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Effects of stocking density on growth and production performance of Monosex male tilapia (*Oreochromis niloticus*) in earthen ponds

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Abstract
To assess the effects of stocking density on growth and production of monosex male tilapia (*Oreochromis niloticus*) in ponds, an experiment was carried out during the period of two months from March to May 2015. Three stocking densities used were 50, 100 and 150 fish/decimal and designated as T1, T2 and T3, respectively with three replications. Fish were fed with commercial pelleted feed containing 30% crude protein. After two months, the growth performance was evaluated by comparing mean final body weight and specific growth rate (SGR). The result of the present study showed that, the fish in T1 stocked at the rate of 50 fish/decimal resulted the best individual weight gain (35.97g) followed by T2 (34.27g) and T3 (32.13g), respectively. The SGR ranged between 8.77 and 8.95%. There was no significant variation (P<0.01) among the survival rate (%) which ranged from 74.56 to 78%. The production was 1.40, 2.58 and 3.59kg/decimal in T1, T2 and T3, respectively. But the highest production of 3.59kg/decimal was obtained in T3 with stocking of 150 fish /decimal due to higher stocking density. Although the highest production was obtained in T3 but individually growth performance of monosex male tilapia was higher in T1. Based on the result of present experiment, farmers could be suggested to rear tilapia (*O. niloticus*) at lower stocking density (50 fish/dec) to get higher growth and survival in a short period of time.

Keywords: Stocking density, Growth, Production, Monosex male tilapia.

1. Introduction
Plenty the fisheries sector plays an important role in the agro-based economy of Bangladesh, through providing food and nutrition, alleviating poverty, creating employment opportunities and earning foreign exchange. Fisheries sector contributes 4.43% to the national GDP and 22.21% to the total agricultural GDP. The country's export earnings from this sector are 2.73% in 2010-11. Fish alone is supplementing about 60% of animal protein in our daily dietary requirement. The average growth rate of this sector during the last three years was 6.11%. About 10% of the total population is directly or indirectly employed in fisheries sector. Fisheries of Bangladesh have immense prospects and scope of development [1]. Tilapia is the common name applied to three genera of fish in the family Cichlidae, *Oreochromis, Sarotherodon* and tilapia which are widely distributed in many countries of the world. Now it can be found in more than 100 countries [2]. The Species those are most important for aquaculture is in the genus *Oreochromis*, including the Nile tilapia (*O. niloticus*), the Mozambique tilapia (*O. mossambicus*) and the blue tilapia (*O. aureus*). The introduction of tilapia in Bangladesh from Thailand was first initiated in 1954 with *T. mossambicus* [3] and later in 1974, high yielding species of tilapia (*O. niloticus*) was introduced by UNICEF [4]. with a hope that it would make a significant contribution to fish production but the attempt was not successful because of very little efforts were made to understand the culture management by the farmers. Bangladesh Fisheries Research Institute (BFRI) again brought a fresh batch of *O. niloticus* from Thailand in 1987 and developed low input and low cost technologies. Tilapia has good resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, ability to convert efficiently the organic and domestic waste into high quality protein, rapid growth rate and tasty flavor [5]. Tilapia can tolerate dissolved oxygen concentration of 1 mg/L and can survive by using atmospheric oxygen when dawn DO concentration dropped to less than 1 mg/L [6].

It has also the ability to survive under extremely low dissolved oxygen by reducing activity [6]. Tilapia production is increasing rapidly in Asia, with an average annual growth rate of 10%, during 1989 to 1999. The People's Republic of China, Indonesia, Malaysia, the Philippines, Srilanka, Thailand, Taiwan and Vietnam, account for most tilapia production in Asia and its production is increasing rapidly in Bangladesh. Bangladesh has increased its production at a tremendous rate in recent years. In 2002 the production was under 10,000 mt and by 2012 it had surpassed 100,000 mt.

However, tilapia culture has expanded rapidly during the last decade as a result of technological advancement associated with the intensification of culture practices. These include the development of new strains and hybrids, monosex male tilapia culture, formulated diets, a variety of semi-intensive and intensive culture systems and utilization of greenhouses, geothermal, or industrial waste and advanced water treatment methods. Fish farms raise tilapia in ditches, ponds, cages, pens and concrete tanks, depending on the nature of their farmland and on their capacity to invest. The use of monosex male tilapia is intrinsically desirable in a variety of fish species in a range of aquaculture production systems. The potential advantages sought from their use may include one or more of the following features: achievement of higher average growth rate, elimination of reproduction, reduction of sexual/territorial behavior, production variation in harvest size and reduction of risk of environmental impact resulting from escapes of exotic species. Fish as a group have systems of sex determination which are of considerable biological interest and significance for studies in evolutionary biology. However, they are very variable, relatively poorly understood and give rise to much variation in sex ratio between and within species enough is known, however, to enable us to say that these systems are often employed in ways which sharply distinguish the fishes from groups such as mammals, birds and reptiles. As a consequence manipulations of sexual phenotype designed to produce monosex populations are not straightforward and the results are not necessarily predictable. At this initial stage of monosex male tilapia farming the farmers must have adequate information about a proper stocking density to serve their purpose. With this point of view, the present research has been designed primarily to understand some practical information on different stocking density including feeding with formulated diet. The main objectives of the research were to study the effect of stocking density on the growth and production performance of monosex male tilapia in ponds and to determine the suitable stocking density for culture of monosex male tilapia in ponds.

2. Methodology

2.1 Pond selection and preparation

The experiment was carried out for a period of two months from 14 March to 18 May 2015 to evaluate the effects of stocking density on growth and production of monosex male tilapia in nine experimental ponds situated in the Field Laboratory Complex, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The area of each pond was 2 decimal with an average depth of 1.2 m all ponds were rectangular in shape possessed similar size, basin conformation and bottom type. Prior to stocking, ponds were dried and cleaned for weeds and unwanted aquatic animals. The dried ponds were left exposed to sunlight for several days and then limed at the rate of 250 kg/ha. Five days after liming, ponds were filled-up with deep tube well water up to the depth of 1 meter**.** After three days, ponds were fertilized with cowdung at the rate of 1,000 kg/ha.

2.2 Experimental design

The ponds were selected randomly to accumulate the relevant treatments. The experimental layout is shown in Table 1.

Table 1: Experimental layout of monosex male tilapia culture in ponds.

Treatments	Replications (Pond no.)	Pond size (dec)	Stocking density/pond	Stocking size(g)
T1	R-1 (1)	2	100	0.117
	R-2 (2)	2	100	0.117
	R-3 (3)	2	100	0.117
T2	R-1 (4)	2	200	0.117
	R-2 (5)	2	200	0.117
	R-3 (6)	2	200	0.117
T3	R-1 (7)	2	300	0.117
	R-2 (8)	2	300	0.117
	R-3 (9)	2	300	0.117

2.3 Collection of fries

The monosex male tilapia fries (*O. niloticus*) were collected from the Reliance Hatchery, Shikarikanda, Mymensingh and transported to the farm in oxygen filled polythene bags covered by jute bags. After acclimatization the fries were transferred to culture ponds. During stocking sufficient care was taken in respect to physico-chemical condition.

2.4 Fish stocking

Fries of monosex male tilapia (*O. niloticus*) were stocked in 20 March 2015 according to the experimental design. All ponds of various sizes were divided into three groups viz. group-1, group-2 and group-3. The ponds belongs to group-1, group-2 and group-3 were stocked with monosex male tilapia fries at the stocking density of 12,500 (T1), 25,000 (T2) and 75,000/ha (T3), respectively.

2.5 Feeding strategy

At the beginning of the experiment feed was supplied at the rate of 30% of the body weight of reared monosex male tilapia and gradually it was readjusted to 25%, 20%, 15%, 14%, 13%, 12% and 10%, respectively.

2.6 Water sampling and analysis

Water quality parameters such as water temperature, transparency, pH, dissolved oxygen (DO) and total alkalinity were determined at weekly interval between 0900 to 1000 hrs. Temperature was recorded using a Celsius thermometer, dissolve oxygen was measured by a portable digital DO meter (Jenco 9713) and pH was measured by pH meter (Hanna pH 300).

2.7 Analysis of experimental data on growth performances
Experimental data was collected during the growth trial were used to determine mean weight gain (g), average daily weight gain (g), specific growth rate (%/day) and survival rate (%).

2.8 Production (kg/dec/2 months)
At the end of the experiments, most of the fishes were caught by net and the rest by draining out the ponds. It was calculated as:
Production = No. of fish harvested × Average final weight of fish (g)

2.9 Statistical analysis
The data obtained on the growth performance of fish, survival rate and production were statistically analyzed to see whether the influence of different treatments (stocking densities) on these parameters were significant or not. One way analysis of variance (ANOVA) was done with the help of SPSS (Statistical Package for the Social Sciences).

3. Results

3.1 Water quality parameters
Mean values of physico chemical parameters over the period are presented in Table 2. The temperature fluctuation was same for each of the 3 treatments. The temperature ranged from 26.53 ºC to 30.13 °C during the study period. The maximum water temperature was 30.13 °C in T1 in 6th week and the minimum water temperature was found 26.53 °C in T3 in 1st week. The means (±SE) values of water temperature were recorded (28.08±0.46), (28.40±.42) and (28.38±0.41) in T1, T2 and T3, respectively. The pH fluctuation was same for each of the 3 treatments. The pH ranged from 6.68 to 8.71.The highest value of pH 8.71 was recorded from T1 in 3rd week and the lowest value 6.68 was recorded from T2 in 2nd week. The means (±SE) values of pH were recorded (7.62±0.19), (7.36±0.15) and (7.40±0.12) in T1, T2 and T3, respectively.
The dissolved oxygen fluctuation was same for each of the three treatments. The dissolved oxygen ranged from 4.8 to 5.83 mg/L. The maximum dissolved oxygen was 5.83 mg/L in treatment T2 in 2nd week and the minimum dissolved oxygen was found 4.8 mg/L in treatment T1in 2nd week. The means (±SE) values of dissolved oxygen were recorded (5.24±0.09), (5.39±0.13) and (5.30±0.09) in T1, T2 and T3, respectively. The values of water transparency were noted to vary from 32.2 to 44.8 cm. Remarkable variation of water transparency were found in the ponds throughout the study period with the minimum values of 32.2 cm from T1 in 9th week and the maximum values of 44.8 cm from T3 in 1st week.

Table 2: Average (Mean ±SE) values of water quality parameters under different treatments throughout the study period.

Treatments	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Transparency (cm)
T1	28.08± 0.46	5.24±0.09	7.62±0.19	35.38±0.89
T2	28.40±0.42	5.39±0.13	7.36±0.15	38.58±1.27
T3	28.38±0.41	5.30±0.09	7.40±0.12	39.38±1.33

3.2 Growth and production performance
The growth rate of monosex male tilapia (*O. niloticus*) under different stocking densities were recorded weekly and the results of growth performances have been presented in Table 3. The result indicated higher growth in weight (g) at lower stocking densities and growth rate gradually decreased with increasing densities. The growth performances of tilapia in terms of mean weight gain (g), mean percent weight gain (%), specific growth rate (SGR) (%/day), survival rate (%) and production (kg/dec/2 months) were calculated in Table-3.

Table 3: Average (Mean ± SE) values of growth parameters of monosex male tilapia (*O. niloticus*) under different treatments during the study period.

Parameters	Treatments			LSD	Level of sig.
	T1	T2	T3		
Initial weight (g)	0.117	0.117	0.117	-	NS
Final weight (g)	35.97±0.58a	34.27±0.16a	32.13±0.67b	1.51	**
Weight gain (g)	35.85±0.58a	34.15±0.16a	32.02±0.67b	1.51	**
(%) Weight gain	30640.74±496.74a	29187.75±124.18a	27364.39±543.55b	1292.04	**
Average daily weight gain (g)	0.560±0.009a	0.534±0.002a	0.500±0.01b	0.017	**
SGR (%/day)	8.95±0.025a	8.87±0.007a	8.77±0.01b	0.08	**
Survival rate (%)	78.00±2.31b	75.17±1.74b	74.56±0.99b	5.29	NS
Fish production (kg/dec)	1.40±0.064c	2.58±0.07b	3.59±0.11a	0.25	**

- **= significant at 1% level of probability ≤0.01
- NS= Not significant
- In column figures with same or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

3.2.1 Mean weight gain (g)
Highest mean weight gain (g) was 35.85g in T1 on 18 May 2015 and lowest mean weight gain (g) was 32.02g in T3 on 18 May 2015 (Table-3). There were significant (p<0.01) differences among all the three treatments. The values was significantly (p<0.01) highest in T1 (35.85g) followed by T2 and T3 (Table-3).

3.2.2 Percent weight gain (%)
Highest percent weight gain (%) were 30640.74% in T1 and lowest percent weight gain (%) were 27364.39% in T3, respectively on 18 May 2015. There were significant (p<0.01) differences among all the three treatments (Table-3).

3.2.3 Average daily weight gain (g)
Highest average daily weight gain (g) was 0.56g in T1 and lowest average daily weight gain (g) was 0.50g in T3 on 18 May 2015 (Table-3). There were significant (p<0.01) differences among all the three treatments. The values was significantly (p<0.01) highest in T1 (0.56g) followed by T2 and T3.

3.2.4 Specific growth rate (SGR) (%/day)
The mean growth rate of monosex male tilapia in different treatments ranged between 8.77 and 8.95 the significantly (p<0.01) and the highest SGR values (8.95) was found in T1 whereas the lowest SGR values (8.77) was found in T3 (Table-3).

3.2.5 Survival rate (%)
The survival rate (%) was 78, 75.17 and 74.56% in T1, T2 and T3, respectively (Table 3). There were no significant (p<0.01) differences among all the three treatments. The values was highest in T1 (78%) followed by T2 and T3.

3.2.6 Production (kg/decimal/2 months)
The Production (kg/decimal/64days) was 8.4, 15.48 and 21.54 in T1, T2 and T3, respectively (Table 3). There were significant (p<0.01) differences among all the three treatments. The values was significantly (p<0.01) highest in T1 (1.40) followed by T2 and T3.

4. Discussion
Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organisms. Growth, feed efficiency and feed consumption of fish are normally governed by a few environmental factors [7]. The range of temperature (26.53 ºC to 30.13 °C) in the experimental ponds is within the acceptable range for tilapia farming that agrees well with the findings [8-10]. The range of water temperature from 26.06 to 31.97 °C is suitable for fish culture [11]. Transparency was consistently higher in all the treatments, because sing did not consume plankton in adult stage. For this reason plankton abundance was found in all the ponds of treatments. The dissolved oxygen in the morning was low in ponds stocked with high density of fish compared to ponds stocked with a low density [12, 13]. Fluctuation of dissolved oxygen might be attributed to photosynthetic activity and variation in the rate of oxygen consumption by fish and other aquatic organisms [11]. However the level of dissolved oxygen is within the acceptable might in all the experiment ponds.

pH range 7.03 to 9.03 in fish ponds located in Trishal, Mymensingh [14]. The observed pH values of water ranging from 7.3 to 9.0 indicated that the experimental ponds were suitable for fish culture [11]. During the study period, the pH values of pond water under different treatments were found to be alkaline.

Water transparency (cm) is an important factor, which indicates the productivity of a water body. In the present study, the values of water transparency were noted to vary from 32.2 to 44.8 cm. Water transparency (cm) in ponds of BAU Campus, Mymensingh was found to vary from 54 to 90 cm, 25 to 67 cm, 26.5 to 36.6 cm, 15 to 58 cm, 27 to 35 cm and 12 to 19 cm, respectively [15-20]. The maximum transparency might be due to less plankton production and the minimum values might be due to abundance of plankton and turbid water due to rainfall. Thus it may be concluded that all of water quality parameters were suitable for fish culture.

During the present study, growth performance of monosex male Tilapia (*Oreochromis niloticus*) was investigated in this experiment. The highest mean weight gain was 35.85g in T1 with lowest stocking density of 50/decimal compared to other T2 (100/decimal) and T3 (150/decimal) although same feed was supplied in all treatments. These phenomenon indicated that lower stocking density reduces competition among the fishes which influenced them to take feed properly and it might be absent in the treatments with higher stocking densities. The present results agreed with the findings which achieved the best growth at lower stocking densities [21, 22]. The highest weight gain (10.64g) in lower stocking densities compared to higher stocking densities [23].

There was significant difference (p<0.01) among the different treatments. The highest mean (±SE) value (30640.74±496.74) of percent weight gain was found in T1whereas the lowest mean (±SE) value (27364.39±543.55) of percent weight gain was found in T3. The results indicated that the percent weight gain varied in different stocking densities [23]. He found percent weight gain ranged from 3971 to 5415%. The percent weight gain of the present study was lower than findings this might be due to the initial size of the fry released in the ponds and the difference in the culture system. The values of specific growth rate of monosex male tilapia were observed as 8.95%, 8.87% and 8.77% in treatments TI, T2 and T3, respectively. There was significant difference (P<0.01) among the different treatments. The specific growth rate ranged 2.363 to 2.655%, 3.65 to 3.79% and 3.09 to 3.34%. They obtained the highest values of specific growth rate at lowest stocking densities [24, 25, 23].

The specific growth rate ranged between 3.14% and 3.32% [26]. The difference of SGR values of *O. niloticus* in the present study might be due to the temperature difference between regions and natural productivity of the ponds. The other reason might be due to the initial size difference of *O. niloticus* used for the experiment and also might be due to the difference of culture season.

The highest survivability was recorded in T1 (78%) and the lowest survivability was in T3 (74.56%). There was no significant difference (P<0.01) among the different treatments. The survival rate ranged from 79.44 to 89.83%, 84 to 92% and 78.67% to 85.67% [27, 25, 23]. Survival rate was found to be negatively influenced by different stocking densities such as the lowest stocking density showed the highest survivability. It might be due to high competition for food and space among the fishes.

The highest production was observed to be 3.59 Kg/dec/2 months in T3 and the lowest production was observed to be 1.40 Kg/dec/2 months in T1. Although the mean weight gain (g) in T1 was highest but total production was highest in T3 which might be due to higher number of fishes. The best production from higher stocking densities compared to that achieved with the lower ones [25, 23].

5. Conclusion
In the present study, the highest production of 3.59kg/decimal was obtained in T3 with stocking of 150 fish/decimal due to higher stocking density. Although the highest production was obtained in T3 but individually growth performance of monosex male tilapia was higher in T1. Based on the result of present experiment, farmers could be suggested to rear tilapia (*O. niloticus*) at lower stocking density (50 fish/dec) to get higher growth and survival in a short period of time.

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