Recent Research in Science and Technology 2012, 4(11): 46-50
ISSN: 2076-5061
Available Online: http://recent-science.com/

# Comparative growth performance of mixed-sex and monosex Nile tilapia at various stocking densities during cage culture

**Suman Bhusan Chakraborty[1*] and Samir Banerjee[2]**

[1]Department of Zoology, Serampore College, Hooghly - 712201, West Bengal, India.
[2]Aquaculture Research Unit, Department of Zoology, University of Calcutta, India.

**Abstract**

Information related to impact of stocking density on growth performance of androgen-treated monosex Nile tilapia, *Oreochromis niloticus* during cage culture in West Bengal, India is limited. The aim of this study was to compare the growth potential of mixed-sex control and hormone-treated monosex tilapia at various stocking densities and to determine an ideal stocking density for cage culture of monosex fish. Mixed-sex control and 17α-methyltestosterone treated monosex tilapia were stocked separately in standing surface cages at different stocking densities (1, 5, 10, 15, 25, 50, 75 and 100 fish/$m^3$). At the end of 5-month culture period, the highest growth was observed in the 50 fish/$m^3$ groups for both the control and hormone treated categories. More over, the monosex androgen treated tilapia in each density class showed significantly higher (P-value < 0.05) weight, length and depth compared to mixed-sex fish in the corresponding density class. The survival rate of the fish did not alter significantly with hormone treatment but stocking density had significant effect (P-value < 0.05) on it. Thus, cage culture of hormone treated monosex tilapia at a density of 50 fish/$m^3$ may be considered ideal for augmented production of the fish under Indian context.

**Keywords:** Nile tilapia; Cage culture; Stocking density; Monosex.

## INTRODUCTION

In aquaculture, 'stocking density' should denote the concentration at which fish are initially stocked into a system. However, it is generally used to refer to the density of fish at any point of time. It is considered to be one of the important factors that affect fish growth, feed utilization and gross fish yield (Liu and Chang 1992). The full utilization of space for maximum fish production through intensive culture can improve the profitability of the fish farm. Fish intensification by increasing stocking density is also found suitable to overcome the problem of land shortage (Khattab et al. 2004). On the other hand, several studies have indicated an inverse relationship between the stocking density and growth rate of tilapia (Ridha 2006). Again, relationship between the survival of the fish and stocking density is not found consistent (El-Sayed 2002). In practice, the densities at which farmers keep their stock are based on experience and institution, with codes of practice and handbooks being used as a guide. Information regarding effect of stocking density on fish performance during intensive tilapia culture is limited, inconsistent and sometimes controversial (El-Sayed 2002). Thus, the ideal stocking density of the fish under the culture methods and ecological condition of the Indian subcontinent needs to be addressed in a coherent manner.

For many years, Nile tilapia (*Oreochromis niloticus*) has drawn attention of the farmers for their better growth performance. It is currently ranked second only to carps in global production (Ridha 2006). The efficiency of reproduction in tilapia has paradoxical consequences. This aptitude allows easy and rapid propagation of the fish in various environmental conditions, but can as well be a source of problem. Within a limited environment, uncontrolled multiplication of the fish not only reduces the faunal diversity of the system but also produces dwarf fish population of poor market value (Hepher and Pruginin 1981; Coleman 2001). Monosex culture of male tilapia was postulated to solve this problem and dietary supplementation of synthetic androgens was a potent method for production of all-male tilapia population (Smith and Phelps 2001).

Tilapia has been widely introduced in the shallow and seasonal ponds of eastern region of India. The fish can form a readily available source of animal protein in the diets of rural and urban dwellers belonging to the lower socioeconomic strata. Hence, new techniques for maintenance of high growth rate of tilapia are the need of the day. Considering these aspects, the present study aims to evaluate the comparative growth performance of the control mixed-sex and hormone treated monosex tilapia at various stocking densities and determine an ideal stocking density for tilapia culture under the climatic and ecological conditions prevailing in the Gangetic plains of West Bengal, India.

## MATERIALS AND METHODS

Initially, two groups (mean weight 0.025 ± 0.009 g; mean length 1.25 ± 0.012 cm) of 3 days old mixed sex juveniles of Nile tilapia *Oreochromis niloticus* (Linnaeus) were reared in glass aquaria for one month. During this period, one of the groups was given control diet at a rate of 20% body weight / day while the other was fed with 17α methyltestosterone (17αMT) treated diet with a dose of

Received: July 12, 2012; Revised: Oct 11, 2012; Accepted: Nov 24, 2012.

*Corresponding Author
Suman Bhusan Chakraborty
Dept. of Zoology, Serampore College, Serampore, Hooghly - 712201, West Bengal, India

Tel:+ 91-33-26622322; Fax: 91-33-26623816
Email: sumanbc76@gmail.com

10 mg/ kg at the same rate. Hormone treated diets were prepared by the alcohol evaporation technique (Shelton et al. 1978).

After one month, the control and androgen treated tilapia were transferred to separate 1 $m^3$ standing surface cages made of bamboo frames and nylon wires with a mesh size of 1.3 cm at eight different stocking densities (1, 5, 10, 15, 25, 50, 75 and 100 fry/$m^3$). The cages were equipped with covers to prevent fish losses from jumping or bird predation, placed in a large natural pond selecting an ideal location to allow sufficient water current and easy access for management practices and were separated from each other as well as the bottom substrate by enough distance to optimize water quality. The experiment was conducted in three replicating units and culture was continued for five months. During this period the fish were given control food (crude protein content 30% and total digestible energy 3000 ± 400 kcal/Kg food) made from a mixture of fine fish meal and rice bran, sieved to a size of less than 1 mm, at a rate of 10% body weight per day for the first two months and 5% per day for the rest three months. The total daily feed ration was divided into four equal portions. Throughout the entire culture period different water quality parameters like temperature, $DO_2$, free $CO_2$, pH, total alkalinity and turbidity were regularly monitored using the standard procedures of American Public Health Association (APHA 1998) and maintained within ideal value limits for all the culture systems. During the experimental period, water temperature was 30.5-31.2$^0$C, pH was 7.3-8.1, turbidity was 27.8-40.6 cm, alkalinity was 122.1-143.6 mg/l, $DO_2$ was 4.8-6.3 mg/l and free $CO_2$ was 2.8-7.6 mg/l. Fish from each cage were measured individually for weight, length and depth every 4 weeks and at the end of the culture period.

The data were expressed in terms of mean ± standard error (SE). One way ANOVA was performed to compare the survival percentage and growth of different density classes. When appropriate, Duncan's multiple tests (at 5%) (Duncan 1955) was applied to evaluate the differences among means and the statistically homogenous means were denoted by similar alphabets. But, two way ANOVA was applied to compare the growth parameters of different density classes for mixed-sex control and monosex androgen treated fish separately. Appropriate LSD test (at 5%) was performed to compare the interaction mean, if found significant.

## RESULTS

The survival percentage of the fish did not alter significantly with hormone treatment (Figure 1a) but stocking density had significant effect on it (Figure 1b). Fish survival was reasonably good till the density of 50 fry/$m^3$, but after that it decreased gradually and the density of 100 fry/$m^3$ had only ~60% survival rate (Figure 1b).

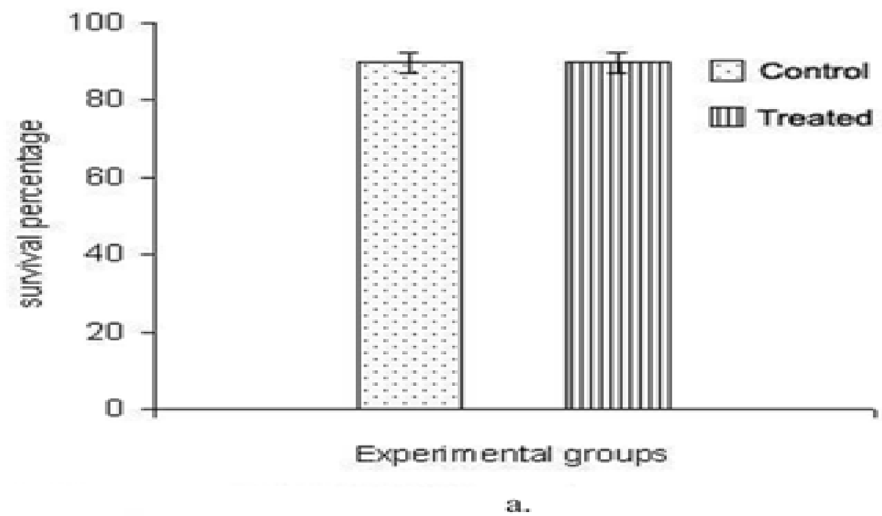



Fig 1a. Survival percentage of control and hormone treated fish.

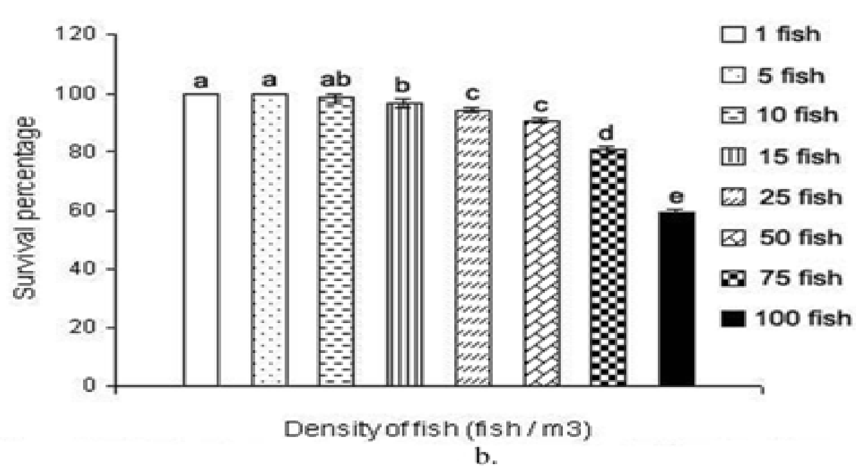


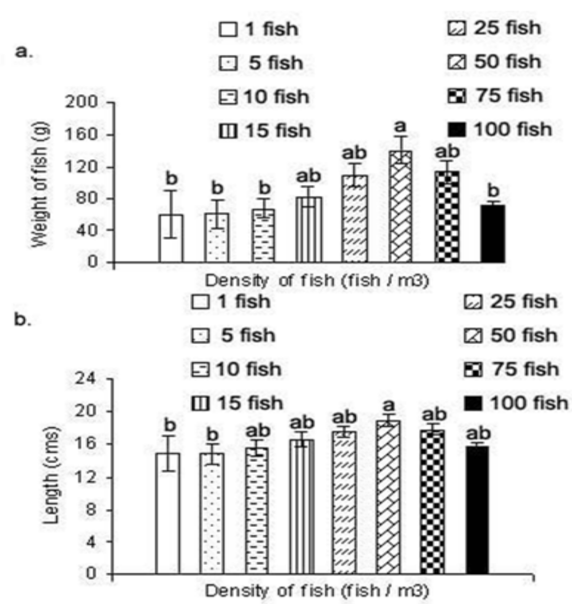

Fig 1b. Survival percentage of fish at different stocking densities. Similar alphabets denote homogenous means.

After one month of culture in the laboratory, the androgen-treated monosex fish grew significantly more (P-value < 0.05) compared to the hormone-untreated mixed-sex fish (Table 1). At the end of 5-month culture in cages, the final growth of all the density classes within monosex culture category was significantly more (P-value < 0.05) compared to the corresponding density classes under mixed-sex category (Table 1)

Table 1. Growth performances of mixed-sex control and monosex hormone treated tilapia at various stocking densities.

| Treatment category | Density classes | Weight (g) | | Length (cm) | | Depth (cm) | |
|---|---|---|---|---|---|---|---|
| | | 1 month | 5 months | 1 month | 5 months | 1 month | 5 months |
| Mixed-sex | 1 fish / m$^3$ | 5.8 ± 0.0 | 30.0 ± 0.0 | 7.6 ± 0.0 | 12.7 ± 0.0 | 2.3 ± 0.0 | 4.3 ± 0.0 |
| | 5 fish / m$^3$ | 5.95 ± 0.05 | 30.5 ± 0.5 | 7.9 ± 0.1 | 12.6 ± 0.1 | 2.6 ± 0.1 | 4.25 ± 0.05 |
| | 10 fish / m$^3$ | 5.55 ± 0.07 | 35.3 ± 0.23 | 7.55 ± 0.06 | 12.98 ± 0.1 | 2.5 ± 0.03 | 4.6 ± 0.08 |
| | 15 fish / m$^3$ | 5.76 ± 0.09 | 45.26 ± 0.17 | 7.66 ± 0.06 | 13.78 ± 0.06 | 2.46 ± 0.07 | 4.8 ± 0.04 |
| | 25 fish / m$^3$ | 5.7 ± 0.07 | 50.53 ± 0.16 | 7.65 ± 0.06 | 14.68 ± 0.04 | 2.79 ± 0.3 | 5.16 ± 0.04 |
| | 50 fish / m$^3$ | 5.7 ± 0.07 | 71.25 ± 1.95 | 6.89 ± 0.03 | 16.11 ± 0.9 | 2.09 ± 0.04 | 6.3 ± 0.05 |
| | 75 fish / m$^3$ | 5.7 ± 0.07 | 50.63 ± 0.18 | 7.65 ± 0.06 | 14.7 ± 0.06 | 2.78 ± 0.3 | 5.15 ± 0.05 |
| | 100 fish / m$^3$ | 5.69 ± 0.07 | 40.31 ± 0.13 | 7.66 ± 0.06 | 13.45 ± 0.04 | 2.52 ± 0.03 | 4.72 ± 0.03 |
| Monosex | 1 fish / m$^3$ | 13.0 ± 0.0 | 90.0 ± 0.0 | 9.1 ± 0.0 | 17.1 ± 0.0 | 3.4 ± 0.0 | 4.3 ± 0.0 |
| | 5 fish / m$^3$ | 12.5 ± 0.3 | 90.85 ± 0.35 | 8.6 ± 0.3 | 17.1 ± 0.1 | 2.95 ± 0.25 | 6.55 ± 0.05 |
| | 10 fish / m$^3$ | 12.55 ± 0.06 | 100.48 ± 0.26 | 8.5 ± 0.1 | 18.2 ± 0.07 | 2.85 ± 0.03 | 6.65 ± 0.06 |
| | 15 fish / m$^3$ | 12.52 ± 0.2 | 120.48 ± 0.19 | 8.6 ± 0.2 | 19.5 ± 0.07 | 2.9 ± 0.2 | 7.36 ± 0.1 |
| | 25 fish / m$^3$ | 12.5 ± 0.09 | 170.56 ± 0.14 | 8.5 ± 0.1 | 20.3 ± 0.07 | 2.86 ± 0.08 | 7.57 ± 0.07 |
| | 50 fish / m$^3$ | 12.5 ± 0.09 | 210.61 ± 0.14 | 9.18 ± 0.04 | 21.8 ± 0.08 | 2.87 ± 0.04 | 8.02 ± 0.08 |
| | 75 fish / m$^3$ | 12.5 ± 0.09 | 175.52 ± 0.19 | 8.52 ± 0.1 | 20.99 ± 0.09 | 2.86 ± 0.08 | 7.91 ± 0.08 |
| | 100 fish / m$^3$ | 12.51 ± 0.09 | 100.5 ± 0.16 | 8.54 ± 0.1 | 18.1 ± 0.06 | 2.86 ± 0.08 | 6.53 ± 0.04 |

Comparing the density classes in a combined manner for both the control and treated groups an interesting observation was found (Figure 2). The highest growth performance was observed in the density class of 50 fish/m$^3$ while other density classes both above and below this density had less growth potentials. For weight values, the lower density groups like 1, 5, 10 fish/m$^3$ and the highest density group of 100 fish/m$^3$ showed a homogenous growth rate that is significantly less than the growth performance of 50 fish/m$^3$ density class. The growth potentials of 15, 25 and 75 fish/m$^3$ belonged to both the higher and lower homogenous subsets (Figure 2a). Again, for length values, there were two homogenous subsets. Density group of 1 and 5 fish/m$^3$ belonged only to the lower subset while that of 50 fish fish/m$^3$ was placed only in the higher one. Rest of the density groups belonged to both the homogenous subsets (Figure 2b). On the other hand, for depth values, there were three homogenous subsets. Density group of 1 fish/m$^3$ belonged only to the lowest subset while that of 50 fish/m$^3$ was placed only in the highest subset. Density groups of 5, 10 and 100 fish/m$^3$ was placed both in the lower and intermediate homogenous subset while density groups of 15, 25 and 75 fish/m$^3$ belonged to the intermediate and the higher homogenous subsets (Figure 2c).



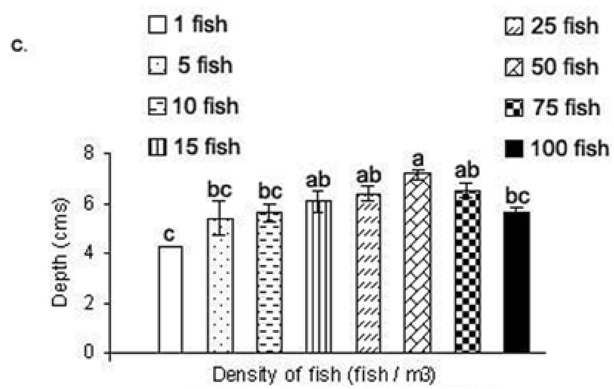



Figure 2

Fig 2. Growth performances (a. weight; b. length; c. depth) of tilapia at various mstocking densities. Similar alphabets denote homogenous means.

## DISCUSSION

The similar survival percentage of fish for both the mixed-sex and monosex categories indicates that hormone treatment has no adverse effect on general fish health. The mesh size and arrangement of cages provide adequate open space for good water circulation through the cage to renew the oxygen supply and remove waste. A few studies have demonstrated the enhanced yield of monosex male Nile tilapia populations under experimental conditions (Mair *et al.* 1995). In *Oreochromis mossambicus* (Peters, 1852) also, 17$\alpha$MT treated fish is reported to show higher growth compared to the untreated fish reared under similar conditions (Macintosh et al. 1985). Dan and Little (2000) observed that on average, monosex tilapia grew more than 10% faster than mixed-sex fish in cages. Several studies are in agreement that testosterone produces muscle hypertrophy by increasing muscle protein synthesis (Bhasin et al. 2001). The increased growth performance of the androgen treated fish may be analyzed considering this knowledge.

Stocking density is highlighted as an area of particular concern in the welfare of intensively farmed fish. Different authors had found limited effect of stocking density on fish survival and demonstrated that cannibalism could be a main cause of tilapia fry mortality at high stocking densities (El-Sayed 2002). According to our study, although the survival potency of the fish is inversely related with stocking density, it is not of important magnitude upto a particular optimum level. Stocking fish beyond such optimum level will cause a significant increase in fish mortality leading to reduced production. Moreover, the growth performance of tilapia is significantly related with the stocking density of the fish. The results of this study indicate that there is an inverse relationship between the density and growth potential of the fish when it is stocked at a very high density. But interestingly, at a very low density also the fish has a poor growth rate. The maximum growth of the fish is obtained at an intermediate stocking level (Figure 2) that also provides a reasonably well survival percentage. However, few studies have indicated better growth of Nile tilapia at comparatively lower stocking density than the present observation (Liu and Chang 1992) and subsequent analysis with a narrow range of stocking density classes with respect to the optimum density class obtained in the present study is required in this regard.

The negative correlation between growth rates and stocking density of fish fry has been postulated by a number of authors. Yi and Lin (2001) stated that increased fish biomass of Nile tilapia in cages had a significant negative effect on the final mean body weight. Diana et al. (2004) reported that sex reversed Nile tilapia stocked in ponds at a low density showed better growth than at a higher density. The lower growth performance of tilapia at higher stocking density could have been caused by voluntary appetite suppression, more expenditure of energy because of intense antagonistic behavioural interaction, competition for food and living space (Diana et al. 2004) and increased stress (Ouattara et al. 2003). Dambo and Rana (1992) reported that increasing stocking density of Nile tilapia fry might have lead to diminishing social dominance, resulting in lower individual growth rates. In addition, the resting plasma cortisol concentrations of Nile tilapia fingerlings were found to rise with increased stocking density (Barcellos et al. 1999). Such high cortisol concentration can be considered as a ‘chronic stress response’ attributed to ‘social stress’caused by increased density. This, in turn, leads to impaired fish growth, presumably due to the mobilization of dietary energy by the physiological alterations evoked by the stress response (Kebus et al. 1992). Furthermore, stress due to reduction in space availability was reported to be the primary factor for growth inhibition in other fish like Summer flounder (*Paralichthys dentatus*) stocked at high densities (King et al. 2000). Increase in stocking density may also cause deterioration in water quality, resulting in stressful conditions (Barton and Iwama 1991; Pankhurst and Van der Kraak 1997).

On the other hand, at the low stocking densities, lack of competition for food and/or social hierarchy can lead to decreased feed utilization efficiency resulting in stunted growth. Here, the difficulty of tracing food particles may have lead to the reduction of feed consumption, and to the flushing of uneaten food with the drainage water, causing the deterioration of feed utilization efficiency. Such wastage of feeding materials can increase the production cost to a great extent and the gross yield at such low densities is also small to compensate the cost. Hence, an optimum density level in terms of economic viability of tilapia culture must be established.

Finally, the major conclusions that can be articulated from the present study are: 1. The hormone treated males show higher growth rates than their control counterparts, 2. Additional advantages of larger fish and higher yields are gained through culture of such sex reversed fish, 3. Tilapia shows poor growth potential at very high and low stocking densities, 4. Culture of tilapia at density of 50 fish/$m^3$ shows the highest growth among all density classes. Thus, this study enables us to postulate an optimum stocking density level of tilapia for maximum utilization of food and space with minimum stress and energy expenditure resulting in higher growth potential of the fish.

## ACKNOWLEDGEMENTS

This work is financed by the University Grants Commission (Minor Research Project, No.F. PSW - 032/07-08). The first author is sincerely thankful to the Principal, Serampore College for providing necessary infrastructural support.

## REFERENCES

[1] APHA. 1998. Standard Methods for the Examination of Water and Wastewater. 20th edn. APHA (American Public Health Association), Washington, USA.

[2] Barcellos, L.G.J., Nicolaiewsky, S., de Souza, S.M.J. and Lulhier, F. 1999. The effects of stocking density and social interaction

on acute stress response in Nile tilapia (*Oreochromis niloticus*) (L.) fingerlings. *Aquaculture Research* 30: 887-892.

[3] Barton, B.A. and Iwama, G.K. 1991. Physiological changes in fish from stress in aquaculture with emphasis on the response and effects of corticosteroids. *Annual Reviews of Fish Diseases* 10: 3-26.

[4] Bhasin, S., Woodhouse, L. and Storer, T. W. 2001. Proof of the effect of testosterone on skeletal muscle. *Journal of Endocrinology* 170: 27-38.

[5] Coleman, R. 2001. Cichlids and Science: Bad Cichlids? *Cichlid News Magazine* 10(2): 32-34.

[6] Dambo, W.B. and Rana, K.J. 1992. Effects of stocking density on growth and survival of Nile tilapia *Oreochromis niloticus* (L.) fry in the hatchery. *Aquaculture and Fisheries Management* 23: 71-80.

[7] Dan, N.C. and Little, D.C. 2000. The culture performance of monosex and mixed-sex new-season and overwintered fry in three strains of Nile tilapia (*Oreochromis niloticus*) in northern Vietnam. *Aquaculture* 184: 221-231.

[8] Diana, J.S., Yi, Y. and Lin, C.K. 2004. Stocking densities and fertilization regimes for Nile tilapia (*Oreochromis niloticus*) production in ponds with supplemental feeding. Proceedings of the Sixth International Symposium on Tilapia in Aquaculture: 487-499.

[9] Duncan, D.B. 1955. Multiple range and multiple F tests. *Biometrics* 11: 1-42.

[10] El- Sayed, A.M. 2002. Effect of stocking density and feeding levels on growth and feed efficiency of Nile tilapia (*Oreochromis niloticus* L.) fry. *Aqaculture Research* 33: 621-626.

[11] Hepher and Pruginin. 1981. Commercial Fish Farming. John Wiley and Sons, New York. 291 pp.

[12] Kebus, M.J., Collins, M.T., Brownfield, M.S., Amundson, C.H., Kayes, T.R. and Malison, J.A. 1992. Effects of rearing density on stress response and growth of rainbow trout. *Journal of Aquatic Animal Health* 4: 1-6.

[13] Khattab, Y.A.R., Abdel-Tawwab, M. and Ahmad, M.H. 2004. Effect of protein level and stocking density on growth performance, survival rate, feed utilization and body composition of Nile tilapia fry (*Oreochromis niloticus* L.). Proceedings of the Sixth International Symposium on Tilapia in Aquaculture: 264-276.

[14] King, N.J., Howell, W.H., Huber, M. and Bengtson, D.A. 2000. Effects of stocking density on laboratory-scale production of summer flounder *Paralichthys dentatus*. *Journal of the World Aquaculture Society* 31: 436-445.

[15] Liu, K.M. and Chang, W.B. 1992. Bioenergetic modeling of effect of fertilization, stocking density, and spawning on growth of the Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management* 23: 291-301.

[16] Macinosh, D.J., Varghese, T.J. and Satyanarayana, G.P. 1985. Hormonal sex reversal of wild-spawned tilapia in India. *Journal of Fish Biology* 26(2): 87-94.

[17] Mair, G.C., Abucay, J.S., Beardmore, J.A. and Skibinski, D.O.F. 1995. Growth performance trials of genetically male tilapia (GMT) derived from YY-males in *Oreochromis niloticus* L.: On station comparisons with mixed sex and sex reversed male populations. *Aquaculture* 137: 313-322.

[18] Ouattara, N.I., Teugels, G.G., Douba, V.N. and Philippart, J.C. 2003. Aquaculture potential of the black-chinned tilapia, *Sarotherodon melanotheron* (Chiclidae). Comparative study of the effect of stocking density on growth performance of landlocked and natural populations under cage culture conditions in Lake Ayame (Cote d'Ivoire). *Aquaculture Research* 34(13): 1223-1229.

[19] Pankhurst, N.W. and Van der Kraak, G. 1997. Effects of stress on reproduction and growth of fish. In: Iwama, J.K. and Pickering, A.D. (eds) Fish stress and health in aquaculture, Cambridge university Press, Cambridge, pp. 73-93.

[20] Ridha, M.T. 2006. Comparative study of growth performance of three strains of Nile tilapia, *Oreochromis niloticus*, L. at two stocking densities. *Aquaculture Research* 37: 172-179.

[21] Shelton, W.L., Hopkins, K.D. and Jensen, G.L. 1978. Use of hormones to produce monosex tilapia for aquaculture. The Second International Symposium on Tilapia in Aquaculture. ICLARM Conference Proceedings 15: 10-33.

[22] Smith, E.S. and Phelps, R.P. 2001. Impact of feed storage conditions on growth and efficacy of sex reversal of Nile tilapia. *North American Journal of Aquaculture* 63(3): 242-245.

[23] Yi, Y. and Lin, C.K. 2001. Effect of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in an integrated cage-cum-pond system. *Aquaculture* 195: 253-267.