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# Effect of stocking densities on growth, production and survival rate of red tilapia in hapa at fish hatchery Chilya Thatta, Sindh, Pakistan

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**Abstract**

Effect of stocking density on growth, production and survival of red tilapia (*Oreochromis mossambicus* × *O. niloticus*) were conducted in *hapa* for 60 days at Chilya Thatta. Tilapia fry (4.5±0.02 cm, 2.0±0.01 g) were stocked into *hapa* (4.5x2.4x1 m). Three treatments with two replicates were used: $T_1$-200; $T_2$-250 and $T_3$-300 fry/*hapa*. Fry were fed twice a daily with pelleted feed containing 35% protein, 5% of total biomass. After 60 days, the highest growth were determined in $T_1$ (49.8±0.0 g) while in $T_3$ lowest growth (29.09±0.0 g) was recorded. Production (9.56, 10.13 and 8.12 kg/m$^3$/60days) in $T_1$, $T_2$ and $T_3$ respectively were significantly different ($P<0.05$) to each other. Feed conversion ratio of 0.48, 0.48 and 0.49 in $T_1$, $T_2$ and $T_3$, respectively not significantly different ($P>0.05$). Survival was significantly different among treatments ($P<0.01$). Highest survival (100%) was attained in $T_1$ with lower stocking density, followed by $T_2$ (98%) and $T_3$ (95%). Water quality parameters recorded throughout the study period were found within the ranges for fish culture such as temperature 27.2 to 28.5 °C, dissolved oxygen 5.8 to 6.4 mg/l, pH 6.9 to 7.6, ammonia from 0.45 to 0.51 mg/l, hardness 106 to 110 ppm and nitrite 0.151 to 0.162 mg/l.

**Keywords:** Stocking density, growth performance, survival, red tilapia, production, *hapa*

## INTRODUCTION

Aquaculture is rapidly gaining importance due to increase in human population and reduced natural fisheries resources. Pond aquaculture is growing fast in many Asian countries (Azim *et al.* 2003). Due to omnivore in feeding, survive in poor water quality, breed easily in confined different types of water body and cheap source of animal protein in human diet fish farmers consider tilapia into farming (Pillay 1990). Today, tilapia has become one of the most common farm raised fish in the world, after the carps in terms of total production (Watanabe *et al*. 2002).

Nile tilapia (*Oreochromis niloticus*), Mozambique tilapia (*O. mossambicus*) and blue tilapia (*O. aureus*) are the most commercially important species found in the genus *Oreochromis*. Red tilapia were first isolated in Taiwan by crossing of *O. niloticus* with a red *O. mossambicus*. They are presently produced in the United State of America, Philippines, Greece, Israel, Jamaica, India and other countries (Wohlfarth *et al.* 1990). Intensive culture of tilapias in concrete tanks is practiced in some Asian countries such as Taiwan, Malaysia and Philippines etc. Red tilapias are cultured in 100 $m^2$ octagonal tanks with exchange of water and aeration, with weighing of 100 to 200 g and with the densities 50 to 100/$m^2$. The growing popularity of tilapia among consumers and the always increasing need to improve production of food, execute the need to seek production alternatives to culture tilapia. Red hybrid tilapia are gaining popularity among culturists due to their resemblance to premium marine species such as sea bream *(Chrysophrys major)* and red snapper *(Lutjanus campechanus)* (Fitzgerald 1979, Liao and Chen 1983, Fassler 1984, Stickney 1986) and excellent growth and feed conversion rates in freshwater (Liao and Chen 1983). Production culture is conducted "extensively" in pond systems or more "intensively" in cages and tanks. Tilapia grows well at high densities in the confinement of tanks when good water quality is maintained. Tilapia fry can be produced in ponds, *hapas* and concrete tanks (Bautista 1987, AIT 1994). *Hapa* are commonly used in the Philippines (Santiago *et al.* 1985, Bautista 1987) and Thailand (Little *et al.* 1995, 1997; AASP 1996). A *hapa*-in-pond system, has been developed through intensive research efforts over the last decade (AASP 1996; Little *et al.* 1995, 1997; Bhujel *et al.* 1998). This involves spawning, rearing and culture of tilapia fish in large nylon *hapa* on fertilization and artificial feed in ponds this technology has been commercialized recently and proven to be economically viable (Little *et al.* 1997, Bhujel 1997). Acceptance of this technology is now taking place rapidly because of its ability to carry large quantities of good quality tilapia seed surely (Bhujel *et al.* 1998). Stocking density can influence seed production in tilapia culture conditions (Hughes and Behrends 1983, Guerrero and Guerrero 1985, Obi and Shelton 1988).The effect of various stocking densities and sex ratios on hatchery production of tilapia was reported in land-based (concrete tanks) and lake-based (*hapa* nets) systems (Bautista *et al.* 1988). Studies concerning the relationship between stocking density and growth of tilapia have shown that optimal stocking density for obtaining the highest possible fish yields depend upon the amount and the quality of food available (Zonneveld and Fadholi 1991). However, the use of high stocking density as a technique to maximize water usage and thus increase stock production has also been shown to have an adverse effect on growth (Trzebiatowski *et al.* 1981, Andrews *et al.* 1971, Refstie 1977, Essa and Nour 1988, Schreck *et al.* 1985).

The rate of stocking is decided based on the expected growth increment of fish species and production levels, provided with a given level of input (Liu and Chang 1992). It has been also investigated that fish stocked at higher stocking density reduced growth performance due to some factors. Stocking density is a key factor to achieve the optimum production because it is directly associated with physiological and physical parameters like, water quality, capacity, nutrition, and type of culturing system, biochemical stages (Islam *et al.* 2006). Stocking density is also found suitable to overcome the problem of land shortage (Ahmad *et al.* 2004). The full utilization of space for maximum fish production through intensive culture can improve the profitability of the fish farm. On the other hand, several studies have indicated an inverse relationship between the stocking density and growth rate of tilapia (Ridha *et al.* 2006). In practice, the densities at which growers keep their stock are based on knowledge and organization, with codes of practice and handbooks being used as a guide. Yet no information is available about of the Red Tilapia, hybrid (*O. mossambicus* × *O. niloticus*). Therefore Present study was conducted to observe the effect of different stocking densities on growth performance, survival and production rate so that this information can be transferred to the local fish farmers what is the optimal stocking density will be beneficial to get maximum production from minimum resources in Pakistani environment.

## METHODOLOGY

The study was conducted in six *hapa* (4.6×2.4×1.0 m) each were installed in a rectangular concrete pond size (15.24×7.62×1.2 m) with the help of rope and clips at Fish Hatchery Chilya Thatta, Sindh, Pakistan. Treatment replicates were randomly distributed to the *hapa* and stocked with red tilapia (hybrid) fry collected from the Chilya Hatchery and acclimatized for 5 days. After acclimatization, fry of red tilapia (mean initial weight, 2.0±0.01 g; and mean length 4.5±0.02 cm respectively) were reared for 60 days (June to July 2012) at three different stocking density groups of 19, 24 and 29 fish/$m^3$ corresponding to 200 ($T_1$), 250 ($T_2$) and 300 ($T_3$) fry per *hapa* (replicated twice). To prepare formulated feed from locally available ingredients such as fish meal, mustard oil cake (MOC), rice protein, rice bran, wheat bran, wheat flour and vitamin premix were ground thoroughly and sieved to pass through 0.5 mm mesh size. An experimental diet was formulated contain 35% protein. All ingredients were mixed together then put into the manually operated pellet machine for the preparation of pellet feed of diameter 1 mm. The composition of pellet feed is shown in (Table 1). The fish were fed thrice a day at 8:30 am, 12:30 pm and 4:30 pm with 5% of the biomass. Fish from each replicate treatment were randomly sampled and weighed fortnightly and released to the *hapa*. Their weights were taken with an electronic scale to the nearest 0.01 g after gently blotting with a towel. During sampling, 15% of the stocked fish in each *hapa* were scooped out with a scoop net and weighed individually and based on the weight gains feed was adjusted accordingly. After the sixty (60) days of culture period. All the fish in the *hapa* were weighed individually and the total number of fish in each *hapa* counted. Growth response and survival rate were calculated with following parameters (ANOVA followed by DNMRT 1995):

Weight Gain = Mean final weight – Mean initial weight

Daily Weight Gain = Fresh weight gain in fish (g) / Culture period (days)

Feed Conversion Ratio (FCR) = (Wet weight gain/Dry feed intake) x 100

Specific growth rate/day (SGR)= [(Log final weight – Log initial weight) × 100] / Culture period (days)

Survival rate (SR) = (Final number of fish/Initial number of fish) x 100

Condition factor (CF) = (final weight/final lenght$^3$) x 100

**Table 1:** Ingredients of formulated feed with 35 % gross protein level

| *Sl. No.* | *Ingredient* | *Protein (origin)* | *Amount %* | *Protein (%) contain* |
|---|---|---|---|---|
| 1. | Fish meal | 60 % | 28.5 | 17.1 |
| 2. | Rice protein | 42 % | 23.5 | 9.9 |
| 3. | Mustered oil cake | 30 % | 13 | 3.9 |
| 4. | Rice bran | 13 % | 13 | 1.7 |
| 5. | Wheat bran | 12 % | 16 | 1.9 |
| 6. | Wheat flour (as binder) | 10 % | 5 | 0.5 |
| 7. | Salt + vitamin and mineral Premix | | 1 | |
| | ***Total*** | | ***100 %*** | ***35.0*** |

The water quality parameters such as temperature, pH, dissolved oxygen (DO), alkalinity, ammonia, hardness and nitrite were monitored daily throughout the experimental period. Water temperature of the tanks was measured with the help of thermometer (G H ZEAL LTD-LONDON-ENGLAND). Water oxygen of the tanks was measured by using an oxygen meter (JENWAY 9500 DO2 Meter). A pH meter (EZDO-6011 CE) was used to measure the pH of water. API $NH_4^+/NH_3$ ammonium test kit was used to determine the values of ammonia and nitrite. Hardness was determined by Hanna (HI3812) Hardness Kit. All analyses were done in the laboratory of fish hatchery Chilya Thatta.

***Statistical Analysis:*** One way analysis of variance (ANOVA) was used to determine the effects of stocking density on the growth and survival rate of Red Tilapia (Hybrid). This was followed by Duncan's New Multiple Range Test (DNMRT), (Duncan 1995) at 5% level of significance to study any difference among treatment means.

## RESULTS

The growth parameters of red tilapia (hybrid) in different treatments in terms of mean weight gain, weight gain, daily weight gain, SGR, FCR, survival (%) production (kg/m$^3$/60 days) and total yield (kg) were calculated and are presented in Table 2 and Figure 1. Growth of red tilapia in *hapa* indicated that the growth rate varied among different treatments. $T_1$ showed significantly ($P$<0.05) highest growth rate among the treatments. The net length and weight gain of individual fish in $T_1$ was higher (15.95 cm and 47.8 g) than those of $T_2$ (14.47 cm and 42.5 g) and (12.1 cm and 29.09 g) in $T_3$ respectively. The survival and specific growth rates were also found highest in $T_1$ (100% and 1.69 respectively) followed by $T_2$ (98% and 1.64), while significantly ($P$<0.05) lowest survival rate and SGR was recorded (95% and 1.46) in $T_3$. The daily weight gain was 0.83 in $T_1$, 0.74 in $T_2$ and 0.52 in $T_3$, FCR was more or less same in all treatments, 0.48 in $T_1$, 0.48 in $T_2$, and 0.49 in $T_3$ respectively. Table 2 shows that the values obtained for feed conversion ratio were not significantly different among treatments ($P$>0.05). Total production of red tilapia was 10.13, 9.56 and 8.12 kg/m3/60 days in $T_2$, $T_1$ and $T_3$ respectively. Overall production of $T_2$ and $T_1$ was significantly higher than $T_3$.

**Table 2:** Comparison of growth parameters of red tilapia on different stocking densities at fish hatchery Chilya Thatta

| *Parameters* | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Mean initial weight (g) | 2.0±0.09 | 2.0±0.05 | 2.01±0.1 |
| Mean final weight (g) | 49.8±3.8 | 44.51±2.9 | 31.1±1.9 |
| Mean initial length (cm) | 4.52±0.22 | 4.55±0.08 | 4.55±0.11 |
| Mean final length (cm) | 15.95±0.41 | 14.47±0.33 | 12.13±0.19 |
| Weight gain | 47.8±0.07 | 42.5±0.05 | 29.09±0.06 |
| DWG | 0.83±0.01 | 0.74±0.02 | 0.52±0.01 |
| SGR | 1.69±0.02 | 1.64±0.01 | 1.46±0.02 |
| Feed conversion ratio | 0.48±0.01 | 0.48±0.01 | 0.49±0.01 |
| Survival rate (%)** | 100±0.0$^b$ | 98±0.3$^{ab}$ | 95±0.1$^b$ |
| Condition factor | 1.2±0.01 | 1.5±0.02 | 1.7±0.01 |
| Fish production (kg/m$^3$)* | 9.56±0.04$^a$ | 10.13±0.01$^b$ | 8.12±0.02$^{ab}$ |
| Total yield (kg)* | 9560±0.7$^a$ | 10125±0.3$^b$ | 8124±0.2$^{ab}$ |

*Values having a different superscripts are significantly different (*P<0.05; **P<0.01)*

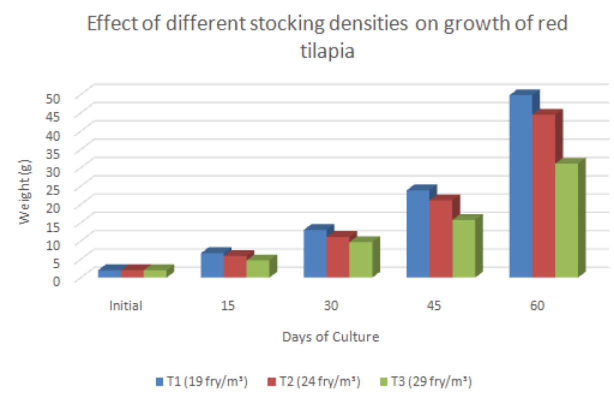


**Figure 1:** Weight gain of Red tilapia on three treatments during 60 days study period

The mean values of the water parameters are shown in Table 3. All water quality parameters measured had no significant differences among treatments ($P$>0.05). Mean temperature ranged from 27.2 to 28.5 °C. Concentrations of dissolved oxygen ranged from 5.9 to 6.4 mg/l, pH from 6.9 to 7.6 mg/l, ammonia from 0.42 to 0.50 mg/l, hardness 106 to 110 ppm and nitrite from 0.151 to 0.162 mg/l. Water parameters were within tolerable range throughout the experimental period.

**Table 3:** Showed month-wise variation in water quality parameters in *hapa* throughout the study period

| ***Treatments*** | ***Parameters*** | | | | | |
|---|---|---|---|---|---|---|
| | ***Temperature (°C)*** | ***DO (mg/l)*** | ***pH*** | ***Ammonia (mg/l)*** | ***Hardness (ppm)*** | ***Nitrite mg/l*** |
| $T_1$ | 27.20±0.20 | 6.4± 0.11 | 6.9± 0.15 | 0.45± 0.03 | 106±2.0 | 0.151± 0.005 |
| $T_2$ | 28.00±0.17 | 5.8± 0.25 | 7.4± 0.20 | 0.48± 0.02 | 110±2.6 | 0.157± 0.002 |
| $T_3$ | 28.50±0.14 | 5.9± 0.26 | 7.6± 0.15 | 0.51± 0.03 | 108±2.4 | 0.162± 0.004 |

## DISCUSSION

The effect of stocking density on growth and survival of red tilapia was conducted and observed that the growth performance of fry in *hapa* varied on different stocking densities. $T_1$ showed significantly highest growth among the treatments ($P$<0.05). The net length and weight gain of individual fish in $T_1$ was higher than those of $T_2$ and $T_3$ respectively. These results match with the findings of (Haque *et al.* 1984, Kawamoto *et al.* 1957) who achieved best growth at lower stocking densities. It is well-known fact that growth rate progressively increases as the stocking density decreases and vice-versa. This is because a relatively less number of fish of similar size in a pond could get more space, food, less competition and dissolved oxygen etc. reported by various authors (Johnson 1965, Wiener and Hameman 1982, Haque *et al.* 1984, Irwin *et al.* 1999, Ahmed 1982, Benetti *et al.* 2002, Narejo *et al.* 2005 and 2010, Hanibal *et al.* 2011).

The percentage of survival as recorded in the present study was 100, 98 and 95% for $T_1$, $T_2$ and $T_3$ respectively these results are similar with the findings of (Maniruzzaman 2001, Sayeed *et al.* 2008, Cremer *et al.* 2002). Survival was found to be negatively influenced by stocking densities. It might be due to the high competition and space among the fishes. Lower density gave larger size and higher survival rate in *Clarias macrocephalus* reported by Mollah (1985). Lower stocking density showed higher survival of *C. angullaris* reported by Ita *et al*. (1989). Survival rates were higher in the larvae of *C. batrachus* raised at the stocking densities of 2, 4 and 8 fish per liter as compared to those obtained 16 fish/liter reported by Barua (1990). The highest weight gain and survival rate of *Heteropneustes fossilis* in lower stocking density reported by Narejo *et al.* (2005 and 2010), highest weight gain and survival rate of *Trachinotus blochii* on lower stocking density was reported by (Hanibal *et al.* 2011). Fish production rate were found higher in $T_2$ followed by $T_1$ and $T_3$ was recorded significantly ($P$<0.05) lower production rate. It might be due higher numbers of fry stocked (250 fry/*hapa*) and proper feed intake within the space. The present result agreed with the findings of (Mollah 1985, Ita *et al.* 1989, Barua 1990, Narejo *et al.* 2005 and 2010, Hanibal *et al.* 2011) they obtained the highest production from higher stocking density.

The negative correlation between growth rates and stocking density of fish fry has been claimed by a number of authors. It was observed that increased fish biomass of tilapia had a significant negative effect on the final mean body weight (Yi and Lin 2001). Tilapia stocked at a low density showed better growth than at a higher density (Diana *et al.* 2004). The lower growth performance of tilapia at higher stocking density could have been caused by voluntary appetite dominance, more expenditure of energy because of intense aggressive developmental contact, competition for food and living space (Diana *et al.* 2004), and increased stress (Ouattara *et al.* 2003). It was also reported that increasing stocking density of Tilapia fry might have lead to falling social supremacy, resulting in lower individual growth rates (Dambo and Rana 1992).

The water quality parameters were recorded throughout the study period and were within the acceptable ranges for fish culture as reported by (Barua 1990; Narejo *et al.* 2003, 2005 and 2010; Hannibal 2011; Shah *et al.* 2014). The results of the present study indicated that a stocking density of (250 fry/*hapa*) might be suitable for the culture of red tilapia (hybrid) in *hapa* on artificial feed give optimal growth.

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## REFERENCES

AASP (1996) Final Report: ODA Support for Aquaculture at the Asian Institute of Technology, Dec. 1992–May 1995 and Aquaculture Support Project _Jun.–Nov. 1995. Agricultural and Aquatic Systems Program, School of Environment, Resources and Development, Asian Institute of Technology, 126 pp.

Ahmad MH, Abdel-Tawwab M and Khattab YAE (2004) Effect of dietary protein levels on growth performance and protein utilization in Nile tilapia (*Oreochromis niloticus*) with different initial body weights. In: The sixth international symposium on tilapia in aquaculture, Manila, Philippine. pp. 249-263.

Ahmed GU (1982) Intensive culture of *Labeo rohita* (Hamilton) in floating ponds with special reference to different stocking, M. Sc. Thesis, Department of Fisheries Biology and Limnology, Bangladesh Agricultural University, Mymensingh, Bangladesh. 38 pp.

AIT (1994) Partners for development, the promotion of sustainable aquaculture. AIT Aquaculture, Asian Institute of Technology, Bangkok, Thailand. 98 pp.

Andrews JW, Knight LH, Page, Mastuda JW and Brown EE (1971) Interactions of stocking density and water turnover on growth and food conversion of channel catfish reared in intensively stocked tanks. The Progressive Fish-Culturist 33(4): 197- 203. DOI: 10.1577/1548-8640(1971)33[197:IOSDAW]2.0.CO;2

Azim OME, Verdegem MCJ, Singh M, van AA, Dam and Beveridge MCM (2003) The effect of periphyton substrate and fish stocking density on water quality, phytoplankton, periphyton and fish growth. Aquaculture Research 34(9): 685-695. DOI: 10.1046/j.1365-2109.2003.00867.x

Barua G (1990) Gonadal development and fry rearing of *Clarias batrachus*, Ph.D. thesis submitted to the Dept. of Fisheries Biology and Limnology, Bangladesh Agricultural University, Mymensingh, Bangladesh. 310 pp.

Bautista AM (1987) Tilapia hatchery and nursery systems, operation and management, pp. 9-13. In: Guerrereo III RD, Guzman DL, Lantican CM (Eds.), Tilapia Farming. Proceedings of of the First National Symposium and Workshop on Tilapia Farming. November 24-26, PCARRD, BFAR and SEAFDEC Aquaculture Department. Los Banos, Laguna. PCARRD Book Series No. 48. 68 pp.

Bautista AM, Carlos MH and Son Antonio AI (1988) Hatchery production of *Oreochromis niloticus* (L.) at different sex ratio and stocking densities. Aquaculture 73(1-4): 85-89. DOI: 10.1016/0044-8486(88)90043-9

Benetti DD, Matera JA, Stevens OM, Alarcon JF, Feeley MW, Rotman FJ, Minemoto Y, Banner-Stevens G, Fanke J, Zimmerman S and Eldridge L (2002) Growth, survival, and feed conversion rates of hatchery reared mutton snapper, *Lutjanus analis* cultured in floating net cages. Journal of the World Aquaculture Society 33(3): 349-357. DOI: 10.1111/j.1749-7345.2002.tb00511.x

Bhujel RC (1997) A new record! Tilapia fry sale reached nearly 10 million a month. AASP Newsletter. 2-4. 16.

Bhujel RC, Little DC and Turner WA (1998) Quality monitoring of sex-reversed tilapia fry. Fish Farmer September October issue. pp. 34-37.

Cremer MC, Jian Z and Enhua Z (2002) Pangasius catfish production in ponds with soy-Based Feeds American Soybean Association, URL: http://www.soyaqua.org/pdf2/02.

Dambo W Band and Rana KJ (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.

Diana JS, Yi Y and Lin CK (2004) Stocking densities and fertilization regimes for Nile tilapia (*Oreochromis niloticus*) production in ponds with supplemental feeding, in Proceedings of the Sixth International Symposium on Tilapia in Aquaculture, R. Bolivar, G. Mair and K. Fitzsimmons, Eds. Manila, Philippines, BFAR, Philippines pp.487-499.

Essa MA and Nour AM (1988) Effect of stocking density and supplementary feeding on growth rate, food utilization and cost of tilapia hybrid production (*Oreochromis niloticus* X *O. aureus*) in cages. Proc.lst Conf. Develop. Fish. Res. Alexandria, Egypt, 6-8 August pp. 75-82.

Fassler R (1984) Golden Tilapia The catch of tomorrow. Hawaii Fishing News 9(3): 24-25.

Fitzgerald WJ (1979) The red orange tilapia, a hybrid that could become a world favourite. Fish Farming International 6(1): 26 - 27.

Guerrero III RD, Guerrero LA (1985) Further observations on fry production of *Oreochromis niloticus* in concrete tanks. Aquaculture 47(2-3): 257-261. DOI: 10.1016/0044-8486(85)90072-9

Hannibal MC, Amparo LF and Aurelio AC (2011) Effect of Stocking Density on Growth Performance, Survival and Production of Silver Pompano, *Trachinotus blochii* (Lacépède, 1801) in Marine Floating Cages. Asian Fisheries Science 24:321-330.

Haque MM, Islam MA, Ahmed GU and Haq MS (1984) Intensive culture of java tilapia (*Oreochromis mossumbica*) in floating pond at different stocking density. Bangladesh Journal of Fisheries 7: 55-59.

Hughes DG and Behrends LL (1983) Mass production of *Tilapia nilotica* seed in suspended net enclosures. In: Fishelson L, Yaron Z (Eds.), Tilapia Aquaculture. Proceedings of the International Symposium on Tilapia Aquaculture, Israel Tel Aviv University, Nazareth pp. 394-401.

Irwin S, Halloran JO and Fitzgerald RD (1999) Stocking density, growth and growth variation in juvenile turbot, *Scophthalmus maximus* (Rafineseque). Aquaculture 178: 77-88.

Islam AM, Das DR, Khalequzzaman SM, Kamal D and Abdul Halim KM (2006) Extensive culture of red tilapia with four stocking densities at Beel Kodalia, Bagerhat, Bangladesh. Pakistan Journal of Biological Sciences 9(10): 1965-1969. DOI: 10.3923/pjbs.2006.1965.1969

Ita EO, Madu CT, Omorinkoba WS and Pandogari A (1989) Preliminary estimator of the survival rate of *Clarias angullaris* fry under outdoor hatchery management system. Annu. Rep. Natl. Inst. Fish. Res. (Nigeria), 88-94.

Johnson WE (1965) On mechanism of self-regulation of population abundance in *Oncorhynchus nerca* Mitt. Int. Verin. theor. Angew. Limnol., 13: 66-87.

Kawamoto NY, Inoye Y and Nakanishi S (1957) Studies on the effects by the pond areas and densities of fish in the water upon the growth rate of carp (*Cyprinus carpio* L). Rep. Faculty Fish. Prefect. Univ. Mic 2: 437-447.

Liao IC and Chen TP (1983) Status and prospects of tilapia culture in Taiwan. pp. 588-598. In: Fishelson L and Yaron Z (compilers) Proceedings of the International Symposium on Tilapia in Aquaculture, Nazareth, Israel 8-13.

Little DC, Lin CK and Turner WA (1995) Commercial scale tilapia fry production in Thailand. World Aquaculture 26(4): 20-24.

Little DC, Turner WA and Bhujel RC (1997) Commercialization of a hatchery process to produce MT-treated Nile tilapia in Thailand. pp. 108–118. In: Alston DE, Green BW, Clifford HC (Eds.) IV Symposium on aquaculture in Central America: focusing on shrimp and tilapia, 22–24 April 1997, Tegucigalpa, Honduras, Asociacion Nacional de Acuicultores de Honduras and the Latin American Chapter of the World Aquaculture Society. 237 pp.

Liu KM and Chang WB (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.

Maniruzzaman M (2001) Polyculture of *Pangsius sutchi* with carps at a fish farm of Saleque Enterprize, Namopara, Rajshahi, MS Thesis, Department of Fisheries, RU, Rajshahi, 49 pp.

Mollah MFA (1985) Effects of stocking density and water depth on the growth and survival of freshwater catfish, *Clarias macrocephalus* Gunther larvae. Indian Journal of Fisheries 32: 1-17.

Narejo NT, Dayo A, Dars BA, Mahesar H, Laghari MY and Lashari PK (2010) Effect of stocking density on growth and survival rate of *Labeo rohita*

(Hamilton) fed with formulated feed. Sindh University Research Journal (Sci. Ser.) 42(1): 35-38.

Narejo NT, Rahmatullah SM and Mamnur Rashid M (2003) Effect of different feeds on growth, survival and production of freshwater mud eel, Monopteruscuchia(Hamilton) reared in cemented cisterns. Indian Journal of Fisheries 50 (4): 473-477.

Narejo NT, Salam MA, Sabur MA and Rahmatullah SM (2005) Effect of stocking density on growth and survival of indigenous catfish, *Heteropneustes fossilis* (Bloch) reared in cemented cisterns fed on formulated feed. Pakistan Journal of Zoology 37 (1): 49-52.

Obi A and Shelton WL (1988) Effects of broodstock density on fry production in *Oreochromis hornorum* (Trewavas). Journal of Aquaculture in the Tropics 3: 107-110.

Ouattara NI, Teugels GG, Douba VN and Philippart JC (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.

Pillay TVR (1990) Aquaculture. Principles and Practices. University Press, Cambridge. Fishing News Books. Proceedings of the Fifth International Symposium on Tilapia in Aquaculture (eds. Fitzsimmons K and Filho JC), Rio de Janeiro, Brazil 2: 341-345.

Refstie T (1977) Effect of density on growth and survival of rainbow trout. Aquaculture 1: 329-334.

Ridha MT (2006) Comparative study of growth performance of three strains of Nile tilapia, *Oreochromis niloticus*, L. at two stocking densities. Aquaculture Research 37: 172-179.

Santiago CB, Aladaba MB, Abuan EF and Laron MA (1985) The effects of artificial diets on fry production and growth of *Oreochromis niloticus* breeders. Aquaculture 47: 193-203.

Sayeed MAB, Hossain GS, Mistry SK and Huq KA (2008) Growth performance of Thai pangus (*Pangasius hypophthalmus*) In polyculture system using different supplementary feeds. University Journal of Zoology, Rajshahi University 27: 59-62.

Schreck CB, Pating R, Pring CK, Winto JR and Holway JE (1985) Effect of rearing density on indices of smoltification and performance of coho salmon (*Oncorhynchus kisutch*). Aquaculture 45: 345-358.

Shah SA, Malik A, Kalhoro H and Kalhoro IB (2014) Growth performance of exotic catfish Pangas, *Pangasius hypophthalmus* (Sauvage, 1878) at Fish Hatchery Chilya Thatta, Sindh, Pakistan. Sindh University Research Journal (Sci. Ser.) 46(2): 205-208.

Stickney RR (1986) A review of tilapia salinity tolerance. Progressive Fish-Culturist 48:161-167.

Trzebiatowski R, Filipiak J and Jakubowski R (1981) Effect of stock density on growth and survival of rainbow trout (*Salmo gairdneri*, Richardson). Aquaculture 22: 289-295.

Watanabe WO, Losordo TM, Fitzimmons K and Hanley F (2002) Tilapia production systems in the Americas: Technological advances, trends and challenges. Reviews in Fisheries Science 10: 465-498.

Wiener JG and Hameman WR (1982) Growth and Condition of Bluegills in Wisconsin Lakes, Effects of Population Density and Lake Ph. Transition of the American Fishery Society 111: 761-767.

Wohlfarth GW, Rothbard S, Hulata G and Szweigman D (1990) Inheritance of red body coloration in Taiwanese tilapias and in *Oreochromis mossambicus*. Aquaculture 84: 219-234.

Yi Y and Lin CK (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(3-4): 253-267. DOI: 10.1016/S0044-8486(00)00558-5

Zonneveld N and Fadholi R (1991) Feed intake and growth of red tilapia at different stocking densities in ponds in Indonesia. Aquaculture 99: 83-94.