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Effect of Feeding Frequency on Growth Performance and Survival of Nile Tilapia (*Oreochromis niloticus* L. 1758) in a Cage Culture System in Lake Hora-Arsedi, Ethiopia

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Abstract

In this study, the growth performance and survival rate of Nile tilapia (*Oreochromis niloticus*) subjected to different feeding frequencies were evaluated in cage culture. Juveniles with mean initial weight of 35.99 ± 0.23g were stocked in 1 m^3 net cages and assigned to a duplicate of 50 fish in a completely randomized design in six treatments. T1 were fed 3% of their body weight divided into four equal meals per day for the first three months and then allowed to feed two times a day for the next three months; T2 and T3 were fed 3% of their body weight divided equally at frequency of four and two feedings/day, respectively, throughout the experiment. Feed was given once a day (without dividing) for T4 and once every other day (without dividing) for T5 throughout the experiment. All treatments were fed pelleted diet except the control groups in which fish were provided with only the natural food. The mean specific growth rates (SGR), Feed conversion ratio (FCR) and Feed conversion efficiency (FCE) were statistically similar for T1 and T2, but they were higher than T3, T4 and T5. However, mean weight gain, mean daily gain and Condition Factor (CF) showed a significant difference (P<0.05) among experimental groups. In conclusion, growth performance and net yield were increased with increased feeding frequency, so frequent feeding was recommended for optimum result of *O. niloticus* in cage culture. It was also revealed that cage culture at experimental level has no effect on the water quality and plankton abundance.

Keywords: Cage culture; Feeding frequency; Growth performance; *Oreochromis niloticus*; Survival

Introduction

Diet supplementation and selection of appropriate species for culturing environment are important criteria in aquaculture. Nile tilapia (*Oreochromis niloticus*) is a widely-cultured species all over the world [1-3], as it is easily spawned, tolerance to handling, and resistance to disease, efficient conversion of natural and prepared feeds, controllable reproduction, good marketability, tolerates poor water quality and grows rapidly at warm temperature [3-5]. Since the feed cost accounts approximately 50% of the operating costs in intensive culture systems [4,5], the economic viability of the culture operation depends on appropriate use of feed [6].

Nutrition is one of the most important factors influencing performance of cultured fish and is influenced by factors such as behaviour of fish, stocking density, quality of feed, daily ration size, feeding frequency and water temperature. Feeding frequency mainly depends on species cultured, age, size, feed quality and environmental factors [5,7-11]. These characters of species and environmental factors influence gastric evacuation time (return of appetite) of cultured organisms and gastric evacuation time of cultured organism on the other hand influences feeding frequency [12]. De Silva and Anderson [7], Tran et al. [13] and Malcolm et al. [14] reported that determining optimum ration size and feeding frequency is an important step in aquaculture operation since they are important to ensure maximal Feed Conversion Ratio (FCR) of cultured organism.

Several researches were carried out on effects of feeding frequency on growth of different fish species at different life stages, environmental conditions and culture conditions; but optimal feeding frequency is highly variable from species to species [15-22]. On the other hand, there is little information about optimum feeding frequency of farmed *O. niloticus*. Therefore, the aim of this study was to investigate effect of feeding frequency on growth performance and survival of *O. niloticus*.

Materials and Methods

Study site and experimental design

The study was conducted in Lake Hora-Arsedi, one of the Crater Lakes in Ethiopia and located at altitude of 1850 m asl and 8° 46'' N and, 38° 59'' E, is 45 km southeast of Addis Ababa (the capital of Ethiopia). The jetty was constructed from wood (eucalyptus) (at site 1) which is perpendicular to the water current [4,23-25]. It has an average depth between 6-7 m, 25 m length and 1m width, which is 7 meter away from the shore. The control site (site 2) was selected to sample plankton and for measuring physical parameters and compare that with the experimental site. Cages with the size of 1 m^3 (1m × 1m × 1m) were constructed from frame (PVC type 50, tube of 10 cm with 1 mm polyethylene material) and the enclosure nylon netting material with mesh size of 4 mm as an enclosure material. The cages were placed side by side in rows under the jetty with equal interval (0.75 meter apart).

Mixed sex juveniles of *O. niloticus* were collected from Lake Hora-Arsedi using beach seine hauls 50 m × 2.5 m (with stretching mesh size of 20 mm). Immediately after screening, the fingerlings were transported to experimental cages by plastic barrel half-filled with lake water. The total length (TL. by measuring board) and total weight (TW. digital balance) were measured and fingerlings with length 115

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mm to 138 mm and weight of 30-40 gm were selected as experimental juveniles. Equal numbers of mixed sex juveniles (50 fingerlings) were stocked in duplicates of six treatments (T1, T2, T3, T4, T5 and T6) in a completely randomized manner.

Supplementary feed and feeding frequencies

Experimental diet was formulated to contain 30% crude protein which was optimum for *O. niloticus* as suggested by El-Sayed [5], and was prepared from locally available materials; Niger seed (*Guizotia abyssinica*) cake (20%), mill sweeping (16%), meat and bone meal (28%), wheat bran (32%) and wheat flour (4%). Water stability of the pellet was tested in fishery lab of Addis Ababa University. The average analyzed proximate nutritional compositions of food types are listed in Table 1.

The first four treatments (T1, T2, T3 and T4) were fed extruded feed (sinking pellet) 3% of their body weight daily, but T5 were fed 3% of their body weight every other day. Control groups (T6) were fed directly from the natural environment only. The feeding frequency and timing in different treatments over the experimental period is shown in Table 2. All treatments had free access to natural foods. Feed ration was placed in feeding trays, which was suspended at the midpoint in each cage. The amount of feed was adjusted every two weeks according to the new mean fish weight in each treatment.

Data collection

Water temperature was measured with thermometer *in-situ* monthly at 25 cm below the surface of water at experimental and control sites. Concentration of dissolved oxygen (DO) and pH of the water were measured *in-situ* using oxygen meter and pH meter respectively monthly from January 16 to July 14, 2012. Euphotic depth of the lake was also estimated using Secchi disc at two sites to evaluate the effect of cage culture on water quality.

Weight and length of stocks were recorded starting from January 16, 2012 for each cage and dead fish were removed and recorded. During sampling, 30% of the stocked fish in each cage were scooped from each treatment randomly by use of scoop net every two weeks till July 14, 2012. The fish length and weight were measured using measuring board and digital balance respectively, and recorded. At the end of the experiment, the fish were harvested, counted; the weight and length of all the fish were measured.

Feed types	Nutrient Compositions by %					References
	Moisture	Crude Protein	Crude fat	Crude fiber	Ash	
Wheat flour	8.60	19.29	2.10	6.25	0.80	Tekeba Eshetu in 2005 [10]
Wheat bran	11.00	18.00	4.80	11.00	7.00	Stanton and Levallecy in 2010 [35]
Meat and bone meal	10.83	52.48	11.36	4.18	20.86	Asfaw Alemayehu in 2010 [21]
Niger seed cake	13.95	33.80	9.10	19.00	11.00	Tadelle Dessie and Ogle in 1997 [9]

Table 1: Feed types used and their nutrient proximate composition.

Treatments	Feeding frequency	Timing
T_1	A restricted daily ration divided into four equal meals and given four times a day for the first three months	8:00 a.m., 11:00 a.m., 2:00 p.m., 5:00 p.m.
	A restricted daily ration divided into two equal meals and given two times a day for the second three months	8:00 a.m., 5:00 p.m.
T_2	A restricted daily ration divided into four equal meals and given four times a day throughout the experimental time	8:00 a.m., 11:00 a.m., 2:00 p.m., 5:00 p.m.
T_3	A restricted daily ration divided into two equal meals and given two times a day throughout the experimental time	8:00 a.m., 5:00 p.m.
T_4	A restricted daily ration given once a day (without dividing) throughout the experimental time	8:00 a.m.
T_5	A restricted daily ration given once every other day (without dividing) throughout the experimental time	8:00 a.m.
T_6	Controls (Fed directly from the natural environment only)	-

Table 2: Feeding frequency and timing in different treatments over the experimental period.

Data analysis

Growth performances and feed utilizations were calculated in terms of Weight Gain, Daily Growth Rate, Specific Growth Rate, Feed Conversion Ratio, Food Conversion Efficiency, Survival Rate and Net yield based on the following relationships:

$$Weight\ Gain\ = Final\ weight\ (W_2)\ -\ Initial\ Weight\ (W_1)$$

$$Daily\ Growth\ Rate\ (DGR,\ g\ /\ day)\ = \frac{Final\ Weight - Initial\ Weight}{Cultured\ days}$$

$$Specific\ Growth\ Rate\ (SGR,\ g\ \%/\ day)\ = \frac{(In(W2) - In(W1))}{-No\ of\ Cultured\ days} \times 100$$

where W_1 and W_2 are initial and final weight (g) respectively

$$Survival\ rate\ (SR,\ \%) = \frac{N2}{N1} \times 100$$

where N_2 = No. of fish harvested and N_1= No. of fish stocked

$$Food\ Conversion\ Ratio\ (FCR) = \frac{Total\ weight\ of\ dry\ feed\ given}{Total\ weight\ gain\ by\ fish}$$

$$Food\ Conversion\ Ratio\ (FCR) = \frac{Total\ weight\ of\ dry\ feed\ given}{Total\ weight\ gain\ by\ fish}$$

$$Food\ Conversion\ Efficiency\ (FCE,\%) = \frac{Gain\ in\ wet\ weight\ in\ fish}{Feed\ fed} \times 100$$

The well-being of fish was studied by calculating the Fulton Condition Factor (FCF);

$$FCF\ (\%\ in\ gm\ /\ cm^3) = \frac{TW}{TL^3} \times 100$$

where TW is total weight (gm) and TL = total length (cm)

The significance of relationships of growth performance data were statistically tested using one-way ANOVA by SPSS statistics software version 20. Moreover, one-way ANOVA was used to check the variation in physical parameters, zooplankton and phytoplankton abundance between site 1 and site 2. All statistical tests were considered significant at $p<0.05$.

Results

Physical features of lake hora-arsedi

During the study period maximum water temperature (25.8°C) occurred in April in site two, while the minimum (22.6°C) was measured in February in sites 1. The DO measured at the two sites varied from 5.16 to 8.05 at site1 to 5.59 to 8.07 at site 2. The pH of the water ranged from 8.4 to 8.8 at site 1 and 8.3 to 8.8 at site 2. Secchi depth ranged from 91.5 to 110 cm at Site 1 and 91 to 111.5 cm at Site

2 (Table 3). All physical parameters were not significantly affected by culture conditions (p>0.05) but were affected by experimental dates alone (p<0.05).

Growth performances

The highest mean weight (205.17 g) was recorded at T1 and 201.07 g at T2 followed by 172.39 and 168.79 g at T3 and T4, respectively. The lowest mean weight was recorded at feeding frequency of T5 but all were better than T6 (non-feeding group) (Table 4). The maximum mean (0.947 $gday^{-1}$) and minimum mean (0.557 $gday^{-1}$) daily growth rates (DGR) were observed in T1 and T5 among feeding treatments, respectively. The least DGR of (0.302 $gday^{-1}$) were recorded for control group (non-feeding group). Daily growth rate decreased with decreasing feeding frequency and without supplementary feeding (Figure 1). Maximum mean specific growth rate (SGR) of 0.979% $day^{-1}fish^{-1}$ and 0.953% $day^{-1}fish^{-1}$ were recorded for treatment T1 and T2, respectively; whereas the minimum mean SGR was recorded as 0.743% $day^{-1}fish^{-1}$ in treatment T5. The mean specific growth rate also decreased with decreasing of feeding frequency (Table 4).

The best mean FCR, FCE, net yield and annual total net production was recorded at T1 and T2 whereas the lowest was recorded at T5. There was no significant difference in food conversion ratio in the T1 and T2 before twelve weeks, while the least FCR was observed in T5 until week 12. Based on this, FCR for T1 and T2 differed significantly (p<0.05) from T5 and was better but not significant than T3 and T4 until week 12. However, mean FCR was not significantly different (p >0.05) among treatments at the end of the experiment (Table 4). The Fulton condition factor decreased as feeding frequency decreased and the lowest Fulton condition factor was observed in T5 from feeding treatments and in control group T6 (Figure 2). There was no significant difference observed in T1 and T2 during the experimental period (p >0.05), but they were superior and varied significantly from T3, T4, T5 and T6 (p<0.05). There was also no significant difference observed between T3 and T4, however they differed significantly from T5 and T6 (p<0.05). Survival rate was not significantly affected by feeding frequency and experimental period among feeding treatments (p> 0.05) but it showed significant variation from control group (p<0.05).

Discussion

It was revealed from data during the study period that water quality parameters were within the range that provides good growth for *O. niloticus* in cage culture and which were recommended by Stickney [3] and El-Sayed [5]. There was no significant difference observed in water temperature, pH, dissolved oxygen and Secchi depth during the study period at the two sites (p>0.05). These showed that cage culture has no effect on water quality at experimental level. It was also revealed from monthly data that there was insignificant variation (p>0.05) in the abundance of planktons between two sites. This is due to small amount

Sampling dates	Water temperature (⁰C)	pH	Dissolved oxygen (mg/l)	Secchi depth (cm)	Euphotic depth (cm)	Stations
16, Jan 2012	22.7	8.6	7.60	101.5	304.5	Site 1
	22.7	8.5	7.20	102.0	306.0	Site 2
15, Feb 2012	22.6	8.8	8.05	94.0	282.0	Site 1
	23.0	8.5	8.07	94.5	283.5	Site 2
16, Mar 2012	23.0	8.8	5.38	91.5	274.5	Site 1
	23.4	8.8	5.65	91.0	273.0	Site 2
15, Apr 2012	25.5	8.4	6.50	92.5	277.5	Site 1
	25.8	8.3	6.72	94.5	283.5	Site 2
15, May 2012	25.1	8.6	5.16	99.0	297.0	Site 1
	25.2	8.6	5.59	98.5	295.5	Site 2
14, Jun 2012	24.1	8.6	6.30	104.5	313.5	Site 1
	24.5	8.8	6.35	106.0	318.0	Site 2
14, Jul 2012	24.0	8.5	6.76	110.0	330.0	Site 1
	24.1	8.4	6.79	111.5	334.5	Site 2

Table 3: Physical parameters in Lake Hora-Arsedi during the experimental period.

		Treatments			
Parameters	T_1	T_2	T_3	T_4	T_5
Mean weight of initial stock (gm)	35.06 ± 0.539^a	36.16 ± 0.562^a	36.30 ± 0.539^a	36.11 ± 0.515^a	35.80 ± 0.613^a
Mean weight of final stock (gm)	205.17 ± 5.124^d	201.07 ± 3.521^d	172.39 ± 4.092^c	168.79 ± 4.799^b	135.56 ± 5.150^a
Mean length of initial stock (mm)	132.27 ± 0.911^a	133.63 ± 1.406^a	131.63 ± 0.835^a	133.77±1.097^a	132.2 ± 0.999^a
Mean length of final stock (mm)	201.03 ± 5.242^d	198.10 ± 5.898^c	196.33 ± 5.782^b	196.43 ± 5.197^b	194.07 ± 4.961^b
Weight of feed (kg)	71.58	71.37	61.45	60.39	45.97
Food conversion Ratio (FCR)	3.73^a	4.21^a	4.66^a	4.79^a	4.69^a
Specific growth rate (SGR) %$day^{-1}fish^{-1}$	0.98^c	0.95^c	0.87^b	0.86^b	0.74^a
Mean daily growth ($gmday^{-1}$)	0.95^c	0.92^c	0.78^b	0.75^b	0.56^a
Fulton condition factor (FCF) (% in gm/cm^3)	2.55^a	2.54^a	2.12^b	2.11^b	1.82^c
Survival rate (SR, %)	100	100	100	100	98
Stocking density ($fish/m^3$)	50	50	50	50	49
Total net yield ($kgyear^{-1}$)	17.25	16.73	13.79	13.44	9.94
Total weight gain ($kgcage^{-1}$)	8.51	8.25	6.80	6.80	4.90
Values in the same rows with different superscripts are significantly different (p<0.05).					

Table 4: Growth parameters, total amount of feed supplied, food conversion ratio and total net yield of feeding treatments during experimental period.

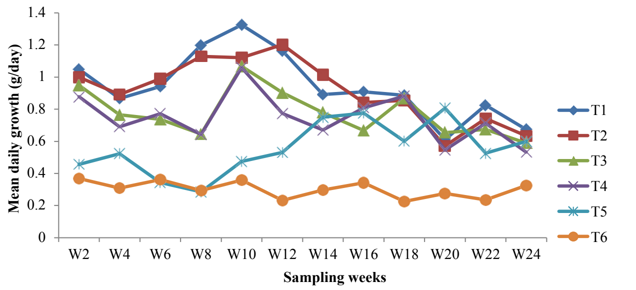

Figure 1: Mean daily growth rates of *O. niloticus* at different feeding frequency and control group.

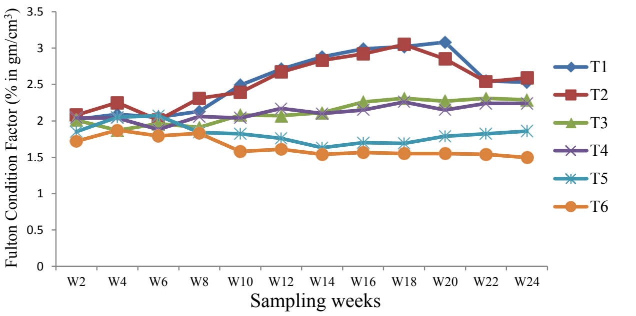

Figure 2: Fulton condition factor of *O. niloticus* at different feeding frequency and control group.

of nutrients entering in to the lake at experimental level compared to huge cage culture industries.

In this study feeding frequency had a significant effect ($p<0.05$) on growth of *O. niloticus* and there is a positive relation between growth and increasing feeding frequency of this species. This agrees with the justification of Riche and Garling [26], Pillay and Katty [4], El-Sayed [5], Lim et al. [27] and Suresh and Bhujel [28]. They were explained that due to continuous feeding behaviour and smaller stomach capacity, tilapia respond better to more frequent feeding than other finfish and benefited from multiple daily feeding. Parker [29] also reported that tilapia cannot consume their daily requirement of feed for maximum growth in a single meal of a short duration, thus more than one feeding is needed each day. The work of Gaber and Hanafy [30] also confirmed this result. *O. niloticus* showed better growth at a feeding frequency of four times a day than two times a day without depending on the protein sources (fish meal protein or soybean meal protein) when fed restricted daily ration. Lim et al. [27] and El-Sayed [5] further explained that dividing the daily ration of tilapia reared in cages would probably reduce the exposure time of feed in the water and reduce the leaching rate of pellet and loss of nutrients. Thus, they recommend that dividing daily ration help to assure rapid and complete ingestion of the offered amount of feed and result in maximum FCR and good growth performance in this species.

Craig and Helfrich [31], Nandlal and Pickering [32] and El-Sayed [5] noted that feeding frequency should be lowered as fish grow. El-Sayed [5] noted that during larval stages, tilapia requires a daily ration of about 20% to 30% of their body weight divided into six to eight feedings. It must feed 3% to 4% of their body weight divided three to four times a day at the age of fingerlings. Board on Agriculture [33] in USA and Suresh and Bhujel [28] noted the nutrient requirements of fishes and identified the daily feeding allowance and frequencies for various species of fishes at different sizes. They stated that feeding allowance and feeding frequency varied with the size of fish and species under the culture condition. For tilapia species for instance, for fish size ≥ 20 g and ≤ 100 g, feeding allowance must be 4% to 3% of their body weight at frequency of three to four times a day. However, for fish size >100 g, 3% to 2% of their body weight must be provided at frequency of two to three times a day for good growth. In this study however, T1 (changed frequency from four times a day to two times a day) has shown insignificant difference in weight gain than T2, which was fed four times a day throughout the experiment.

Since we don't have data on the amount of waste feed and the amount of feed used by fish for growth, it is difficult to calculate FCR in cage culture. However, in this research we compared the FCR of treatments based on the amount of feed given daily for different treatments. Based on the above assumption the FCR of T2 and T1 varied significantly ($p<0.05$) from other treatments until the twelve week. This might be due to the somatic growth stage of the fish. Since the stomach at this stage was small, they benefited from frequent feeding of small amount and used extracted nutrients to build new tissue. The values obtained for Feed Conversion Efficiency (FCE) were also reflection of FCR values. FCE was >50% in early stage for T1 and T2 indicating that increasing feeding frequency maximizes efficient conversion of feed and good growth at early stage of the fish. The mean highest FCE was also observed in feeding frequency of T1 and T2. These results were in agreement with the finding of Siraj et al. [34,35] on red tilapia, (*Oreochromis mossambicus*) hybrid. They found that feeding frequency has significant effect on FCR of this species when feed restricted daily ration frequently when they are small sized.

However, the mean FCR of all the fish was not significantly affected by feeding frequency in the present study ($p>0.05$). This agreed with the study of Gaber and Hanafy [30] on *O. niloticus* in concrete tanks. They reported that feeding frequency has no significant effect on FCR of the fish if the species was fed restricted daily ration. Gokcek, et al. [18] study on *Barbus luteus*, Abid and Ahmed [36] on juvenile *labeo rohita,* Ayo-Olalusi and Ugwumba [37] on Juvenile *Clarias gariepinus* and Tiril and Alagil [19] on rainbow trout, showed similar result to this experiment. They noted that feeding frequency has no significant effect on the FCR of those species.

Mean maximum SGR was attained for T1 and T2 and the minimum was observed in T5 from feeding treatments. This showed that supplementary feeding and increasing feeding frequency needed to ensure maximum percentage body weight increase per day. Similar result was observed in research done by Gaber and Hanafy [30] on *O. niloticus*. They reported that increasing feeding frequency has positive effect on SGR on this species. Nekoubin and Sudagar [22] on juveniles of Grass Carp and Priestley et al. [17] on Common Gold fish also confirmed that increasing feeding frequency to certain extent is important to attain better percentage body weight increase per day.

It was also revealed from this study that increased feeding frequency maximized the well-being of this species. The possible justification for better FCF for T1 and T2 was that they were fed frequently small amount of feed and this made them attain maximum FCE and FCR which resulted in good growth performance than other treatments. However, all treatments were in better condition than T5 and T6 (a non-feeding group). T5 were deprived of feed for three days per week and didn't feed 72 days from a total of 180 stocking days. This might have resulted in growth retardation in this group however; the lowest FCF in control group was due to absence of supplementary feed in this treatment. Contrary to this result, Gaber and Hanafy [30] findings on *O. niloticus* cultured on concrete tanks show that condition factor is not affected by feeding frequency if the fish were fed four times or twice a day.

It was found out that *O. niloticus* benefited from frequent feeding of small amount and used extracted nutrients for growth with better FCR, SGR, MDG, and FCF than less frequent feeding. In addition, net yield and total weight gain (kgcage^{-1}) were directly related to feeding frequency. However, feeding frequency has no effect on survival of this species at this experimental condition.

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