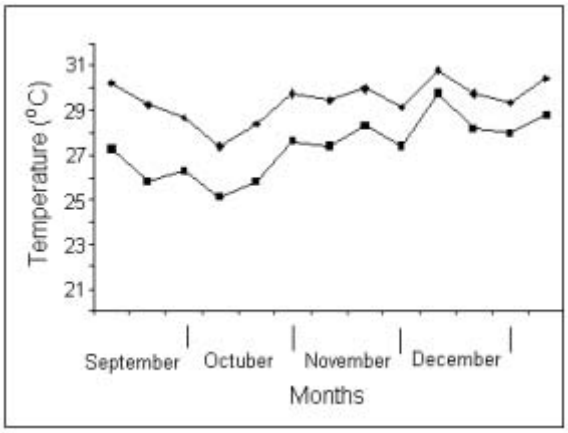

Figure 4 – Water temperature variation in the non sex-reverted fish group from September to December, 2001. Triangular and square marks mean maximum and minimum water temperatures, respectively.

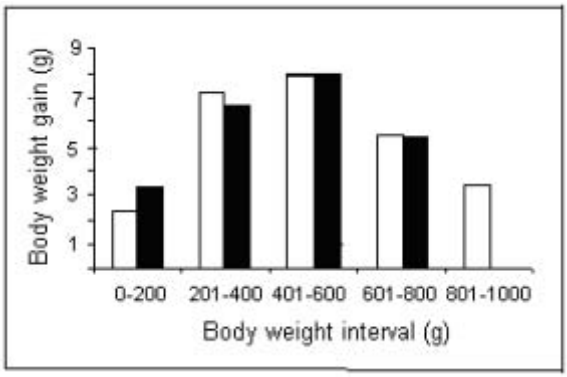

Figure 5 – Daily bodyweight gain of sex-reverted (white bar) and non sex-reverted tilapia fish (black bar) reared in cages at Xingozinho fish farming ground.

similarity on the growth performance. Non sex-reverted fish reared during September and December grew much faster than those (including, sex-reverted fish) reared between April and July. Since temperature can advance or retard physiological activities in tilapia (BARAS et al., 2001), the difference on growth performance between the groups can be explained by the difference of water temperature registered in the experiments, as it was hotter from September to December.

Similarly, non-reverted tilapia fish showed a rapid growth performance when reared in commercial net-cage farming. As shown in the comparative results, non sex-reverted tilapia fish can also reach a desirable commercial size in a period similar to the reverted ones.

Another important point observed in the present investigation was that the number of male fish was always much bigger than the female's, even among the non-reverted fish group. For tilapia, as in most teleost fish (DEVLIN; NAGAHAMA, 2002), sex-ratio can be influenced by some specific environmental factor, such as temperature, for instance, while salinity does not have any effect on sex determination. Low temperature does not cause any effect on the sex ratio, when it is applied during inappropriate periods but, when it is used during early life phases (before ten days of life), can promote feminization effects. High temperatures have induced masculine offspring in thermosensitive

tilapia fish (BAROILLER et al*.,* 2000); (BAROILLER; D'COTTA, 2001). Since the non-reverted fish used in the present experiments were all born in warm water, it seems that temperature brought about the predominance of males found among them, which in turn, promoted better growth performance in the concrete tanks and net-cages.

It has been shown that Tilapia Chitralada can reach the first maturation with different sizes (NOGUEIRA, 2003), classified into two length categories according to growth performance: big (40.0cm), and small (29.5 cm). This indicates that cross breeding among broods that show fast growth performance can provide offspring with rapid growth characteristics. Therefore, it can be concluded that besides the water temperature and the number of phenotypic males inside the populations, the origin of the offspring can also determine whether farming of non-reverted fish will succeed or not.

CONCLUSIONS

From the obtained results, it could be concluded that the use of steroid hormones in tilapia farming in Northeast Brazil should be of great concern, at least during the hottest periods of the year. Furthermore, besides the water temperature and the number of phenotypic males inside the populations, the origin of the offspring can determine whether the farming of non-reverted fish will succeed or not.

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