

## Original Research Article

# Effect of Different Feeding Rates on Growth Performance and Survival Rate of Tilapia (*Oreochromis niloticus* L. 1758) Fingerlings Reared in Rectangular Hapas

### Abstract

The study was designed with three experimental hapas namely T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> for a period of 8 weeks commencing from 06<sup>th</sup> October to 06<sup>th</sup> December, 2017 to assess the effect of feeding ration on the growth and survival rate of *Oreochromis niloticus*. The hapas were equal in size (0.0725 decimal) and rectangular in shape. A stocking density of 420 fish/decimal was used for the experiment in all three treatments. The fish were dependent on natural food in T<sub>1</sub>, fed at the rate of 8% of their body weight in T<sub>2</sub> and the feeding rate was 12% in T<sub>3</sub>. Feeding frequency was two times in a day in T<sub>2</sub> and T<sub>3</sub>. The proximate composition of the experimental diet (% dry matter basis) was moisture 11%, protein 30%, fat 6%, ash 10% and fiber 7%. The range of water quality parameters (water temperature 28 to 32°C, Dissolved oxygen 5.6 to 7.8 mg/l and water pH 7.5 to 8.6) were found suitable during the experimental period. The mean initial weight of Tilapia fry in three treatments were 3g and the mean final weight of tilapia was (6.8±4.77) g for T<sub>1</sub>, (9.88±5.76) g for T<sub>2</sub> and (19.2±9.9) g for T<sub>3</sub>, respectively. The mean initial length was 5 cm in three treatment and final length was found (8.2±6.15) cm, (9.86±7.36) cm and (12±8.23) cm in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. The highest weight and length gain was found in T<sub>3</sub> having the feeding rate of 12% of the body weight and lowest was found in T<sub>1</sub> in which no supplementary feed was used.

**Keywords:** Feeding Rate, Growth performance, *Oreochromis niloticus*, Survival rate

**Comment [U1]:** I think for a better international understanding of the English language, you need to use the term of - Hapas Fish Cage

**Comment [U2]:** Hapas fish cage

**Comment [U3]:** Please use internationally accepted units of measurement (cm x cm; m x m; square meter; etc.)

**Comment [U4]:** Please use internationally accepted units of measurement (cm x cm; m x m; square meter; etc.)

**Comment [U5]:** Correctly, the experimental diet is expressed on the basis of dry matter, and the total of nutrients (protein, fat, carbohydrates, fiber, ash) must be 100%.

**Comment [U6]:** If you use the term fingerlings in the title, then you must also use the term in the text.

**Comment [U7]:** At the beginning of the experiment did you not calculate the average values of the body mass? That would be right.

**Comment [U8]:** Same question. At the beginning of the experiment did you not measure the average body length values?

**Comment [U9]:** The expression is not correct. Here you need to calculate the average daily gain and the total growth gain, possibly also the feed conversion factor (FCR). If we compare the initial value of 3 g, with the final value of 19.2 for batch T<sub>3</sub>, the percentage of 12% does not make much sense. Please recalculate.

**Comment [U10]:** For better visibility of the article and to increase the number of subsequent citations, use other terms in the keywords section, different from those in the title (Ex. supplemental feed, growth dynamics, growth indices)

## Introduction

Bangladesh is a land of river and fish are very much abundant in rivers and other natural water body. Fish plays a crucial role in the Bangladeshi diet, providing more than 60% of animal source food (DoF, 2015), representing a crucial source of micro-nutrients and possessing an extremely strong cultural attachment. The economy of Bangladesh is primarily based on Agriculture and fish (including shrimp and prawn) and fish is the second most valuable agricultural crop, and its production contributes to the livelihoods and employment of millions. Fisheries contribution to agricultural GDP 23.12% and fisheries contribution to national GDP 3.69% (DoF, 2015). The employment of people (full time & part time) approximately 11% of the total population which in number 17.80 million is involved in fisheries (DoF, 2015). Bangladesh earns 630.24 \$ million foreign exchanges by exporting fish and fisheries product in 2013-14 (DoF, 2015). In Bangladesh the aquaculture production from inland closed water-bodies is 55.15% of the total production. (FRSS, 2015). Bangladesh ranked 5th as aquaculture producing country in the world (FAO, 2015).

The Nile tilapia, *Oreochromis niloticus* is a widely cultured species because it grows and reproduces in a wide range of environmental conditions and tolerates stress induced by handling (Tsadik and Bart, 2007). It is currently ranked second only to carps in global production. The predominant advantage of monosex culture can be achieved in such aquaculture situations. *Oreochromis niloticus* has been considered as one of the most important species of fish in tropical & sub-tropical aquaculture (FAO, 2014). With increase in human population and diminished natural fisheries resources, aquaculture is rapidly gaining importance. Pond aquaculture is growing fast in many resource-constrained Asian countries. In order to maintain the present per capita supply of aquatic products in the future, further growth of aquaculture production is needed as the supply through capture fisheries cannot grow any more. But, fish culture on a small-scale basis has often failed due to inadequate knowledge regarding ideal feeding rate, stocking density and feeding frequency of fish.

However, feeding frequency is generally used to refer how many times the organisms should be fed in a day. It is considered to be one of the important factors that affect fish growth, feed utilization and gross fish yield. The full utilization of space for maximum fish production through intensive culture can improve the profitability of the fish farm. Tilapia has established a secure position in a number of water impoundments of Bangladesh, where one sex displays remarkable growth superiority. Thus, culture of monosex tilapia might prove effective to induce a positive approach towards tilapia culture in Bangladesh. Considering these aspects, the present study aims

**Comment [U11]:** In this sentence you use the term river twice, which is wrong. Please rephrase. (Ex. Bangladesh is a country with many rivers and fish are abundant in them...)

**Comment [U12]:** of the population of Bangladesh

**Comment [U13]:** If this is a citation, it does not appear in the bibliography

**Comment [U14]:** Are you referring to common carp or Cyprinidae fish? Please specify.

**Comment [U15]:** Please, throughout the article use only the common name - Nile tilapia. It is enough to mention the scientific name at the beginning of the article. If you use the scientific name repetitively, the article can be difficult to read later.

to evaluate the growth performance of the all-male monosex tilapia population at various feeding rate and also to evaluate growth performance on natural feed to determine an ideal feeding rate for tilapia culture under this climatic and ecological conditions. Feed cost is one of the largest operational costs in aquaculture. Therefore, the act of feeding may be pointed as one of the most important elements in the culture practice. It is evident from the earlier studies that, rate of feeding plays a vital effect on the digestibility of fish, as excess feeding may lead to leaching of nutrients and limited feeding may reduce the growth rate of fish due to starvation. Therefore, it is important to standardize the feeding frequency for the target species in aquaculture for desired growth. The main objective of the study was to establish a suitable culture method and feeding frequency in which the growth of a major fish species for aquaculture in Bangladesh *Oreochromis niloticus* response best.

Comment [U16]: Nile tilapia

## Methods & Materials

### Study Area and duration

The experiment was conducted in the Bismillah agro farm and hatchery (Fig.1). The study period was conducted between 06<sup>th</sup> October to 06<sup>th</sup> December, 2017. An 8-week experiment was conducted in pond where main source of water was pump and rain water. The water depth of the water body was more than 3 feet on average, where net of the cage (hapa) was set in a manner that it maintains minimum of water level always higher than 1.5 feet inside the cage.

Comment [U17]: International unit for length is meter. Please convert these values.

Comment [U18]: International unit for length is meter. Please convert these values.



Fig. 1: The study area collected from google maps

Comment [U19]: (Source: www.google.com)

### Experimental design

This experiment was conducted by establishing 3 different cages in the water body using net and local bamboo. The size of each cage was 8<sub>L</sub>×4<sub>W</sub>×4<sub>H</sub> feet. Distance of each cage from its neighboring one was maintained 100 cm, and same distance was maintained between the embankment and a cage. Three cages were marked as treatment-1 (T<sub>1</sub>), treatment-2 (T<sub>2</sub>) and treatment-3 (T<sub>3</sub>). In the treatment of T<sub>1</sub>, no supplementary feed was given and fish was completely dependent on natural food. In T<sub>2</sub>, feed was given by 8% of the body weight of the *Oreochromis niloticus* and in T<sub>3</sub> feed was given 12% of the body weight (Table. 01). Stocking density was 420 fish/decimal in all three treatments.

Comment [U20]: Meters. Please convert.

Comment [U21]: comma

Comment [U22]: Nile tilapia

Comment [U23]: The value of 12% is a bit high. In general, juvenile forms of tilapia are given feed at a maximum of 10% of their body mass. Please check.

Comment [U24]: Try using a different unit of measure for density (Ex. fish/square meter; kg fish/square meter)

Comment [U25]: Nile tilapia

Comment [U26]: Try using a different unit of measure

Comment [U27]: Try using a different unit of measure

Table 01: Experimental layout of *Oreochromis niloticus*

Treatment	Size of the cage(dec.)	Stocking density/dec	Number of fish	Fish feed
T-1	0.0725	420	30	No
T-2	0.0725	420	30	8%
T-3	0.0725	420	30	12%

### Collection of fry and Conditioning

The *Oreochromis niloticus* fry was collected from Bismillah Agro based farm, Noakhali. The fry was 40 days old. The average length of the fry was 5 cm and weight were 3 g on average. Same length and weight of fry were selected for this study. All fry were healthy and disease free. The fry was conditioned in the Bismillah Agro farm for 3 hours before stoking in the experimental hapa.

Comment [U28]: Nile tilapia fingerlings, according with the title

Comment [U29]: Hapa fish cage

### Stocking of fish

After preparation of hapa fry (*Oreochromis niloticus*) was stocked into the hapa. All fishes were similar in size and age. For every treatment 30 species were stocked. This species was healthy and disease free. We use salt bath treatment for 3 minutes in 5ppm Epsom Salt Soaking Solution (Magnesium sulfate) before stocking to ensure disease free fish.

Comment [U30]: specimens

### *Water quality parameters*

In the study period, water temperature, Dissolve oxygen, pH, abundance of natural food (plankton) was recorded one times per week respectively. Water temperature of the experimental water body was measured using a mercury Celsius thermometer one time in a week during the study period. During the study period we measured temperature of the experimental water body at the same time one day in a week. pH of the water body was measured one times in a week during the study period. For this operation a digital portable pH meter (Model: HANNA- HI 96107) were used. To determine the dissolve oxygen of the experimental water body a portable DO meter (Model: Lutron-DO-5509) was used and DO was measured in the spot without collecting any water sample in the laboratory.

### *Feeding management*

In this experiment floating starter feed (diameter:  $2.6 \pm 0.3 \text{ mm}$ ) is used throughout the experimental period. Feed was given two times daily at 10:00 am in the morning and 5:00 pm in the afternoon. The composition of the feed is given bellow.

**Comment [U31]:** For 5 cm fish specimens, 2.6 mm grain size is a bit large, don't you think? Please check.

Table 02: Composition of feed used in the experiment

Type of feed	Protein (minimum)	Moisture (maximum)	Fat (minimum)	Fiber (maximum)	Ash (maximum)
Floating starter	30%	11%	6%	7%	10%

**Comment [U32]:** The composition of the feed is unclear. Lipids and carbohydrates are missing. Don't have the manufacturer's specifications? ... or did you design this feed yourself? Please specify.

For T<sub>1</sub>, no supplementary feed was supplied, T<sub>2</sub> feed were supplied according to 8% of the body weight of the fish and for T<sub>3</sub> feed were supplied according to 12% of the body weight of the fish (Fig. 2). Feeding rate was calculated from the average weight of tilapia after each sampling. Feed was kept in air tight polythene bag. Feed was supplied directly without any feeding tray. Feed was distributed evenly over the surface of the water inside the hapa. Half of the ration was supplied at 10:00 am and remaining half was supplied at 5:00 pm everyday respectively.



Fig.2: The measurement of feeding ration

Comment [U33]: If these images are original please mention (Source: authors)

### *Sampling and measurement of length & weight*

Fishes were caught by using a scoop net from the hapa and measured the length and weight of each species and data were recorded. For weighing an analogue balance machine was used and for length a tap was used. Data on length and weight were taken every 7 days interval. During sampling day all fishes were caught to confirm that if any fish have escaped or died. Health condition were monitored during the sampling of fishes. The total sampling process were handled very carefully as the small fry are very susceptible to handling stress. During sampling we tried to minimize the sampling error carefully.

Comment [U34]: specimens

### *Study of growth parameters of fish*

For evaluating the growth of fish, different growth parameters such as length gain (cm), weight gain (g), specific growth rate (SGR % per day) and production (kg/ha/100 days) were taken into consideration and were measured using the following formula:

Weight gain (gm) = Mean final weight (gm) – Mean initial weight (gm)

Production = No. of fishes harvested × average final weight increase of fishes

Survival rate =  $\frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$

FCR= (Amount of feed given by dry weight)/ (Final live weight gain by the fish).

### Statistical analysis

Data that are obtained from the experiment on growth performance, weight gain, increase in length, survival rate and production were statistically analyzed to see whether the influence of different treatments (feed) on these parameters were significant or not. This was done by using different statistical method by the help of statistical software named Microsoft excel (version 2016).

**Comment [U35]:** What are the methods of statistical interpretation. What tests did you use?

## Results

### Water quality parameters

Water quality parameters of this experiment were monitored throughout the experimental period. Temperature, pH, dissolve oxygen and transparency were observed during the whole study period. Temperature, pH and dissolve oxygen were found variable and transparency was found almost similar. All water quality parameter of the experimental water body is represented in the Table 03.

**Comment [U36]:** Water transparency why does not appear in the table? Please correct.

Treatment	Parameter	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
T <sub>1</sub>	pH	8.0	8.5	7.5	7.0	8.4	7.9	7.5	7.8
	DO (mg/l)	7.0	6.3	6.8	7.1	6.4	6.9	6	6.6
	Temperature(°C)	30	32	29	28	30	29	30	31
T <sub>2</sub>	pH	8.0	7.5	7.0	7.8	8.0	7.5	8.5	7.9
	DO (mg/l)	7.0	7.5	7.0	7.4	6.0	6.5	7.4	6.0
	Temperature(°C)	30	29	31	28	30	32	30	29
T <sub>3</sub>	pH	7.8	8.4	7.0	6.5	7.8	7.5	7.0	7.5
	DO (mg/l)	5.8	6.5	6.4	7.6	6.5	7.6	7.3	6.0
	Temperature(°C)	28	30	32	29	30	32	31	32

**Comment [U37]:** mg/L

**Comment [U38]:** mg/L

**Comment [U39]:** mg/L

Table 03: water quality parameter

**Comment [U40]:** What are the factors that led to the differences in temperature, pH and dissolved oxygen in the same week between the 3 experimental groups? I'll give you just one example: pH (week 2): T1-pH=8.5; T2-pH=7.5; T3-pH=8.4. It appears from your exposition that these hapa (cages) were mounted side by side. Where do these differences come from? If you look carefully at the table, there are major differences for the other parameters as well. Please check and explain.

The pH of the experimental water body was measured in every 7 days interval during the study period. The highest pH value was found 8.6 2<sup>nd</sup> week in T1, and the lowest value of pH was found 7.5 in 2<sup>nd</sup> week. Average pH was highest in T<sub>1</sub> during the study period and it was 8.13 (Fig. 3).

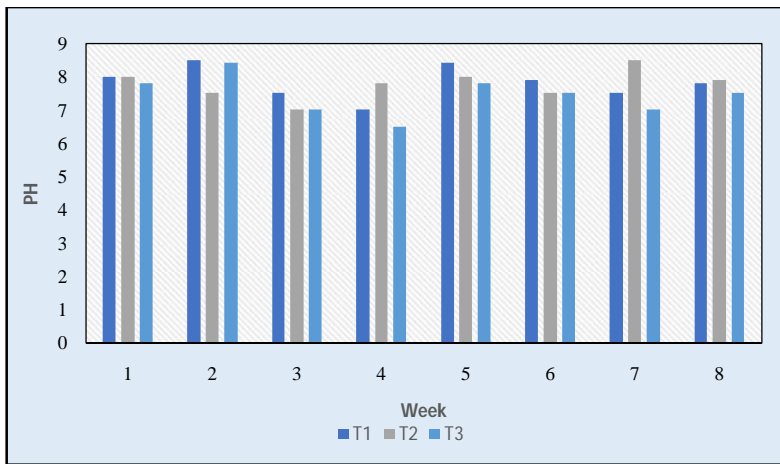


Fig. 3: Variation of water pH during the study period

Comment [U41]: These graphics don't really make sense. All the data have already been presented in table 03. It's just a repetition.

Temperature of the water was found highest 32°C in 2<sup>nd</sup> week in T1 and T3 and in 6<sup>th</sup> and 8<sup>th</sup> week in T2 and T3, respectively. The lowest temperature is recorded 28 °C in T1 2<sup>nd</sup> week and T2 in 4<sup>th</sup> week and T3 1<sup>st</sup> week. The average highest temperature was recorded 30.37 °C in T3 (Fig. 4).

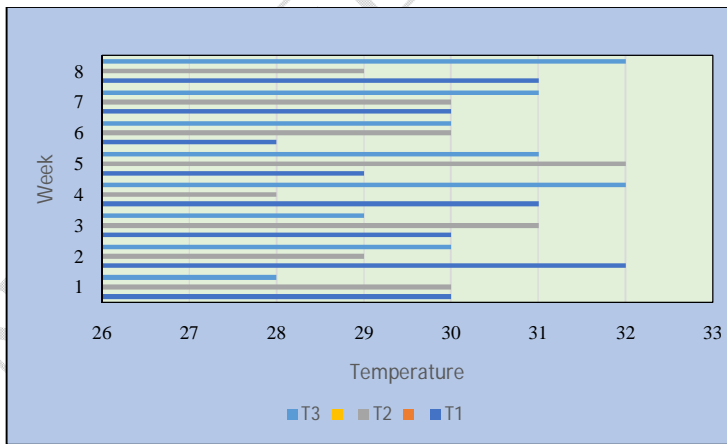


Fig. 4: Variation of water temperature during study period

Comment [U42]: These graphics don't really make sense. All the data have already been presented in table 03. It's just a repetition.

Dissolve Oxygen was measured during the study period in every seven days interval. Highest DO was found 7.6 mg/l in T2. Lowest value of dissolve oxygen was recorded 5.6 mg/l in T1 in 8<sup>th</sup> week. From the figure we observe that the average DO level was higher at the beginning of the

Comment [U43]: mg/L

Comment [U44]: mg/L

study period but the level of DO was decrease with the increase of the study period in all three treatments (Fig. 5).

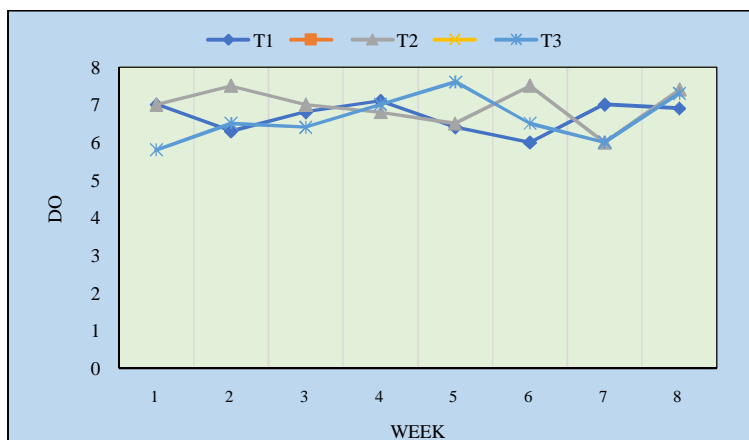


Fig. 5: Variation of water DO during study period

Comment [U45]: These graphics don't really make sense. All the data have already been presented in table 03. It's just a repetition.

#### Growth performance of *Oreochromis niloticus*

Growth performance of Tilapia in different treatment was calculated by weight gain and increase in length. The evaluation of growth performance of *Oreochromis niloticus* in all treatment has been done in term of final weight gain (g), mean weight gain (g), average daily weight gain (g), percent weight gain (g), and survival rate of the species.

Comment [U46]: Nile tilapia

#### Weight performance

Average total weight was calculated by using weight machine. The average initial weight of fish as in all treatments were 5g. Sampling was done randomly and found the weight of *Oreochromis niloticus* variable in different treatment. Weight of all fish increased with the time interval (from 1<sup>st</sup> week to 8<sup>th</sup> week). At the end of the experiment, average weight of *Oreochromis niloticus* in T<sub>3</sub> was found (19.2±9.9) gm, in T<sub>2</sub> weight was found (9.35±5.76) gm, in T<sub>1</sub> average weight was found (6.8±4.77) gm. The average weight gain of T<sub>3</sub> was found higher and lower in T<sub>1</sub> (Fig. 6).

Comment [U47]: Nile tilapia

Comment [U48]: Nile tilapia

Comment [U49]: g

Comment [U50]: g

Comment [U51]: g

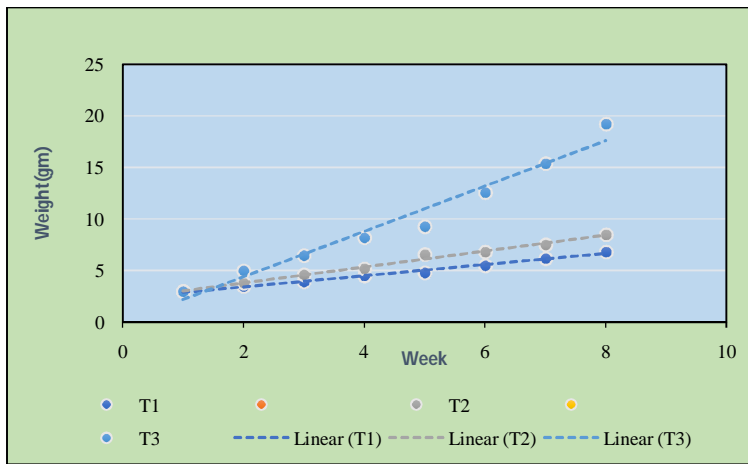


Fig. 6: Weight performance of Tilapia fry in different treatments

#### Observation of length performance

Average total length was calculated by using a scale. Average Initial length of all fishes were 8 cm. For measurement of length of *Oreochromisniloticus*, random sampling was done and found the length variable in three treatments. Length of all fishes increased with the time interval. At the end of the experiment, average length of *Oreochromisniloticus* was found  $(8.2 \pm 6.15)$  cm,  $(9.8 \pm 7.36)$  cm and  $(12 \pm 8.23)$  cm in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. Increase in length was notable in T<sub>3</sub>. Average increase in length was highest in T<sub>3</sub> than other three treatment. On the other hand, increase in length was found lowest in T<sub>1</sub> (Fig. 7).

**Comment [U52]:** In the abstract you said that the initial length of the tilapia fry was 5 cm. Here you say it was 8 cm. How is that right? Please check and modify.

**Comment [U53]:** Nile tilapia

**Comment [U54]:** How many samples did you get at random? Is their number statistically representative?

**Comment [U55]:** Nile tilapia

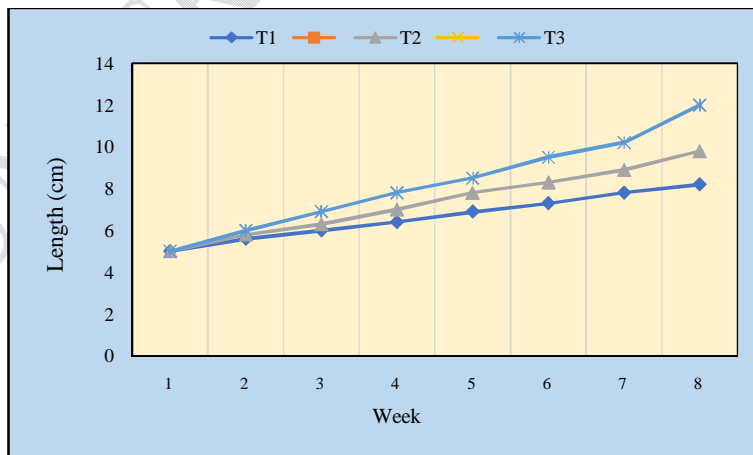


Fig. 7: Length performance of *Oreochromisniloticus* fry in different treatment

### Weight gain of *Oreochromis niloticus*

Comment [U56]: Nile tilapia

Weight gain of *Oreochromis niloticus* fish fry was observed during the study period in each treatment. In each week weight gain was different. Final average weight was found 4.77g, 6.4g and 10.3g in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. In T<sub>1</sub> weight gain was almost similar in every week. The average weight gain in T<sub>1</sub> was (0.677±0.40) gm. In T<sub>2</sub> highest weight gain was recorded in 4<sup>th</sup> week (1.5 gm) and lowest was found in 2<sup>nd</sup> week (0.8 gm). In this treatment average weight gain was (1.05±0.80) gm. In T<sub>3</sub> the highest weight gain was found in 8<sup>th</sup> week (3gm) and the lowest was recorded in 5<sup>th</sup> week (1.1 gm). Average weight gain in T<sub>3</sub> was (1.97±1.12) gm (Fig. 8).

Comment [U57]: Nile tilapia

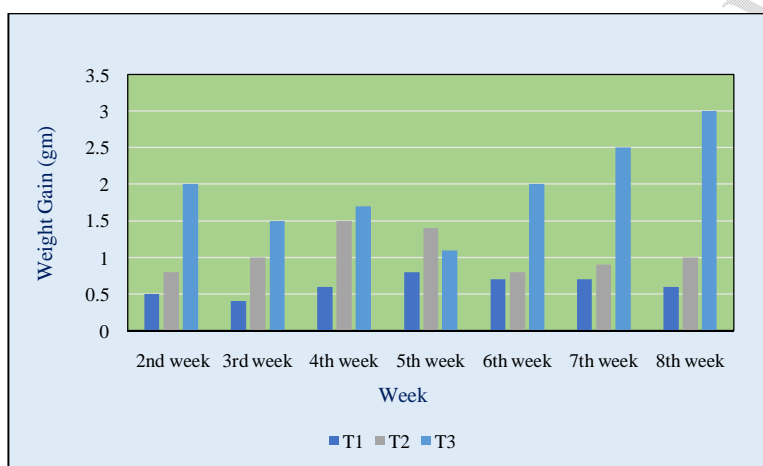


Fig. 8: Variation in weight gain of *Oreochromis niloticus* in different treatment

Comment [U58]: This is where weekly growth variations are to be found and interpreted. What were the factors? If the feed was the same, it means that only the environmental conditions could have generated these variations.

### Length gain of *Oreochromis niloticus*

Length gain of *Oreochromis niloticus* was observed during the whole study period in different treatment. Final average length gain was 6.55 cm, 8.54 cm and 10.4cm in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> respectively. In T<sub>1</sub> highest length gain was found in 2<sup>nd</sup> week (0.6 cm) and the lowest was in 8<sup>th</sup> week and 3<sup>rd</sup> week (0.4 cm). Average length gain in T<sub>1</sub> was (0.454±0.26) cm. In T<sub>2</sub> highest length gain was found in 8<sup>th</sup> week (0.9 cm) and lowest was in 3<sup>th</sup> week (0.5 cm). The average length gain of T<sub>2</sub> was found (0.685±0.69) cm. In T<sub>3</sub> highest growth was found in 8<sup>th</sup> week (1.5 cm) and lowest was in 5<sup>th</sup> week (0.7 cm). The average length gain was (0.967±0.62) cm (Fig. 9).

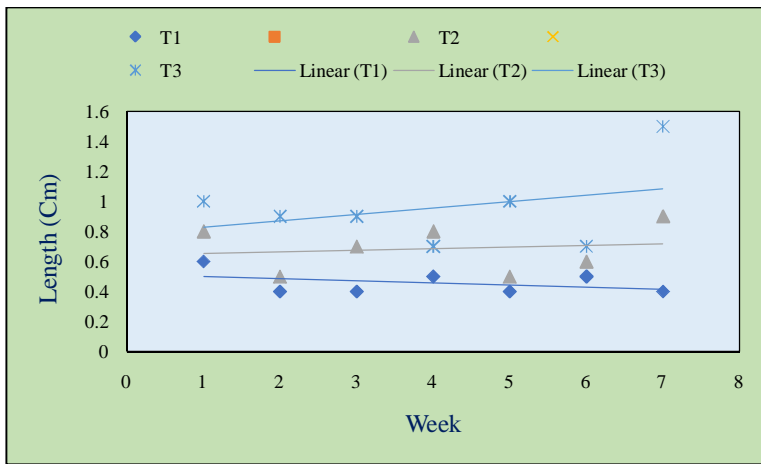


Fig. 9: Variation in length gain in different treatment

### Survival rate

The survival rate of fish was calculated and found variable in different treatment. Highest survival rate was found 96% in T<sub>3</sub>. In T<sub>1</sub> survival rate was lowest and found 90%. In T<sub>2</sub> survival rate was 93%. The variation in survival rate was due to environmental condition and different feeding percentage and feed utilization (Fig. 10).

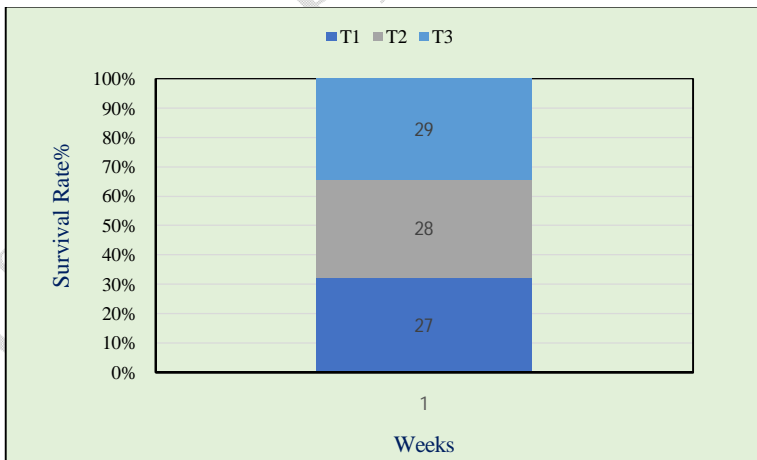


Fig. 10: Survival rate of fry in different treatment

**Comment [U59]:** This graph is hard to understand. I recommend replacing it with another, in a different format.

### Observation of FCR

FCR of the two experimental treatment (T<sub>2</sub>& T<sub>3</sub>) was calculated after the study. In T<sub>2</sub> FCR is found 2.4 and in T<sub>3</sub> FCR was found 3.6. In T<sub>1</sub> no feed were supplied this is why FCR was not applicable for that treatment (Fig. 11).

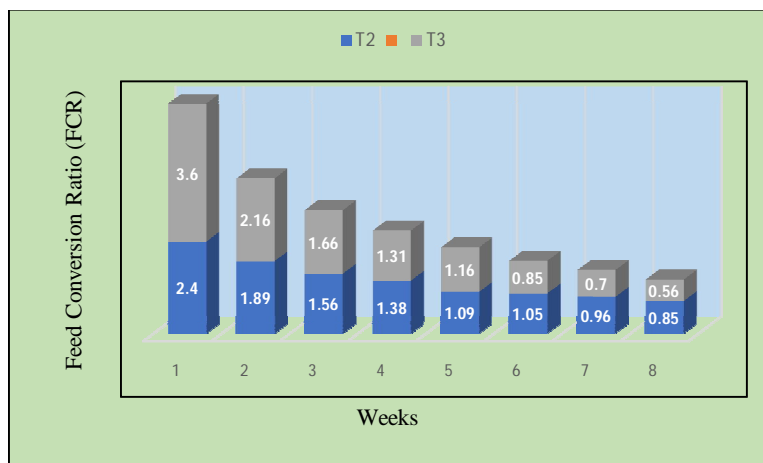


Fig11: Variation of FCR in different treatment

## Discussion

### Growth parameters

#### Weight performance

The mean initial weight of fish fry in all three treatments were 3 g. At the end of the study, the mean weight of *Oreochromis niloticus* were (6.8±4.77) g, (9.35±5.76) g and (19.2±9.9) g in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. The mean weight gains of fry at the end of the experiment were highest in T<sub>3</sub>. The mean weight of *Tilapia* fry at harvest was higher in T<sub>3</sub> (19.2±9.9g), followed by T<sub>2</sub> (8.5±5.76 g) and T<sub>1</sub> (6.8±4.77g). The highest weight gain of *Oreochromis niloticus* was observed in T<sub>3</sub> in which feed was given according to 12% body weight of the fish. Binhet *et al.* (1997) carried out an experiment in metal cage and found similar results in case of *Oreochromis niloticus* by feeding formulated diet prepared by locally available material and used feed daily at a rate that decreased with fish growth from 15% to 3% of body weight. Hussain *et al.* (2000) and Hasan *et*

Comment [U60]: Nile tilapia

Comment [U61]: Nile tilapia

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al. (1992) reported a weight gain of about 128 g for Tilapia in on-farm ponds for a culture period of 6 months fed rice bran at 5-6% of their body weight. Considering the 8 weeks culture period in this study, compared to 6 months period by Hussain *et al.* (2000), Tilapia in the present study performed better in respect of weight gain.

### ***Length performance***

The mean initial length of fish fry in all three treatments were 5 cm. At the end of the study, the mean length of Tilapia was (8.2±6.65) cm, (9.8±7.36) cm and (12±8.23) cm in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. The mean length gains of fry at the end of the experiment were highest in T<sub>3</sub>. The mean length of Tilapia fry at the end of the study was higher in treatment T<sub>3</sub> (12 cm), followed by T<sub>2</sub> (9.8cm) and T<sub>1</sub> (8.2cm). Olurin&Aderibigh (2006) collected One hundred juvenile of *Oreochromis niloticus* after the end of the experiment and found the length of fish ranged from 5.5 to 11.4 cm. In the present study the highest average length was in T<sub>3</sub> (11.38) which was almost similar to the findings of Olurin&Aderibigh (2006).

### ***Survival rate (%)***

The mean survival rates of *Oreochromis niloticus* were recorded 93% in all three treatments. During the study period. In the present study, higher survival was achieved as the fish can survive under adverse conditions like low oxygen, high temperature and high pH value. The results of present study were close to the research findings of Felt *et al.* (1998) who observed that the survival rates of koi (*Anabas testudineus*) were varied from 60-80%. The result of this study also agrees with Kohinoor (2000) for T<sub>1</sub> and T<sub>3</sub> who reported that the survival rates of *Oreochromis niloticus* varied from 79%-92%.

### ***Food Conversion Ratio (FCR)***

In the present study Food Conversion Ratio (FCR) values for Tilapia fry with the commercial feed was 3.60 and 2.40 in T<sub>1</sub> and T<sub>2</sub>, respectively. Lower FCR value (2.40) was obtained in T<sub>2</sub> with supplemental feed at the rate of 8% body weight. Ahmed *et al.* (2013) found that Food Conversion Ratio (FCR) was 1.51 and 1.40 respectively in homemade and commercial feed treatments in Tilapia. Hossain *et al.* (2004) found FCR value formulated diet was 1.71-1.77 which was little different from the present study. This difference could be due to the fact temperature and geographical location difference as well management. In the present study moisture content was 11% which could also a cause of higher FCR value. Cruz and Laudencia (1998) indicated that the fingerlings need 2030% crude protein in ration to give optimum results

Comment [U63]: Nile tilapia

Comment [U64]: Nile tilapia

Comment [U65]: There is a discrepancy here. In the text, the survival rate was 90% in T<sub>1</sub>, 93% in T<sub>2</sub> and 96% in T<sub>3</sub>. What are the correct values? Please check.

Comment [U66]: The internationally accepted common name for this species is Climbing perch. Please modify.

Comment [U67]: Nile tilapia

Comment [U68]: Is this value correct? It is huge...

in ponds. The feed in T<sub>2</sub> and T<sub>3</sub> of the present study also contained crude protein within similar range. So, the change in FCR is not due to protein in feed.

### **Water quality parameters**

Reproduction, growth, survivability and other activities of fish are largely depending on temperature. Clarke (2004) reported that metabolic rates of organisms increase with the increase of temperature. Again Clarke (1999) showed that perciform fish have not developed a mechanism that allows them to adapt to the cold environment. Therefore, temperature has a remarkable effect on overall production of fish. During the present study, the water temperatures were between 28°C and 32°C. Azaza *et al.* (2008) suggested that the growth and feed utilization of *Oreochromis niloticus* juveniles may be higher at 26 and 30 °C. In the present study the temperature range was higher than Azaza. On the other hand, Platt & Hauser (2011) reported that the optimum temperature for feeding is between 28.8 and 31.4°C and the fastest growth rate was at 31.4°C, at which the fish averaged an increase of 3.42% of their body weight in 24 h. This temperature range is similar to the present study. Ridha (2006) showed that (29.0±1.0) °C temperature of water can give a remarkable growth (p<0.5) for (*Oreochromis niloticus*).

**Comment [U69]:** Clarke and Johnson, 1999

**Comment [U70]:** Nile tilapia

**Comment [U71]:** This citation does not appear in the bibliography

**Comment [U72]:** Nile tilapia

Dissolved oxygen of a water body is very important factor for fish culture. During the present study, dissolved oxygen content was between 5.8 to 7.40 mg/l. DoF (1996) reported that suitable DO for fish culture is from 5.0 – 8.0 ppm. The DO level of present study is not similar to DoF report. This is due to environmental condition, type of water body and geographic location. Mollah & Haque (1978) reported that DO level is 1.19 – 7.74 mg/l on average in two ponds in BAU Campus. The findings of present study are similar to his study.

**Comment [U73]:** According to table 3, in the case of T3, in weeks 4 and 6 you had a dissolved oxygen level of 7.6. Please check.

The range water of pH level in this study was 7.4 to 8.5. According to DoF (1996) the optimum level for pH is 6.5 to 8.5. The level of pH in the present study is in optimum level according to Boyd (1984) also described that pH level from 6.5 to 8.0 is acceptable for culture. But Mollah & Haque (1978) said that pH level from 5.66-7.66 is suitable for fish culture. Compared to Mollah & Haque (1978) pH level in the present study is little high. This is due to several environmental condition, geographical location and other operational factors.

**Comment [U74]:** You have lower pH values as follows: T1-week 4 (7.0); T2-week 3 (7.0); T3-week 3 (7.0); T3 week 4 (6.5); Q3-week 7 (7.0). Check table 3 and correct.

## Conclusion

*Oreochromis niloticus* has a high acceptance among the people of Bangladesh for its fastest growth, low price and good taste. This influences fish farmers to culture this species throughout the country. In order to have a good profit farmers need to apply additional food as natural food is not always enough for the higher growth in a limited time. In the view of economic aspect, using commercial or supplemental feed in aquaculture should ensure minimum wastage of feed because feed constitute the major part of the total budget and low feeding rate can reduce the target growth. For that reason, fish farmer should have proper knowledge about the exact feed requirement of the fish. Under the experimental condition, different treatments showed different growth rates. In the present study, the mean final weight was higher in T<sub>3</sub>. Although the individual weight gain in T<sub>3</sub> was highest which might be due to difference in feeding rate. Based on the present experimental condition, it can be recommended that the optimum feeding rate for Tilapia in hapa condition is 12% of their body weight compared to 8% and only natural food is not sufficient for the profitable growth.

Comment [U75]: Nile tilapia

Comment [U76]: taste

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