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Comparative Study on Growth and Survival Rate of *Oreochromis niloticus* (Linnaeus 1758) Treating with Supplementary Feed at Different Feeding Regime

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Authors' contributions

This work was carried out in collaboration between all authors. Author SKP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MBUA, MMH and DNB managed the analyses of the study. Author MI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This experiment was designed with three experimental treatments namely T_1 (natural feed), T_2 (feeding with 10% body weight) and T_3 (feeding with 5% body weight) for ten weeks. In the content of 33.8% of crude protein (CP), 11.2% of crude fiber (CF), 6% of fat and 10.2% of ash content feed were used as an experimental diet in this experiment. The stocking densities were 280 fish decimal^{-1} in three treatments where the mean initial weight of fry was 20 ± 0.2 g in all treatments combined

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and at the end of the experiment the mean final weight was found as 58.9 ± 2.86 g, 134.4 ± 3.62 g and 142.5 ± 4.23 g for T_1, T_2, and T_3 respectively. Mean initial length was 10.2 ± 0.01 cm in three treatments and final length was found as 14.58 ± 1.60 cm, 18.74 ± 1.23 cm and 20.16 ± 2.08 cm in T_1, T_2 and T_3 respectively. The mean weight gains 38.9 ± 1.53 g, 114.4 ± 3.05 g and 122.5 ± 1.5 g, mean length gain 4.38 ± 0.24 cm, 8.54 ± 0.65 cm and 9.96 ± 0.59 cm, mean SGR 1.76%, 3.5% and 3.82% were recorded in T_1, T_2 and T_3, respectively. The highest weight gain, length gain and SGR were found in T_3 and the lowest was found in T_1. The survival rate was 82%, 88% and 94% in T_1, T_2 and T_3, respectively. FCR values were found as 3.49 ± 0.5 and 2.51 ± 0.4 in T_2 and T_3. The result demonstrated that feeding with 5% body weight had a better effect on the growth and survival rate of monosex (male) *O. niloticus*.

Keywords: Oreochromis niloticus; growth; feed and survival rate.

1. INTRODUCTION

O. niloticus has been considered as one of the most prominent fish species in tropical & sub-tropical aquaculture [1]. The high yielding variety of Nile tilapia (*O. niloticus)* was introduced by United Nations International Children's Fund (UNICEF) [2] and considered as the fastest growing species for aquaculture in Bangladesh. Among the species, sex-specific differences in growth are significant where males grow significantly faster and larger and are more uniform in size than females [3]. *O. niloticus* prefers shallow water for a living [4]. It primarily depends on natural food like plankton. [5] Has noted that there were seven plankton species found in the stomach content of *O. niloticus*. But best growth in aquaculture cannot be obtained only by natural food. Intensive tilapia culture is dependent almost exclusively on artificial feeding [6]. The growth performance of tilapia was dependent on the type of feed and feeding frequency & water quality in freshwater recirculation systems [7]. Growth and feed efficiency of *O. niloticus* had no more significant difference than two times fed per day [8].

Feeding strategy may provide a clue for maximum growth because the feeding frequency contributes to feed efficiency and growth response. The feeding frequency is important to ensure best weight gain and best feed conversion ratio (FCR) gain of a cultured organism. FCR value depends on the feeding frequency where the percentage of weight gain and also production increase occurs [9]. However, an important step in the feeding strategy is to determine the optimal feeding frequency. In Bangladesh aspects, most of the fish farmers apply the feed into the pond depending on their own idea which results in wastage of feed and economic loss. However additional supplementary feed increases the production cost. One of the major costs in aquaculture is feeding cost [10]. Besides, the quantity of supplementary feed and growth depends on some other factors of water like p^H, temperature, and dissolved oxygen. The perciforms fish cannot adapt to the cold environment due to their undeveloped physiological mechanism [11]. So water temperature is a crucial part and it has a remarkable effect on the overall production of fish especially for perciforms. Survival rate depends on physicochemical factor of water and feed availability, stocking density and so on. The survival rate of *O. niloticus* was is higher with natural food compared to artificial feed [12]. Remarkable growth and survival performance of tilapia have been observed at around 30ºC [13]. The growth of fish performs better in p^H ranging from 5.66-7.66 [14]. Fish can live in dissolved oxygen ranging from 2.0 to 7.4 mg L^{-1} but for better growth, dissolved oxygen must be higher than 5 mg L^{-1} [15]. No further investigation was attempted on the effect of feeding regime on growth and survival rate. Therefore, the aim of the study was to investigate the effect of feeding on growth and survival rates of *O. niloticus*.

2. MATERIALS AND METHODS

2.1 Experimental Design

The experiment was carried out in three experimental cages (dimension $8_L \times 4_W \times 4_H$ $feet^3$ each) in a seasonal wetland (southeastern part of Bangladesh located in the district of Noakhali) for a period of ten weeks. The average depth of the waterbody was six feet while water depth inside the cage was higher than three feet. The cages were made of locally available bamboo and nylon net. The distance of each cage from its neighbouring one was 100 cm and same distance was maintained between the

embankment and a cage. All experimental cages were cleared off all vegetation prior to the commencement of the experiment. The dead fishes and other aquatic organisms were removed by repeated netting. The experiment was designed with three treatments namely T_1, T_2 and T_3, where T_1 control depended on natural food, and T_2 and T_3 got treated with supplementary feed 10% and 5% of the body weight.

2.2 Stocking Density

After preparation of the experimental site, hormone (17α methyl testosterone) treated mono-sex males were stocked into the cages. 30-day old fries were used where the initial average body weight was 20 ± 0.2 g and the length was 10.2 ± 0.1 cm. with 280 fish decimal^{-1}. Fishes were healthy and disease free and transported from the nearest hatchery by oxygenated polybag. The fishes were kept without feeding for 6 hours for conditioning. No fish was marked as deformed or weak after conditioning. Fin, eye, and scales were good in condition. Before stocking, fishes were treated with Epsom Salt Soaking Solution 5 mg L^{-1} (magnesium sulfate) for 3 minutes.

2.3 Water Parameters

The physicochemical parameters of water were measured at 10 a.m. twice in a week regularly. The temperature was measured with using a mercury thermometer, Celsius, p^H was measured by a digital portable p^H meter (Model: HANNA-HI 96107) and dissolved oxygen was measured by a portable DO meter (Model: Lutron-DO-5509).

2.4 Feed Stuff

The experimental floating diet was formulated with local ingredients based on fish meal, mustard oil cake, wheat flour, corn flour, rice bran, bone meal and starch. The formulated feed was made maintaining 2.0 ± 0.3 mm in diameter. The amount of the feed was adjusted once in seven days' interval based on the body weight of the fish. Thus the amount of daily supplementary feed was calculated using the average body weight and the total number of the fish. Half of the ration feed was supplied at 9:00 a.m. and remaining half were supplied at 4:00 p.m. daily. The nutritional composition of the diet used for the experiment was 91% of dry matter (DM) which contains 33.8% of crude protein (CP), 11.2% of crude fiber (CF), 6% of fat and 10.2% of ash (Table 1). In this experiment, the protein was determined by the Kjeldahl method, fat by the Soxhlet method, moisture by oven drying method, fiber by the acid detergent method and ash by using muffle furnace [16].

Table 1. Ingredients and proximate analysis of the experimental diets

Feed Ingredients	Amount of feed (%)
Fish meal	34.1
Mustard oil cake	16.2
Wheat flour	10.6
Bone meal	9.3
Corn flour	11.3
Rice bran	16.5
Starch	2.0
Total	**100**
Proximate analysis	
Crude protein	33.8
Crude fiber	11.2
Moisture	9
Fat	6
Ash	10.2

2.5 Sampling of Fish

Sampling was done in every 7 days' interval. A scoop net was used to catch about 30 percent of fish from the cage, and the length and weight of each species were measured using a scale and digital balance (Lutron GM-600.0 g×0.1 g) respectively. Mortality of the fish was also recorded throughout the experiment. In the experiment, growth performance (weight and length), survival rate, SGR, and FCR were calculated by the following formula

a) Mean weight gain = Mean final fish weight (g) – Mean initial fish weight (g)

b) Specific growth rate (SGR) (%) = $\frac{\ln \text{final weight} - \ln \text{initial weight}}{\text{Culture period (days)}} \times 100$

c) Mean length gain= mean final length – mean initial length.

d) Survival rate (%) = $\frac{\text{number of harvested fish}}{\text{initial number of fish}} \times 100$

e) FCR= $\frac{\text{Amount of feed given by dry weight during the experimental period}}{\text{final live weight gain by the fish}}$

2.6 Statistical Analysis

The data obtained were subjected to one-way analysis of variance (ANOVA) to test the effect of feeding rate as Factorial in Complete Randomized Design. Duncan's multiple range tests were used to compare between

means at $P \leq 0.05$ using Sigma Stat Program version 3.5.

3. RESULTS AND DISCUSSION

3.1 Water Parameters

Water quality is the precursor parameter for aquaculture. Successful aquaculture also depends on the worth of water. In this study, the ranges of p^H, DO and temperature of water was 7.3~7.9, 4.8~6.8 mg L^{-1} and 30~32.5ºC respectively (Table 2). The physicochemical parameters of water in those cages were normal within the range and little fluctuated among the treatments. The water parameters of the study were similar to the other studies [17,18,19].

3.2 Weight and Length Performance

For each treatment, the weight and the length of fry were almost uniform. After harvesting, the average weight of *O. niloticus was* the highest in T_3 ((142.5 ± 4.23 gm) and then in T_2 (134.4 ± 3.62 gm), and the lowest in T_1 (58.9 ± 2.86 gm) respectively (Fig. 1).

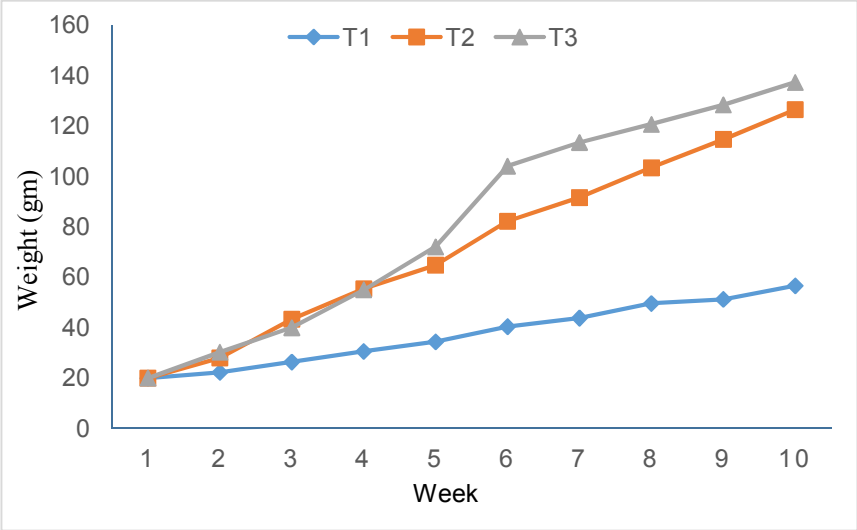

Fig. 1. Weight performance of *O. niloticus* fry in different treatments

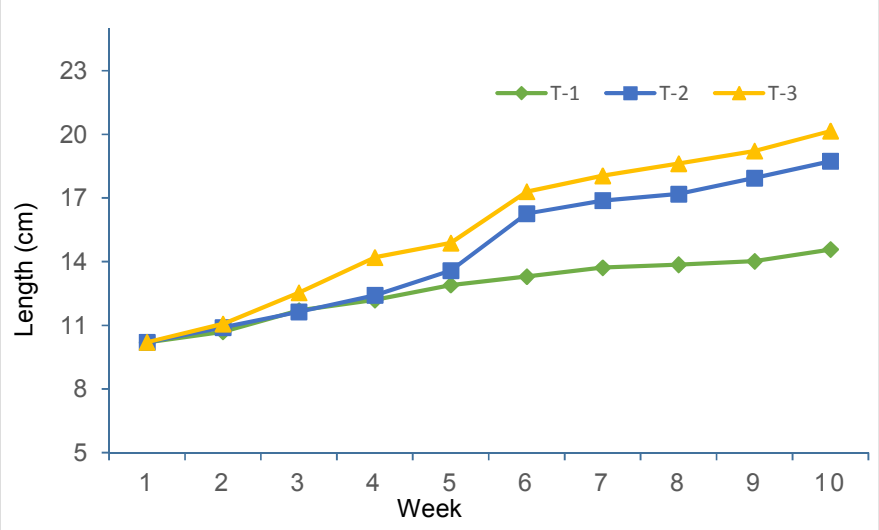

Fig. 2. Length performance of *O. niloticus* fry in different treatments

Table 2. Water quality parameter of the experimental water body

Treatment	Parameter	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week
T_1	p^H	7.5±0.11	7.4±0.16	7.27±0.05	7.43±0.21	7.66±0.16	7.73±0.04	7.47±0.09	7.43±0.07	7.64±0.11	7.47±0.17
	DO (mg L^{-1})	5.2±0.72	6.8±0.43	5.7±0.81	6.3±0.22	5.8±0.43	6.4±0.57	6.0±0.86	5.0±0.32	5.6±0.55	5.2±0.26
	Temperature (ºC)	32.0±1.2	32.5±1.4	30.0±0.84	31.5±1.4	30.8±0.66	30.0±0.62	32.0±0.21	32.5±0.39	30.6±1.1	31.0±0.88
T_2	p^H	7.3±0.12	7.6±0.23	7.22±0.88	7.5±0.31	7.46±0.82	7.86±0.26	7.31±0.13	7.58±0.21	7.5±0.08	7.38±0.18
	DO (mg L^{-1})	4.5±0.44	6.0±0.15	5.8±0.33	5.4±0.52	5.0±0.11	6.00±0.09	7.2±0.08	5.0±0.54	4.8±0.11	5.8±0.22
	Temperature (ºC)	31.5±0.09	32.0±0.17	31.0±0.19	31.0±0.81	30.2±0.66	32.2±0.51	31.0±0.75	31.0±0.31	30.4±0.24	30.0±0.32
T_3	p^H	7.4±0.08	7.46±0.12	7.38±0.11	7.78±0.06	7.5±0.05	7.78±0.16	7.64±0.14	7.38±0.19	7.58±0.06	7.6±0.09
	DO (mg L^{-1})	6.8±0.08	6.4±0.18	6.5±0.22	6.0±0.56	5.6±0.33	5.9±0.21	6.5±0.09	5.4±0.27	5.2±0.33	5.5±0.07
	Temperature (ºC)	31.8±0.17	32.0±0.38	30.5±0.71	31.0±0.93	31.0±0.85	32.0±0.09	32.0±0.12	30.7±0.56	30.0±0.88	30.8±0.29

Table 3. Growth parameters of *O. niloticus* found during the experimental period

Treatment	Measurement	1st Wk.	2nd Wk.	3rd Wk.	4th Wk.	5th Wk.	6th Wk.	7th Wk.	8th Wk.	9th Wk.	10th Wk.	Average per Wk.
T_1	Weight gain (g)	2.3	4.1	4.2	3.8	6	3.4	5.8	1.6	5.4	2.3	$3.9±1.4^b$
	Length gain (cm)	0.5	1.0	0.5	0.7	0.4	0.42	0.14	0.16	0.56	0.5	$0.48±0.2^b$
	SGR	2.18	2.41	2.11	1.67	2.3	1.15	1.78	0.45	1.43	2.18	$1.76±0.5^c$
	Survival rate (%)	100	92	87	82	81	81	77	74	72	72	$82 ±9.0^b$
	FCR			-								
T_2	Weight gain (g)	8.0	15.4	12.0	9.4	17.4	9.4	11.8	11.2	11.8	8	$11.4±2.9^a$
	Length gain (cm)	0.7	0.74	0.78	1.16	2.68	0.62	0.3	0.76	0.8	0.7	$0.92±0.6^a$
	SGR	6.73	6.26	3.49	2.24	3.4	1.55	1.73	1.47	1.4	6.73	$3.5±2.1^b$
	Survival rate (%)	100	94	91	91	88	88	85	83	82	82	$88±5.7^a$
	FCR	3.65	3.98	3.67	3.56	3.98	3.47	3.66	3.23	2.98	2.77	$3.49±0.4^b$
T_3	Weight gain (g)	9.3	12.4	13.3	14.2	12.8	13.2	13.3	12.7	11.2	10.1	$12.2±1.5^a$
	Length gain (cm)	0.87	1.47	1.66	0.68	2.42	0.75	0.57	0.6	0.94	0.87	$1.08±0.5^a$
	SGR	8.31	3.97	4.5	3.85	5.25	1.24	0.88	0.88	0.96	8.31	$3.82±2.7^a$
	Survival rate (%)	100	97	97	95	95	93	93	92	90	90	$94±3.2^a$
	FCR	3.22	3.3	3.16	3.11	2.63	2.22	2.14	1.85	1.83	1.63	$2.51±0.6^a$

Values in the same row having different subscript letters are significantly different ($p < 0.05$)

At the end of the experiment, the average length of *O. niloticus* was found as 14.58 ± 1.60 cm, 18.74 ± 1.23 cm and 20.16 ± 2.08 cm in T_1, T_2 and T_3 respectively. The observed highest length was in T_3 and lowest was in T_1 (Fig. 2). Performance of weight and length of fishes depends on feeding rate, feeding level, stocking density and water quality [20,21].

3.3 Growth and Length Rate

Average weight and length gain, SGR, and FCR were pretentious by feeding rate in this experiment. The average weight gain of T_3 was found highest and lowest in T_1. During the study, weekly weight gain was observed as 3.9±1.4gm, 11.4 ± 2.9 gm and 12.22 ± 1.5 gm; and the sum of total was 38.9 ± 1.53 g, 114.4 ± 3.05 g and 122.5 ± 1.55 g in T_1, T_2 and T_3 respectively. A weight gain of about 128 g for GIFT tilapia in on-farm ponds for a culture period of 6 months fed rice bran at 5-6% of their body weight [22]. Insignificant differences (P >0.05) were found between the treatment of T_3 and T_2 whereas significant differences were observed with T_1. Weight gain was adversely affected by stocking density and feed utilization of fishes [23] and protein level in feed stuff [24]. Length gain has positive correlation with weight gain. In this experiment, total length gain was observed as 4.38 ± 0.2, 8.54 ± 0.6 and 9.96 ± 0.6 cm in T_1, T_2 and T_3 respectively where the highest was in T_3 and the lowest in T_1 (Table 3). The length of *O. niloticus* ranged from 5.5 to 11.4 cm during their experiment [25] which was similar to the present study.

From the study, we found that specific growth rates (SGR) of fishes were 1.76 ± 0.5, 3.5 ± 2.1 and 3.82 ± 2.7 in T_1, T_2 and T_3 respectively with insignificant differences among the treatments. The SGR values were decreasing with the increasing length of the study period (Figure 3). [26] Found that specific growth rates (SGR) of mono-sex tilapia were 3.09 and 2.97 by using homemade and commercial feed which is also close to the present study. In this experiment, we found higher SGR compared to study [26,20].

In this experiment, FCR for tilapia fry with formulated feed were 3.49 and 2.51 in T_2 and T_3, respectively indicated with significant differences among those treatments. Lower FCR value (2.51) was obtained in T_3 with supplemental feed at the rate of 5% body weight (Table 3). FCR were 1.51 and 1.40 respectively in homemade and commercial feed treatments in mono-sex GIFT tilapia [25] but the value of FCR was 1.71-1.77 with used GIFT strain fed on formulated diet [27] which was a little different from the present experiment. This difference could be due to the temperature and geographical location difference as well as management.

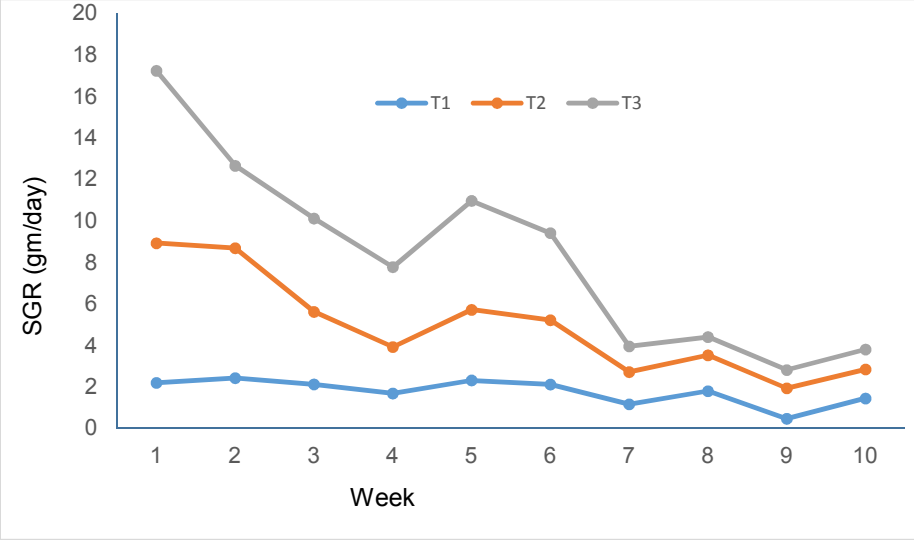

Fig. 3. Specific growth rate (SGR) of *O. niloticus* in different treatments

3.4 Survivability

In the present study, the same survival rate in all of the treatments was not observed. This variation was different feeding percentage and feed utilization. Highest survival rate was found in T_3 (94%), then in T_2 (84%) and T_1 (82%) respectively (Table 3). Among the treatments, there were insignificant differences between T_3 and T_2, but specified significant differences with T_1. Similar survival rate of *O. niloticus* was reported by [20,21, and 28] with different individual research conditions.

4. CONCLUSION

The length, growth performance and survivability were pretentious by 5% & 10% body weight supplementary and natural feed and were significantly different under different feeding rates. Based on the present experimental condition, it can be recommended that the optimum feeding rate for tilapia in cage condition is 5% of their body weight compared to 10% and natural food is not sufficient for the notable growth. Therefore, culturing of mono-sex *O. niloticus* will enable fish farmers to reach the goal of 5% body weight of fish supplementary feed within a relatively shorter period of time.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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