Thesis for the Degree of Master of Fisheries Science

Effects of Different Feeding Regimes on the Growth and Compensatory Growth of Juvenile Nile Tilapia *Oreochromis niloticus*

by

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Pukyong National University

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먹이공급 횟수가 틸라피아 치어의 성장 및 보상성장에 미치는 영향

Advisor: Prof. Chang-Hoon KIM

by

Etah Collins Ayuk

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Abstract

Feed and feeding regimes are relevant to any successful commercial aquaculture investments the world over. Feeding cost alone approximates about 55% of any fish farming venture. The number of feeding days per week and frequency of feed administered influences growth rate amongst other factors. In order to reduce waste and increase profitability in any aquaculture venture, the frequency and number of feeding days per week will obviously play a dominant role. Improved feeding strategies will not

only increase profit margins but will invariably spare additional time for fish farmers to invest in other spheres of economic activities.This research was conducted to investigate the most appropriate feeding regime per week on growth that could be adopted for juvenile Nile tilapia. The phenomenon of compensatory growth was equally investigated as insufficient information is available relating this specie to feed and compensatory growth.

The juvenile Nile tilapia *Oreochromis niloticus* were fed using 4 different weekly regimes. Each treatment was in quadruplet and was fed 3 times daily for 4 days, 5 days, 6 days and 7 days per week. At the end of the growth experiment, treatments in duplicates were fed 3 times daily for 7 days per week to investigate the phenomenon of compensatory growth. The results showed that the optimal growth occurs within 5 to 7 weekly feeding days. Juvenile Nile tilapia demonstrated full or complete compensatory capacity as the least fed group grew and caught up with the most fed group of 7 feeding days per week. These results are discussed in relation to earlier works on feeding rates and compensatory growth.

Keywords: feeding regimes; compensation growth; feeding strategies; Nile tilapia; *Oreochromis niloticus.*

I. INTRODUCTION

Aquaculture is the fastest growing segment of the world agriculture economy. Almost half (47%) of the global seafood production comes from farms (FAO, 2009). Since 1970, this sector has maintained an average annual growth rate of 8.7 percent worldwide excluding China with an annual growth rate of 6.5% (FAO, 2009).

Paradoxically, the life cycles of wild aquatic species, both from fresh and saltwater sources, cannot keep pace with the demand of seafood especially in this era of increasing demographics. The gap between supply and demand of seafood has continued to widen over the recent years. Aquaculture is therefore expected to fill the shortfall in aquatic food products resulting from static or declining capture fisheries (De Silver, 2000; Saalah et al., 2010). Several Countries of the World are now increasing seafood production through aquaculture, fish being a good source of safe animal protein for human life.

Tilapia, a cichlid fish that originated from Africa has been described as the most important aquaculture species of the 21st century (Modadugu et al., 2004).They also mentioned that tilapia culture in its embryonic form is believed to have started more than 4000 years ago in Egypt but the first scientifically oriented culture was conducted in Kenya in 1924. Since then, there have been tremendous developments in tilapia farming.

The Nile tilapia *Oreohromis niloticus* is one of the most farmed fish in the tropical and subtropical regions of the world and is favoured by its rusticity, fast growth, adaptation to diverse environments, good consumer acceptance and high quality low fat content (Petenuci et al., 2008). They are omnivorous, feeding mainly on phytoplankton, bacteria, detritus and other aquatic vegetation, but will readily accept complete pelleted feeds.

It is a robust fish with excellent characteristics such as resistance to diseases and tolerance to poor water quality (Guerrero, 1982; Galman and Avtalion, 1983; Daud et al., 1988; Wangead et al., 1988; Tantwtti et al., 1988).

Water temperature is one of the most important environmental factors affecting fish physiological responses to growth and feed utilization. In the temperate regions, production is carried out in temperature controlled recirculating aquaculture system or indoor tanks. Optimal temperatures for good growth and feed efficiency are typically between 25° C and 34°C (Xie et al., 2011).

In 2008, Nile tilapia culture alone was ranked fifth among the most cultured species in the world, with a total aquaculture production of 2.3 million metric tonnes representing approximately 84% of total global tilapia production (FAO, 2009). As long as fish farming continues to improve human nutrition and livelihood, tilapia will likely play a leading role especially in developing countries like those of Africa where it is widely consumed and accepted by all and sundry (Gopalakrishnan, 1988; Modadugu et al., 2004).The males are preferred for commercial fish culture due to their inherent rapid growth rate (Toguyeni et al., 1997) that are usually about 40% greater than females reared under comparable conditions.

Tilapia, “the water chicken”, can be reared in intensive systems like cultured tanks and the recirculating aquaculture system (RAS). Production in intensive systems will necessitate the rational use of feed to obtain optimal growth. The goal here is for fish to grow rapidly, feed utilized efficiently and wastage kept to the barest minimum so as to achieve economy of scale.

Generally, various factors ranging from temperature, water quality, dissolved oxygen, stocking densities; health status, quality and quantity of feed administer influenced fish growth. Amongst these several factors, feed alone is the principal operating cost and the most important input in any incentive aquaculture industry (Okumus and Bascinar, 2002; Wu et al., 2004). In the Atlantic salmon cage culture for example, feed fish alone represents about 50% - 60% of total production cost (Vielman et al., 2000; Saalah et al., 2010). A restricted feeding rate is often implicated as a potential cause of poor growth, poor feed conversion, and impaired health (Wu et al., 2004).

Conversely, overfeeding could cause overload of stomach and intestine, and decrease the efficiency of digestion and absorption (Jobling, 1986; Storebakken and Austreng, 1987a; Hung and Lutes, 1987; Hung et al., 1989; Fontaine et al., 1997; Du et al., 2006). Proper feed management under production conditions is essential for the farmer to obtain maximum growth, better feed efficiency and economic gains. The quality of feed in terms of nutrients composition including manipulations of feeding strategies can be helpful to minimise feed loss, water pollution and decrease production cost (Du et al., 2006).

Several studies in this domain have been carried out in many commonly farmed aquaculture species (Charles et al., 1984; Chiu, et al., 1987; Hopkins et al., 1988; Carlos, 1988; Kiron and Paulraj, 1990; Tung and Shiau, 1991; Hung et al., 2001; Dada et al., 2002).

The price competitive nature of fish farming nowadays is more like any livestock farming venture requiring an increased precision in rationing feed to reduce input costs while maintaining maximum performance (Saalah et al., 2010). Nutritional scientists have excelled in formulating fish diet of high nutritional value (Paus et al.,1998; Saalah et al., 2010) and digestibility (Booth et al., 2000; Hansen and Storebakken, 2007; Saalah et al., 2010). However, adopting feeding regimes that allow maximum food utilization will invariably provide extra benefit such as lesser wastes and a friendlier environment for the culture fish.

Efficient, viable and sustainable production will take into account feeding regimes that provide optimal growth while reducing feed administered to its barest minimum. This could be an effective way to reduce production cost while increasing profitability in commercial aquaculture production. A good knowledge of feeding regimes is therefore essential as this may influence the success or failure of production operations (Jobling et al., 1995b; Okumus and Bascinar, 2001).

If fish have to grow rapidly, feed utilized more efficiently and wastage kept to the barest minimum, knowledge of nutritional requirements, feeding regimes and management practices is inevitable (Jobling et al., 1995a; Okumus and Bascinar, 2001). Manipulation of feeding time, frequency of daily feeding and numbers of weekly feeding days is of paramount importance in rationing fish feed to minimise waste. Production costs using intensive systems like RAS are generally higher than those for fish grown in ponds.

Thus, it is imperative that the most cost-effective and efficient method of feeding is utilized when fish are grown indoors (Thompson et al., 2000). No sufficient information is available on how weekly feeding regimes affect growth of juvenile Nile Tilapia and therefore investigations in this domain is inevitable and unavoidable. Considering the potential economic benefits associated with improved feeding strategies, it is necessary to consider how weekly feeding regimes can influence the growth of juvenile fish.

Compensatory growth (CG) is a phase of unusually rapid growth, following a period of under nutrition (Dobson and Holmes, 1984; Wang et al., 2000). It is a phase of accelerated growth when favourable conditions are restored after a period of growth depression (Ali et al., 2003). Through this growth spurt, animals subjected to previous nutritional restriction may catch up completely or partially in body size with those that have not undergone food restriction (Dobson and Holmes, 1984; Russell and Wootton, 1992; Kim and Lovell, 1995; Wang et al., 2000). CG could be partial, complete or over compensation and is significantly greater in individuals that have experienced growth depression.

Compensatory growth in fish is not only of theoretical interest, but may also have applications in aquaculture (Quinton and Blake, 1990; Jobling et al., 1994; Wang et al., 2000) as appropriate exploitation of this phenomenon may result in increased growth rate and feed efficiency. CG offsets the effect of growth arrest and reduces variance in size. This could be relevant to fisheries management and life history analysis of the specie.

Results from studies on compensatory growth in fish have yielded inconsistent results. Compensation has been observed in most studies, but only a limited capacity for compensatory growth has been reported in others

(Schwarz et al., 1985; Pirhonen and Forsman, 1998). For species that exhibit compensation growth, the farmer may get similar production values while using less effort to feed the fish (Ali et al., 2003). Restricting food supply could equally provide greater economic flexibility as such feeding strategies could improve management of personnel time and water quality.

However, CG may not be evoked if the food restriction exceeds a certain severity (Ryan, 1990). There are levels of deprivation that are too small to evoke a compensatory response, levels that will provoke a full compensatory response and levels so severe that full recovery cannot be achieved.

Little information is available about the possible response of juvenile Nile tilapia to compensatory growth. As the CG response differs between species (Wieser et al., 1992; Zhu et al., 2001), it will be fascinating to investigate if such phenomenon does exist in juvenile Nile tilapia.

The objective of this study is to determine the effects of weekly feeding regimes (4, 5, 6, and days feeding a week) on growth of juvenile Nile tilapia and to investigate the phenomenon of compensatory growth.

II. MATERIALS AND METHODS

2.1. Growth experiment

2.1.1. Experimental Design

The experiment was conducted between 31st March and 30th of May 2011 at the Aquaculture Engineering Laboratory of the Pukyong National University. The design was made up of sixteen glass aquaria arranged into four systems as shown in Fig 1.

One system consist of four linearly arranged glass aquaria, a pump and a rectangular biofilter concrete tank connected with PVC pipes to form a laboratory model of a closed recirculating aquaculture system (RAS).

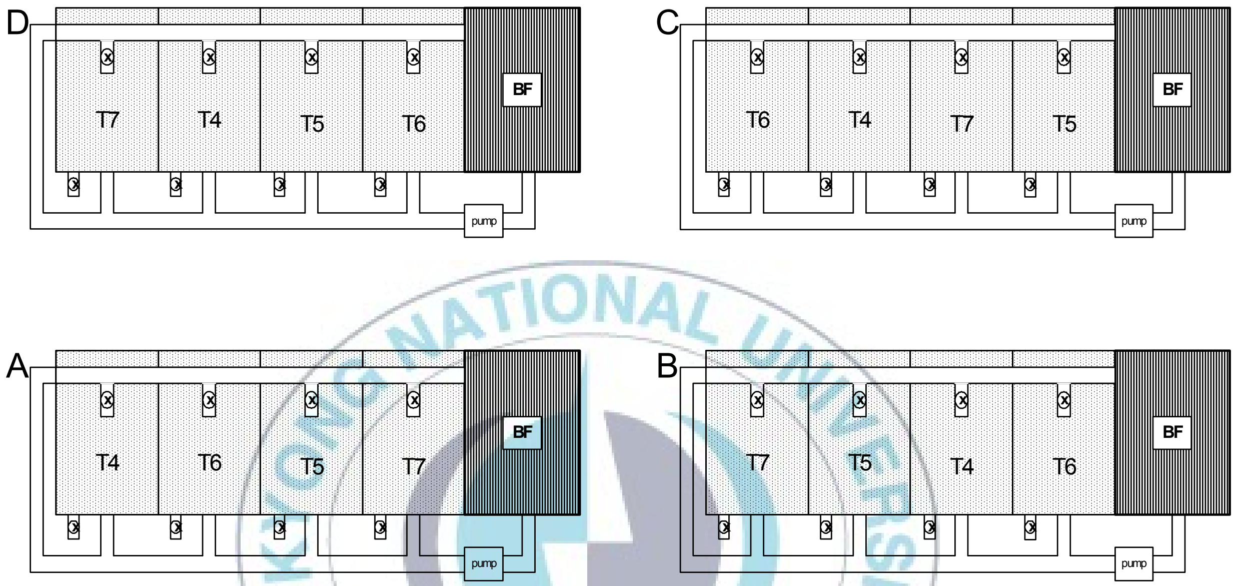

Fig. 1. Schematic diagrams of experimental systems, A, B, C and D for the test of growth of juvenile Nile tilapia *Oreochromis niloticus*. T represents treatment; 4, 5, 6 and 7 represent the number of feeding days per week. BF represents the biofilter concrete tank.

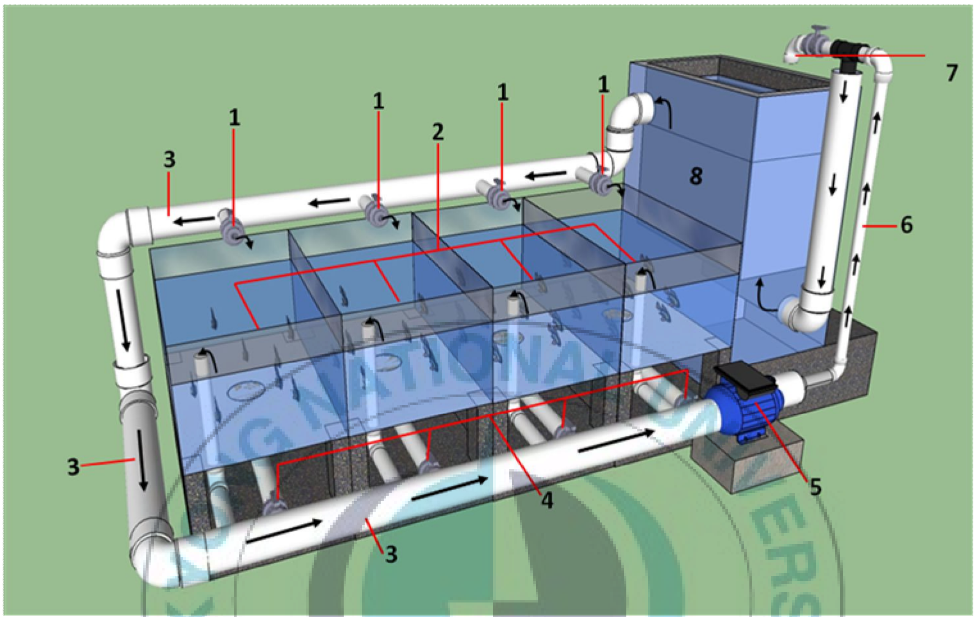

Fig. 2. Schematic drawing of water flow in an experimental system for growth and compensatory growth of juvenile Nile tilapia *Oreochromis niloticus*. 1, Inlet to aquarium; 2, aquarium ; 3, pvc pipe; 4, drainage outlet; 5, pump 6, pvc pipe; 7, inlet pipe to biofilter, 8, biofilter

A pump of capacity 40 L/min, recycled water through a polypropylene microbead biofilter of volume 190 L into the respective aquaria each measuring 0.6m (Length) x 0.5m (Width) x 0.5m (Depth). The water flow rate in each system was adjusted to 12 L/min. During the study, submersible heaters were used and temperature was maintained at 26°C in each of the system.

The water depth was maintained in each of the aquarium at 0.3m to give a water volume of 81.9 L. All the 4 systems were conditioned with old biofilter sludge collected from the biofilters of the Fish Culture Experimental Station, Pukyong National University. Sludge was applied to inoculate nitrifying bacteria in each biofilter. Also ammonia sources were added at a daily ammonia-loading rate of 25g $m^{-3}d^{-1}$ based on the formulation of Roger and Klemenston (1985) for the culture of nitrification bacteria as shown in Table 1.

Table 1. Composition of wastewater for conditioning of biofilter (Roger and Klemenston, 1985) with ammonia-loading rate of 25g $m^{-3}d^{-1}$

Chemical Composition	200L	412.5L (Biofilter tank Vol.)
$(NH_4)_2SO_4$	120.28	249.3
$NaHCO_3$	154.44	318.5
Na_2HPO_4	39.01	80.5
Glucose	32.88	67.8
$MnSO_4$	2.11	4.35

Water quality parameters were analysed on a daily basis in order to ascertain biofilter functionality.

2.1.2. Experimental fish

The juvenile Nile tilapias were captured from the Fish Culture Experimental Station, Pukyong National University (PKNU). Following grading, the harvested Juveniles were treated with formalin at a dose of 40 mg/L for external parasites. 10 weighed juveniles were randomly assigned to each aquarium. Four, five, six and seven weekly feeding days were randomly assigned to each system. Prior to weighing, the juveniles were anaesthetized with MS222 (Tricaine Methanesulfonate) at a dose of 30mg/L.

Experimental juvenile fish were acclimatized for 3 weeks. During the acclimation period, the juveniles were fed with formulated commercial diet twice daily of nutritional composition as shown in the Table 2.

After acclimation, prior to start of experiment, the juveniles were starved 24 hours and weighed the following day. All fish were fed to satiation 3 times daily with a commercial diet as shown in Table 3.

Table 2. Composition of commercial diet for growth experiment

Composition	Percentage
Crude protein	45%
Crude fat	8.0%
Ash	12%
Calcium	1.2%
Phosphorus	2.5%

Table 3. Weekly feeding schedule per treatment for growth experiment.

Feeding days per week	Feeding time		
	Morning	Afternoon	Evening
4 days	7:00AM	1:00PM	7:00PM
5 days	7:00AM	1:00PM	7:00PM
6 day	7:00AM	1:00PM	7:00PM
7 days	7:00AM	1:00PM	7:00PM

The commercial feed was introduced gradually until feeding began to slow. Daily weight (g) of feed consumed in each aquarium was recorded. The faeces from the previous day feeding were drained every morning before introducing new feed. All fish were starved 24 hours after every two weeks before weighing to evaluate growth performance parameters.

Growth performance parameters evaluated were weight gain (WG), feed conversion ratio (FCR) and specific growth rate (SGR) according to Cui et al, 2006.

$$FCR = \frac{C}{\text{weight gain}}$$

$$SGR = 100 \times \left(\frac{\log_e W_t - \log_e W_o}{t} \right)$$

C = amount of feed consumed

W_o = body weight at day zero

W_t = body weight at day t

t = Duration between two measurements.

All treatments were conducted in quadruplet.

2.1.3. Water quality measurements

Ammonia, nitrite, nitrate, dissolved oxygen, temperature and pH readings were measured daily during the first two weeks of experiment and later, once a week until end of experiment. Temperature readings were recorded with a thermometer, dissolved oxygen measured with an Oxyguard®, pH with a pH meter (Eco Met) and ammonia, nitrite and nitrate by HACH DREL, 2000 spectrophotometer (HACH Company, Colorado, USA)

Table 4. Average water quality parameters of growth experiment

Parameters	Values
Nitrate	268.35±29.69 mg L^{-1}
Nitrite	0.53±0.21 mg L^{-1}
Ammonia	0.33±0.10 mg L^{-1}
Dissolved Oxygen	6.38±0.24 mg L^{-1}
Temperature	26.0±0.05°C
pH	6.63±0.04

2.1.4. Proximate analysis of juvenile fish

Five fish were collected randomly prior to start of experiment and 2 from each treatment from system D at end of experiment. They were analysed for moisture, crude protein, crude lipid and ash following standard methods (AOAC 2000).

Samples of fish were dried at 135 °C to a constant weight to determine their moisture content. Ash content was determined by incineration at 600 °C. Crude protein was determined using the Kjeldahl method (N × 6.25) after acid digestion, and crude lipid was determined by soxhlet extraction using the Soxtec system 1046 (Tacator AB, Hoganas, Sweden).

2.1.5. Blood analysis

Five fish were collected randomly prior to start of growth experiment and were analysed for red blood cell count (RBC) and hematocrit (HCT) level. At the end of the growth experiment, two fish were equally collected at random from each of the 4, 5, 6 and 7 weekly treatments in system D and analysed for RBC and HCT.

Blood was collected from the central tail vein with a one ml syringe containing heparin as an anticoagulant. Blood samples were preserved and transported in an ice block box for laboratory analysis. The samples were analysed by an automatic blood analyzer (SEAC h5.m USA) of the Fish Reproduction Laboratory, College of Fisheries Science, PKNU.

2.1.6. Statistical analysis

Data of weight gain, specific growth rate (SGR), feed conversion ratio (FCR), body composition and blood were analysed by one-way ANOVA using Minitab 16 statistical software to test the significance difference. Significant difference among the average mean were evaluated by Tukey test. All statistical analyses were assessed at a significance level of $P \leq 0.05$.

2.2. Compensation growth experiment

2.2.1. Experimental design

At the end of the growth experiment, the second experiment was initiated to investigate compensatory growth in juvenile Nile tilapia. An experimental design used is represented in Fig. 3 and a complete system employed was identical to that of first experiment as depicted in Fig. 2.

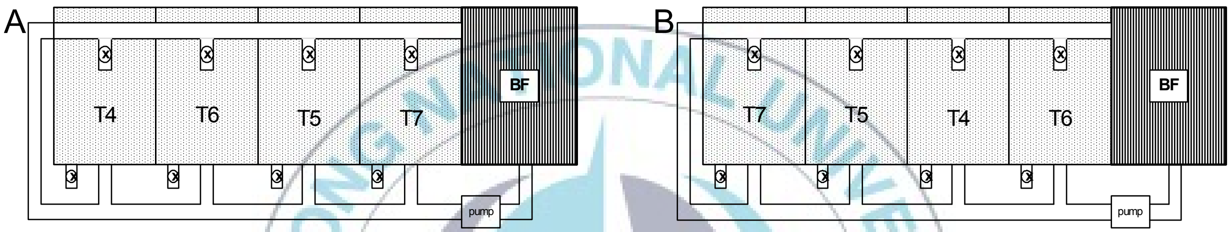

Fig. 3. Schematic diagrams of experimental systems, A, B, for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus*. T represents treatments. 4, 5, 6 and 7 represents numbers of weekly feeding days. BF represents the biofilter.

The design was made up of two systems each consisting of four aquaria, a pump of capacity 40 L/min and a concrete tank containing polypropylene biofilter material of volume 190 L. Water level in each aquarium was maintained at 0.3m The respective treatments of four, five, and six weekly feedings were fed three times daily as those of 7 weekly feeding days for 4 consecutive weeks.

All treatments were in duplicates. Prior to start of experiment, the juvenile fish were staved 24 hours, anaesthetized with MS222 and weighed. Each aquarium had 10 juvenile fish and feeding was given ad-libitum until feeding starts to slow. Feed was administered three times daily in the morning at 7 am, during the afternoon at 1pm and in the evening at 7 pm as shown in the Table 5.

Table 5. Weekly feeding schedule for compensation growth of juvenile Nile tilapia *Oreochromis niloticus*.

Feeding days per week	Feeding time		
	Morning	Afternoon	Evening
4 days	7:00AM	1:00PM	7:00PM
5 days	7:00AM	1:00PM	7:00PM
6 day	7:00AM	1:00PM	7:00PM
7 days	7:00AM	1:00PM	7:00PM

During the experimental period of four weeks, the juveniles were routinely weighed fortnightly to monitor growth parameters. The growth parameters monitored include Weight gain (WG), Feed Conversion ratio (FCR), Specific Growth rate (SGR). Body composition of juveniles and blood were also analysed at end of experiment using same procedures as was done in first experiment. The same commercial feed in the growth experiment was used for compensatory growth experiment.

2.2.2. Experimental fish

The juvenile Nile tilapia from growth experiment were used for the compensatory growth experiment.

2.2.3. Water quality measurements

The method used for water quality measurements was same as in growth experiment.

Water quality parameters were monitored on weekly basis and measured using same methodology as that employed in growth experiment. Temperature was maintained at 26^{o}c, Dissolved Oxygen at 6.0 mg/L, nitrate at 286±11 mg/L, ammonia at 0.36±0.048 mg/L, nitrite 0.38±0.052 mg/L, pH at 6.63±0.240 mg/L and water flow rate at 12 L/min.

2.2.4. Proximate analysis

The same method in growth experiment was used in CG experiment.

2.2.5. Blood analysis

CG experiment method was the same as used in growth experiment.

2.2.6. Statistical analysis

The same methodology as used in growth experiment was employed in CG experiment. Data of weight gain, SGR, FCR, body composition and blood were analysed by one-way ANOVA using Minitab 16 statistical software to test the significance difference. Significant difference among the average mean were evaluated by Tukey test. All statistical analyses were assessed at a significance level of $P \leq 0.05$.

III. RESULT

3.1. Growth experiment

3.1.1. Net mean weight gain

The results of net mean weight gain in Table 6, shows that there is an increased mean weight gain with time in all the treatments. Fish fed 4 days per week had a mean weight gain of 67.7g at second week to 267.4g at eighth week. Five, six and seven days treatments had 267.4g to 366.4g, 108.7g to 368.0g and 122.7g to 365.5g respectively. There was increasing net mean weight gain with increasing number of feeding days until week six. At week eight, 6 days treatment had the highest numerical value, followed by 5 and 7 days treatment. Four days had the lowest value.

Although the net mean weight gain increases with increasing number of feeding days as from second, fourth and sixth week, net mean weight gain for 5, 6 and 7 days treatments were almost similar numerically at eighth week as shown in Table 6 and Fig.4. Statistically, there was no significant difference amongst these treatments.

At second week, 4 days treatment was significantly different from 5, 6 and 7 days. Five days treatment was statistically different from 7 days but no difference exists between 5 and 6, 6 and 7 days treatments. At week four, only 4 days treatment differs significantly from 5, 6 and 7 days treatments. Five, 6 and 7 days net mean weight were not significantly different. The trend at 4^{th} week was same for 6^{th} and 8^{th} week as shown in Table 6 and Fig. 4.

Table 6. Net mean weight gain of treatments for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments.	Initial avg, wt (g)	Net mean weight gain (gr)			
		2 weeks	4 weeks	6 weeks	8 weeks
4 days	126.1±2.74[a]	67.7±7.05[a]	134.3±15.33[a]	214.0±22.05[a]	267.4±29.46[a]
5 days	125.3±3.32[a]	267.4±10.65[b]	196.2±35.71[b]	292.0±34.65[b]	366.4±28.11[b]
6 days	125.8±3.29[a]	108.7±7.49[b,c]	203.6±13.78[b]	303.7±34.75[b]	368.0±46.51[b]
7 days	124.7±2.37[a]	122.7±14.35[c]	208.1±38.37[b]	307.0±47.85[b]	365.5±54.33[b]

*Numbers with different letter in same column shows significant difference.

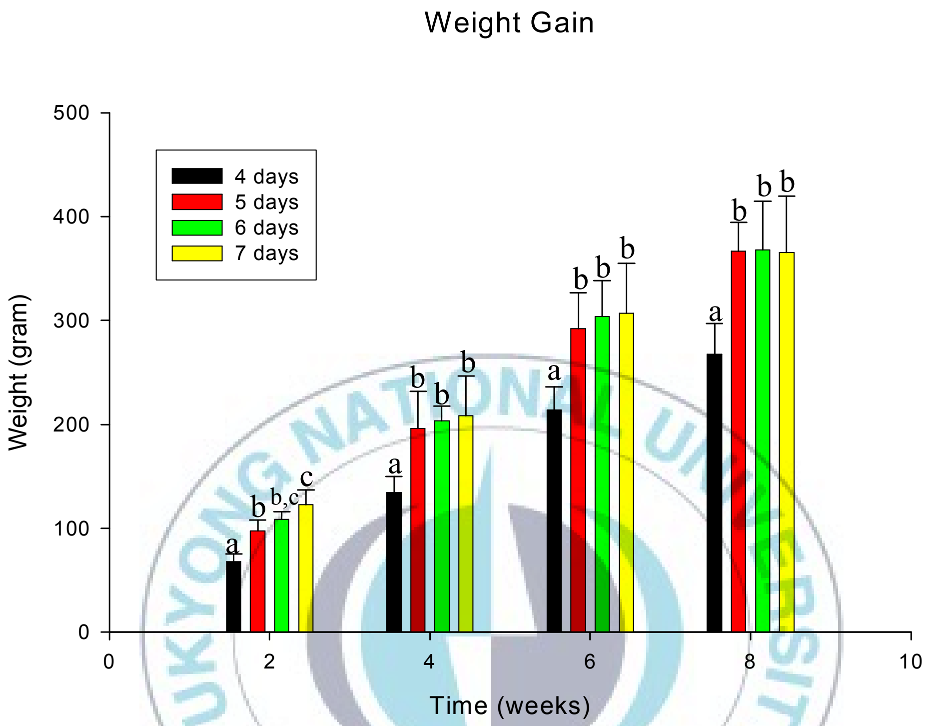

Fig. 4. Net mean weight gain per treatments for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

*Different letters on the bars of same week shows significant difference.

The average weight gain of individual fish for the test of growth of juvenile Nile tilapia is shown in Table 7. The trend was similar to that of increased net mean weight of Table 6. At second week, the was no significant difference between 5 and 6 days, 6 and 7 days treatment while 4 days treatment was statistically different from 5, 6 and 7 days treatment. The pattern at 6^{th} and 8^{th} week was same as that of 4th week. Only 4 days treatment differs significantly from treatment 5, 6 and 7 days treatment at 4^{th}, 6^{th} and 8^{th} week.

Table 7. Average weight gain of individual fish for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatment	Weight gain (gr)			
	2 weeks	4 weeks	6 weeks	8 weeks
4 days	6.8±0.71^{a}	13.4±1.53^{a}	21.4±2.21^{a}	26.7±2.95^{a}
5 days	9.7±1.07^{b}	19.6±3.57^{b}	29.2±3.47^{b}	36.6±2.81^{b}
6 days	10.9±0.75^{b,c}	20.4±1.38^{b}	30.4±3.48^{b}	36.8±4.65^{b}
7 days	12.3±1.44^{c}	20.8±3.84^{b}	30.7±4.79^{b}	36.6±5.43^{b}

*Numbers with different letter in same column shows significant difference.

The percentage weight gain of individual fish for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes is shown in Table 8. In each treatment; there was a progressive percentage weight gain with increasing number of feeding weeks. The maximum percentage at week 8 was observed at 5, 6 and 7 treatments as shown in Table 8. Statistically, there was no difference amongst these treatments. The lowest percentage was observed in 4 days treatment.

Table 9 depicts the feed consumed (g) for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Table 8. Percentage weight gain of individual fish for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	Weight gain (%)			
	2 weeks	4 weeks	6 weeks	8 weeks
4 days	53.9	106.3	169.7	211.7
5 days	77.4	156.4	233.0	292.1
6 days	86.6	162.2	241.7	292.5
7 days	98.6	166.8	246.2	293.5

Table 9. Feed consumed (g) for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	2 weeks	4 weeks	6 weeks	8 weeks
4 days	61.9±1.086	147.3±5.37	241.5±9.63	332.39±9.11
5 days	85.1±4.687	202.8±21.12	316.9±22.93	433.00±61
6 days	103.3±9.78	224.2±19.42	350.8±25.46	491.13±29.34
7 days	121.7±11.06	255.9±17.33	388.4±17.48	549.15±16.96

3.1.2. Specific growth rate (SGR)

There was a progressive decline in mean SGR within all the treatments as from 2 to 8 weeks of the experiment as shown in Table 10 and Figure 5. The mean specific growth rate increases with increasing number of feeding days per week as from the second week to six weeks as shown in table 10. The mean specific growth rate at week 8 for 5, 6 and 7 treatments were numerical similar in values. The nominal values were 0.99±0.030, 0.99±0.068 and 0.99±0.083 for 5, 6 and 7 days treatment respectively.

At second week of the experiment, there was significant difference between 4 days and the other treatments. 5 days treatment equally differs significantly from 7 days treatment at week two. There was no significant difference between 5 and 6, 6 and 7 days treatment. From 4 to 8 weeks, only 4 days was statistically different from 5, 6 and 7 days treatments. There was no significant difference between 5, 6 and 7 days treatments from week 4 to 8 as shown in Table 10 and Fig. 5.

Table 10. Mean Specific growth rate for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

(Unit: % per day)

Treatments	2 weeks	4 weeks	6 weeks	8 weeks
4 days	1.25±0.103[a]	1.04±0.078[a]	0.96±0.057[a]	0.82±0.050[a]
5 days	1.66±0.110[b]	1.36±0.136[b]	1.16±0.072[b]	0.99±0.030[b]
6 days	1.80±0.115[b,c]	1.39±0.059[b]	1.18±0.084[b]	0.99±0.068[b]
7 days	1.99±0.163[c]	1.42±0.163[b]	1.20±0.110[b]	0.99±0.083[b]

*Numbers with different letter in same column shows significant difference.

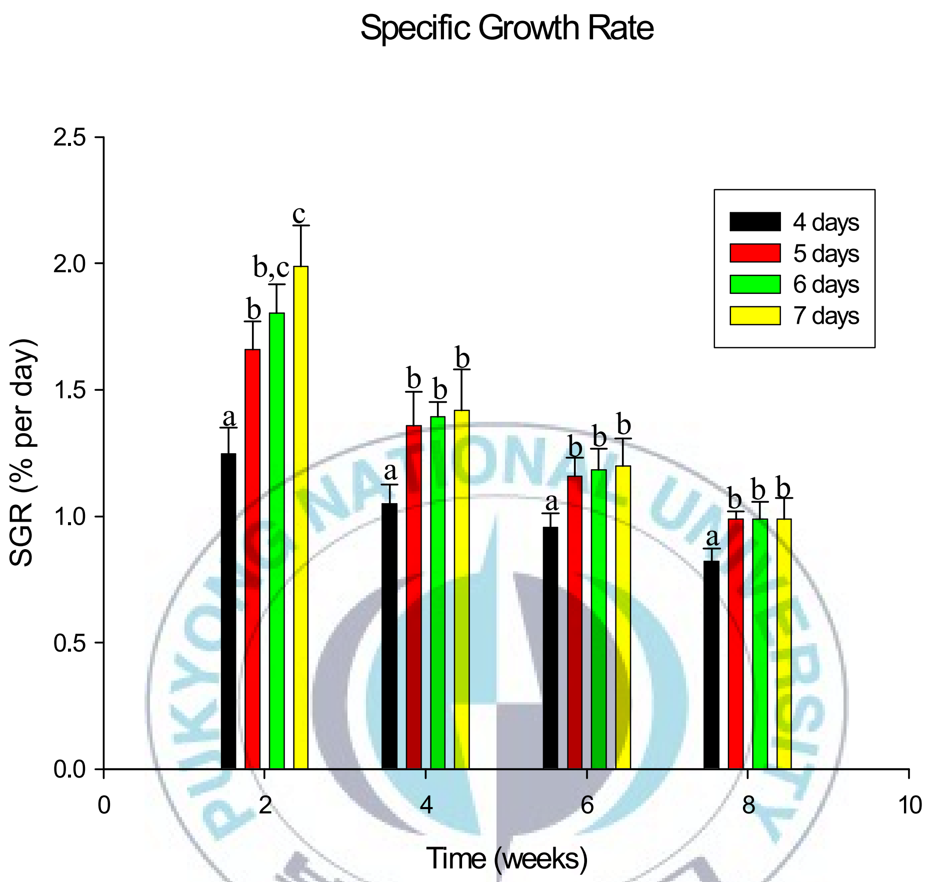

Fig. 5. Mean specific growth rate (SGR) for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

*Different letters on the bars of same week shows significant difference.

3.1.3. Feed conversion ratio (FCR)

The feed conversion ratio increases with increasing number of weeks (time) and feeding frequency as shown in Table 11 and Fig. 6. Although 5 week treatment tends to be numerically smaller than 4 days treatment, statistically there was no significant difference. At week 2 and 8, only 5 days treatment differ significantly from 7 days treatment. All treatments at fourth and sixth week do not differ significantly.

Table 11. Mean Feed conversion ratio for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	2 week	4 weeks	6 weeks	8 weeks
4 days	0.92±0.095^{a,b}	1.10±0.101^{a}	1.13±0.083^{a}	1.25±0.132^{a,b}
5 days	0.88±0.061^{a}	1.04±0.0849^{a}	1.09±0.071^{a}	1.18±0.057^{a}
6 days	0.95±0.087^{a,b}	1.11±0.1425^{a}	1.17±0.140^{a}	1.35±0.1633^{a,b}
7 days	0.99±0.056^{b}	1.25±0.188^{a}	1.29±0.0185^{a}	1.53±0.220^{b}

*Numbers with different letter in same column shows significant difference.

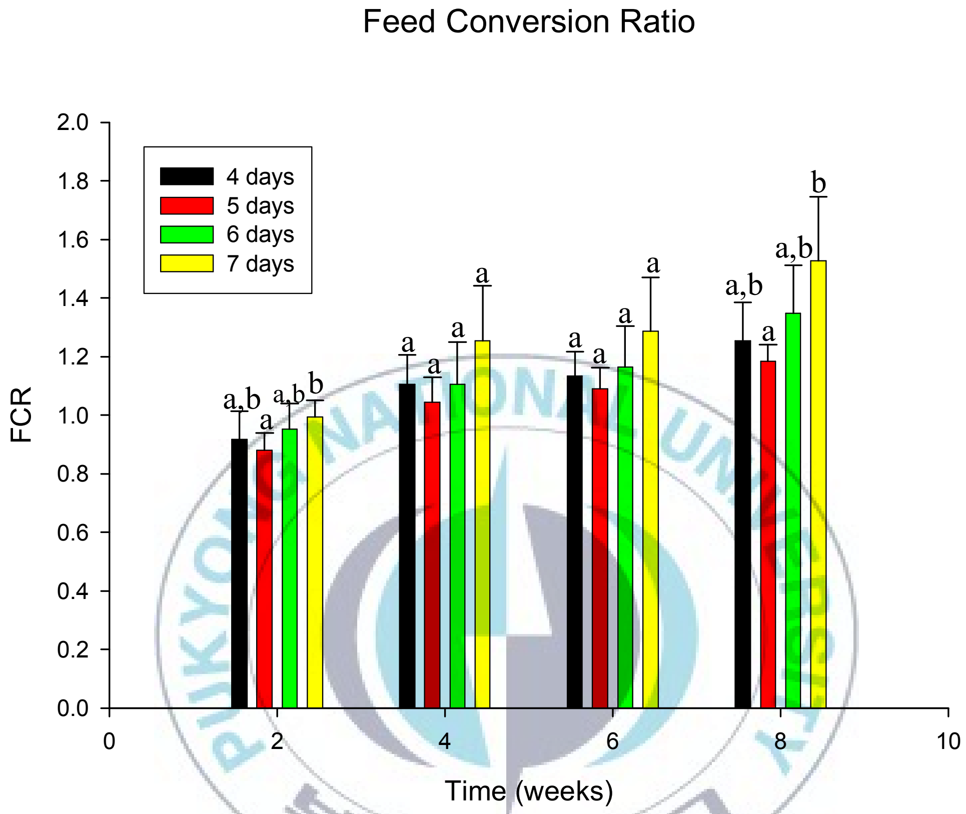

Fig. 6. Mean feed conversion ratio (FCR) for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

*Different letters on the bars of same week shows significant difference.

3.1.4. Blood analysis

Red blood cells

The red blood cells (RBC) count ranges from 2.09±125 x 10^6µL at start of experiment to 2.87±6.35 x 106µL for 7 days treatment at end of experiment as shown in Table 12 and Fig. 7. Juvenile blood at beginning of experiment differs significantly from 4, 6 and 7 days treatments. There was no significant difference between 5 days treatment and RBC at start of experiment.

Table 12.Results of red blood cell count of juvenile Nile tilapia *Oreochromis niloticus* treated on different feeding regimes for 8 weeks.

Treatments	RBC ($x10^6$µL)
Initial	2.09 ± 0.125^{a}
4 days	$2.46\pm0.161^{b,c}$
5 days	$2.21\pm0.042^{a.b}$
6 days	$2.65\pm0.459^{c,b}$
7 days	$2.87\pm0.352^{c,d}$

*Numbers with different letter in same column shows significant difference.

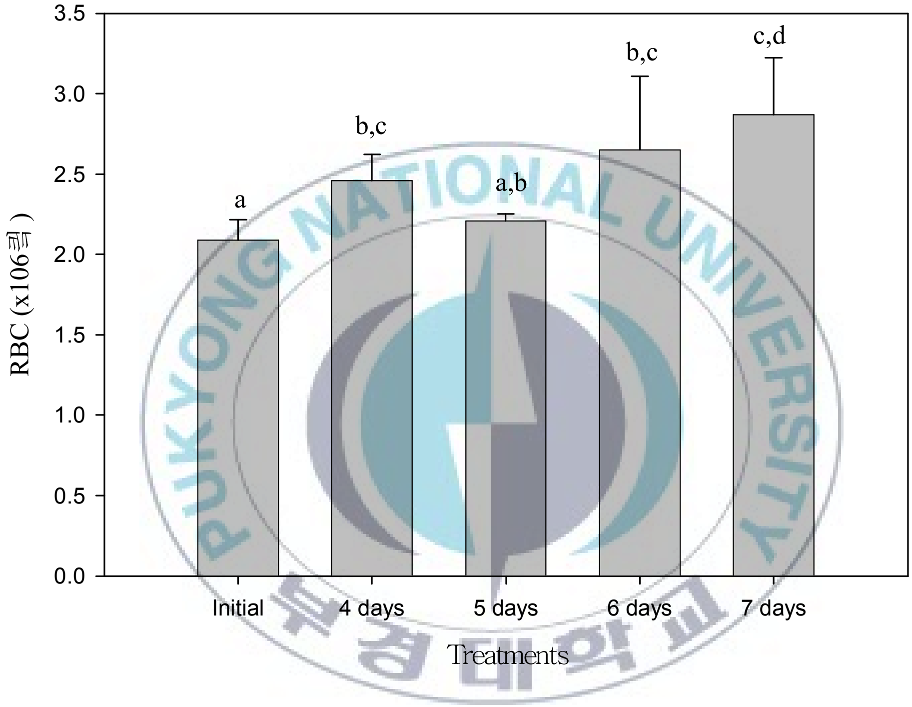

Fig. 7. Results of red blood cell count of juvenile Nile tilapia *Oreochromis niloticus* treated on different feeding regimes for 8 weeks.

*Different letters on the bars of same week shows significant difference.

Hematocrit (HCT)

The HCT values ranges from 30.23±0.45 at start of experiment to 40.27±5.053 of 7 days treatment. Only the 7 days treatment differs significantly from those of initial, 4, 5 and 6 days treatments. These are shown in Table 13 and Fig. 8.

Table 13 Results of hematocrit values (HCT) of juvenile Nile tilapia *Oreochromis niloticus* treated on different feeding regimes for 8 weeks.

Treatment	HCT (%)
Initial	30.23 ± 0.450^a
4 days	31.78 ± 2.073^a
5 days	29.45 ± 0.636^a
6 days	33.30 ± 4.531^a
7 days	40.27 ± 5.053^b

*Numbers with different letter in same column shows significant difference.

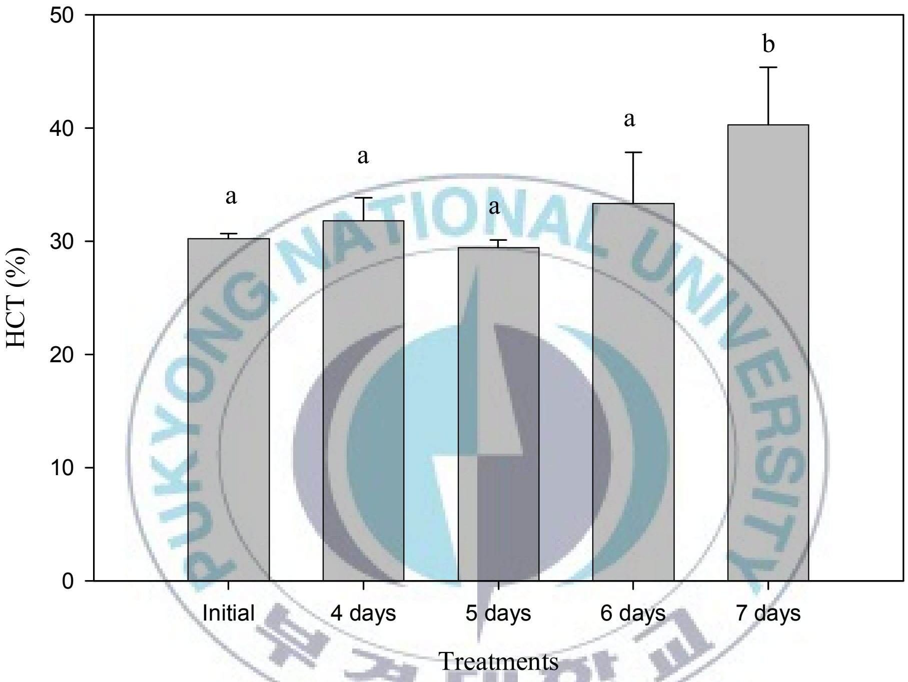

Fig. 8. Results of hematocrit values (HCT) of juvenile Nile tilapia *Oreochromis niloticus* treated on different feeding regimes for 8 weeks.

*Different letters on the bars of same week shows significant difference.

3.1.5. Proximate analysis

Moisture content tends to decrease numerically as from onset to 7 days treatment though 6 days treatment had a higher percentage. Statistically, there was significant difference between 4, 6 and 7 days treatment. Five and 6, and 6 and 7 were also different statistically as shown in Table 14.

Fat had an increasing trend with increasing feeding days per week but 6 days treatment was numerically lower as compared to 5. All treatments were statistically different.

Protein content was fluctuating but with a likelihood to decrease. At the beginning of experiment, crude protein was statistically different from 4, 6 and 7 days treatment. Four days treatment was different from 5, 6 and 7, 5 was different from 6 and 7 days treatment and finally 6 was also different from 7 days treatment as shown in table 14.

Ash had a decreasing trend with increasing number of feeding days per week except for treatment 6. Four and 5 days treatments differ statistically from 6 and 7. Six days treatment was equally different from 7 days treatment.

Table 14. Proximate analysis of experimental fish for the test of growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes**.**

Txt	Initial	T4	T5	T6	T7
Moisture	72.5 ± 0.6^{a}	72.4 ± 0.30^{a}	$71.8 \pm 0.28^{a,c}$	74.9 ± 0.08^{b}	71.2 ± 0.02^{c}
Fat	15.8 ± 0.11^{a}	15.1 ± 0.02^{b}	20.3 ± 0.12^{c}	16.4 ± 0.05^{d}	23.6 ± 0.16^{e}
Protein	63.5 ± 0.05^{a}	64.8 ± 0.06^{b}	63.8 ± 0.11^{a}	69.2 ± 0.18^{c}	61.4 ± 0.23^{d}
Ash	17.6 ± 0.06^{a}	16.6 ± 0.13^{b}	16.3 ± 0.04^{b}	17.26 ± 0.11^{a}	15.4 ± 0.06^{c}

*Numbers with different letter in same row shows significant difference.

3.2. Compensatory growth experiment

3.2.1. Net mean weight gain

The net mean weight gain values are shown in Table 15 and Figure 9. They range from 358.27±32.77 of the most feed deprived group of 4 days feeding per week to 253.63±100.27 of the least deprived fed group of 7 days treatment. Statistically, there was no significant difference in net mean weight gain amongst treatments during the 4 weeks compensatory growth period. Four days treatment were feed deprived for 24 days, 5 for 16 days, 6 for 8 days and 7 for zero days before the onset of the experiment as shown in Table 16.

Table 15. Net mean weight gain of treatments for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	Net mean weight gain (gr)
4 days	358.27±32.77^{a}
5 days	372.45±24.47^{a}
6 days	358.79±40.50^{a}
7 days	253.63±100.27^{a}

*Numbers with different letter in same column shows significant difference.

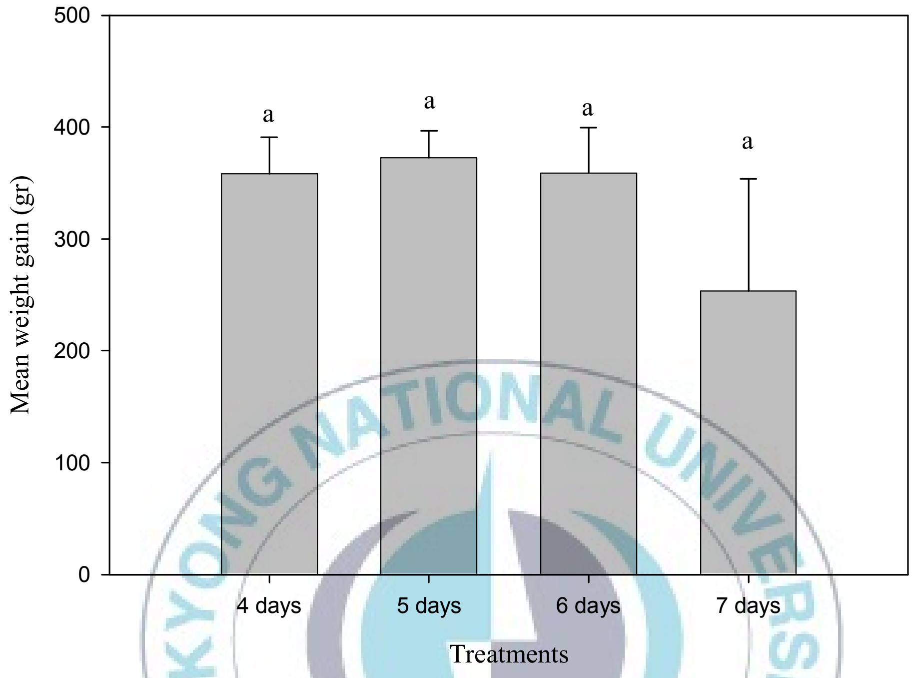

Fig. 9. Mean weight gain of treatments for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

*Different letters on the bars of different treatments shows significant difference.

Table 16. Number of feed deprived days and total avg. feed consumed per treatment for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	Feed deprived days	Total average feed consumed
4 days	24	493.7±6.52
5 days	16	482.1±7.50
6 days	8	480.0±0.54
7 days	0	453.3±0.30

The percentage net mean weight gain to test for compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes is shown in Table17. From the percentage net mean weight gain, it was observed that the trend shows a linear relationship with the number of feed deprived days. It decreases from 4 to 7 days treatment with decreasing number of feed deprived days. It was highest with 4 days treatment and least with 7 days treatment as show in Table 17. During the first 2 weeks, percentage net mean weight reduces from 50.05% of 4 days treatment to 25% of 7 days treatment. At 4 week of the CG experiment, mean percentage weight gain drops from 86.65% of 4 weeks treatment to 47.55% of 7 days treatment.

Table 17. The percentage net mean weight gain for compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments.		1^{st} wk.	2^{nd} wk.	4^{th} wk.	6^{th} wk.	8^{th} wk.	CG Expt.	
							10wks	12wks
4 days	Avg. wt.	127.95	199.43	273.51	359.05	413.5	620.45	771.79
	% net wt. gain		55.87	113.76	180.62	223.17	50.05	86.65
5 days	Avg. wt.	124.14	217.95	299.58	387.51	477.01	689.59	849.46
	% Net wt. gain		75.57	141.32	212.16	284.25	44.57	78.08
6 days	Avg. wt.	124.45	237.78	331.58	442.38	513.18	699.94	871.97
	% net wt. gain		91.06	166.44	239.40	312.36	36.39	69.92
7 days	Avg. wt.	124.7	250.63	358.24	465.04	533.42	666.81	787.05
	% net wt. gain		100.99	187.28	272.93	327.76	25.00	47.55

3.2.2. Specific growth rate (SGR)

The SGR decreases with decreasing number of feed deprived days. The highest value was 0.87±0.025 for 4 days treatment that was feed deprived for 24 days and 0.54±0.167 for 7 days treatment that was feed deprived for zero days. There was no significant difference between 5, 6 and 7 days treatment as shown in Table 18 and Fig.10.

Table 18. Mean Specific growth rate for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	SGR (% per day)
4 days	0.87 ± 0.025^{a}
5 days	$0.81 \pm 0.030^{a,b}$
6 days	0.74 ± 0.003^{b}
7 days	$0.54 \pm 0.167^{a,b}$

*Numbers with different letter in same column shows significant difference.

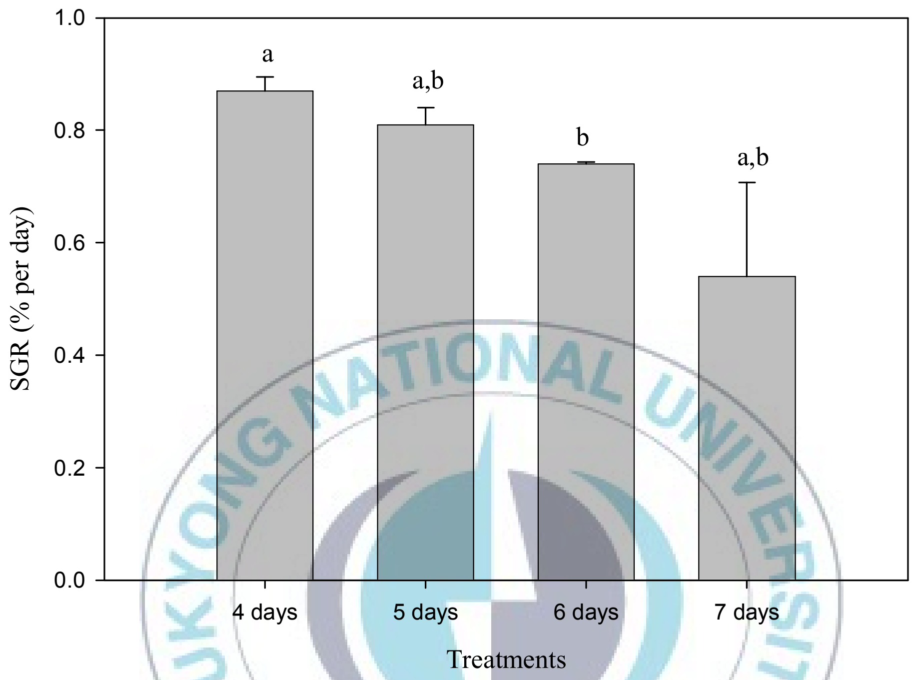

Fig. 10. Mean Specific growth rate for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

*Different letters on the bars of same week shows significant difference.

3.2.3. Feed conversion ratio (FCR)

The FCR shows an increasing trend with decreasing number of feed deprived days. It is highest with 7 days treatment which has the least number of feed deprived days. However no statistical difference exists amongst the various treatments as depicted in Table 19 and Fig.11.

Table 19. Feed conversion ratio for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

Treatments	FCR
4 days	1.38±0.108[a]
5 days	1.30±0.065[a]
6 days	1.35±0.151[a]
7 days	1.94±0.768[a]

*Numbers with different letter in same column shows significant differenc

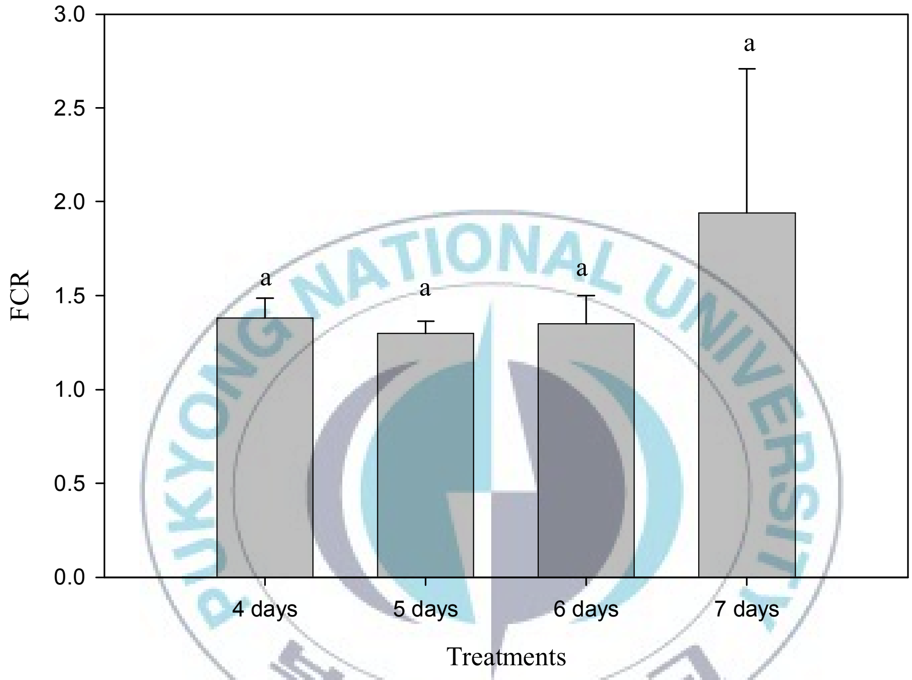

Fig. 11. Feed conversion ratio for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes.

*Different letters on the bars of same week shows significant difference.

3.2.4. Blood analysis

Red blood cell (RBC)

There was fluctuating trend regarding the RBC values. The least numerical values were for 5 days treatment and highest for 4 and 6 days as shown in Table 20 and Fig. 12. There was no significance difference amongst the treatments.

Table 20. Results of red blood cell count of juvenile Nile tilapia *Oreochromis niloticus* for the compensatory growth experiment.

Treatments	RBC (10^6/μL)
4 days	2.52±0.193^a
5 days	2.38±0.134^a
6 days	2.52±0.430^a
7 days	2.49±0.076^a

*Numbers with different letter in same column shows significant difference.

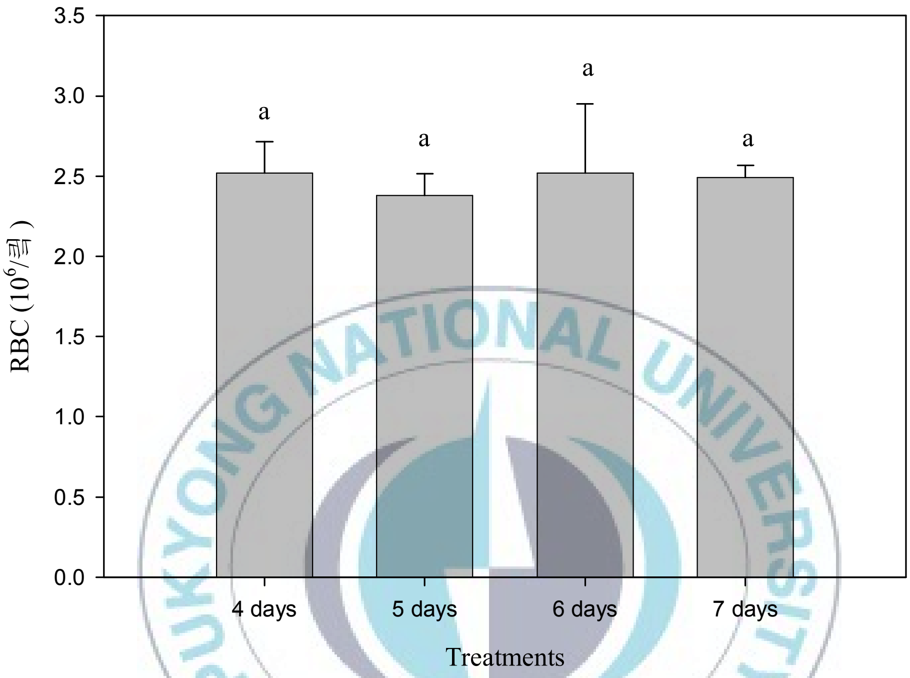

Fig. 12. Results of red blood cell count of juvenile Nile tilapia *Oreochromis niloticus* for the compensatory growth experiment.

*Different letters on the bars of different treatments shows significant difference.

Hematocrit (HCT)

Four days had the highest value. There was an increasing trend from 5 days to 7 days treatment as shown in Table 21 and Fig.13. There was no significant difference amongst treatments.

Table 21. . Results of HCT values for juvenile Nile tilapia *Oreochromis niloticus* for the compensatory growth experiment.

Treatments	HCT (%)
4 days	32.28±3.275^{a}
5 days	31.48±1.916^{a}
6 days	31.75±4.744^{a}
7 days	31.85±1.002^{a}

*Numbers with different letter in same column shows significant difference.

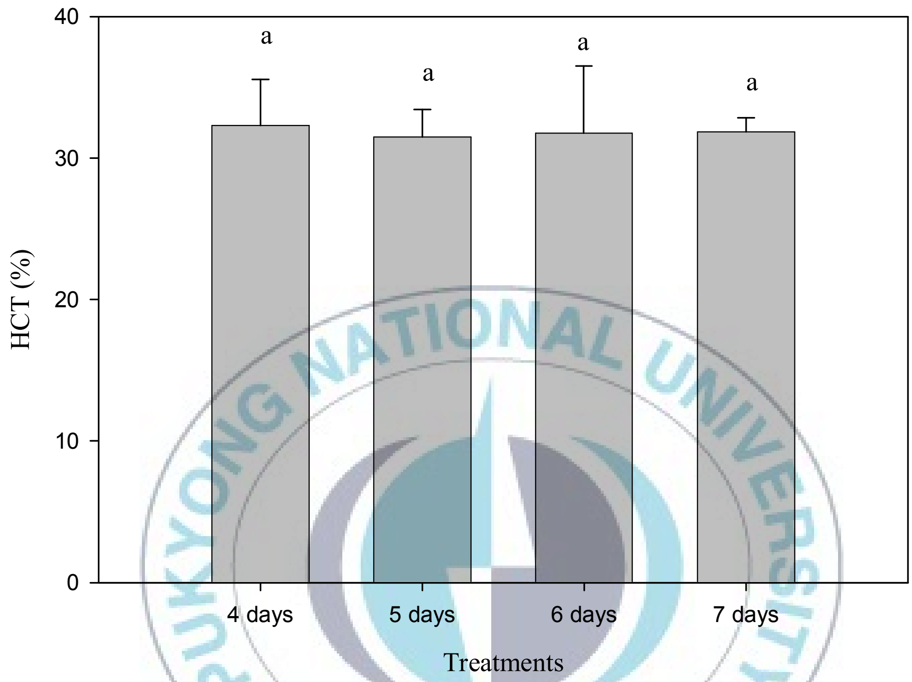

Fig. 13. . Results of HCT values of juvenile Nile tilapia *Oreochromis niloticus* for the compensatory growth experiment.

*Different letters on the bars of same week shows significant difference.

3.2.5. Proximate analysis

Crude moisture increased with decreasing number of feed deprived days. It was highest with 7 days treatment (zero Starved days) and lowest at 4 days treatment (24 starved days). Least starved group (7 days treatment) differs statistically from 4, 5 and 6 days treatment as depicted in Table 22.

Crude fat was high for the starved groups (4, 5, and 6) and low with the least starved group (7 days treatment). The trend seemingly was opposite to that of moisture content. 4 days treatment was statistically different from 5 and 7, 5 was different from 6 and 7, and 6 was different from 7 days treatment as depicted in Table 22.

Crude protein increases from the most starved group (4 days treatment) to the least starved group (7 days treatment). The increasing trend is similar to that of moisture content of whole fish.

Ash seemingly had a similar pattern, increasing from the most starved group to the least starved group although 6 days treatment was lower than 4 and 5 as shown in Table 22.

Table 22. . Proximate analysis of experimental fish for the test of compensatory growth of juvenile Nile tilapia *Oreochromis niloticus* under different feeding regimes**.**

Treatments	T4	T5	T6	T7
Moisture	70.6±0.26b	70.9±0.19^{b}	71.3±0.17^{b}	72.3±0.28^{a}
Fat	23.3±0.05^{b}	22.2±0.16^{c}	23.4±0.08^{b}	18.3±0.01^{d}
Protein	61.4±0.11^{b}	62.0±0.08^{c}	63.9±0.23^{d}	64.5±0.23^{d}
Ash	14.1±0.04^{b}	14.3±0.01^{c}	13.3±0.09^{d}	16.1±0.10^{e}

*Numbers with different letter in same row shows significant difference.

IV. DISCUSSION

4.1. Growth experiment

There were no mortalities in all treatments during the course of the growth experiment. The water qualities parameters and their values were as follows: Dissolved Oxygen 6.38±0.24 mg/L, temperature 26^{o}C, ammonia 0.33±0.10 mg/L, nitrite 0.53±0.21 mg/L, nitrate 268.35±29.69 mg/L, and pH 6.63±0.04 mg/L.

4.1.1. Net mean weight gain

At the beginning of the experiment, there was no significant difference amongst the various treatments in mean weight of juvenile fish. There was an increasing trend of net mean weight gain amongst the various treatments with time. Also the net mean weight gain increases with increasing number of feeding days per week but at week 8, this pattern did not hold for 7 days treatment. Five, 6 and 7 days treatments net mean weight gain were 366.4 g, 368.0 g and 365.5 g respectively. Despite consuming the greatest amount of feed as shown in table 9, seven days treatment had the lowest net mean weight gain as compared to 5 and 6.

Seven days feeding must have exceeded the optimal level of feed at week 8 thus no rapid growth is achieved (Hung et al, 1989; Du et al, 2006).

However, there could be a ceiling to increasing the feeding frequency and a point may be reached where no further improvements in growth occur (Gandra et al., 2007).

Another plausible reason could be due to increase social interactions between males (territorial behaviour) in the presence of females and the interactions between males and females, resulting in increased activity and higher energy expenditure (Toguyeni et al, 1997; Mambrini et al, 2006). This could possibly lead to more feed consumption but lower growth rates. Hayward et al. (2000) also observed lower weight gains when hybrid sunfish *Lepomis cyanellus x L. macrochirus* were held in groups as opposed to individually held fish, indicating how social interactions could affect weight gain. Seven days treatment had the highest number of females which could channel greater metabolic energy into reproductive activities (Toduyeni et al., 1997) and social interaction here may be more when compared to the other treatments.

Five, 6 to 7 weekly feeding days had more feed supply resulting in greater net mean weight gain as compared to 4 days treatment. The observations are consistent with the results obtained by Lee et al. (2000), Harpaz et al. (2005), Li and Robinson (2005), Booth et al. (2008), Wang et al. (2009) and Biswas et al. (2010) who reported that feeding frequency very often affects the weight gain. Other researchers (Meer et al., 1977; Azzaydi et al., 1998; Thompson et al., 2000; Mambrini et al., 2006; Gandra et al., 2007) had documented similar positive relationship between feed intake and growth of fish. Increasing the frequency of feeding has been shown to result in a more regular supply of nutrients (Toguyeni et al., 1997) that are utilised for various physiological and anabolic processes that catalyses growth. There was no significant difference in net mean weight gain of 5, 6 and 7 days treatments despite consuming different amounts of feed.

4.1.2. Specific growth rate (SGR)

In this study, juvenile mean specific growth rate decreases gradually over time within treatments and increases with increasing number of feeding days per week. At week 8, SGR of 5, 6 and 7 days treatment were similar as shown in Figure 6.

Growth rate increases with increasing feeding frequency (Webster et al., 2001, Hossain et al., 2001, Zhou et al., 2003) but it appears to be fast during early life history and slows down gradually as fish ages. No rapid growth and feed efficiency are achieved when feeding rate exceeds a certain level (Hung et al., 1989; Du et al., 2006). This could be the case for 5, 6 and

7 days treatment. There was no significant difference for the SGR of 5, 6 and 7 days treatments.

4.1.3. Feed conversion ratio (FCR)

This study shows that FCR increases with increasing feed consumption. Du et al. (2006) had same consistent results indicating that feed conversion ratio increases with increasing feeding frequency in juvenile grass carp (*Ctenopharyngodon idella*). Similar results were obtained by Lee et al. (2000) with channel catfish *Ictalurus punctatus* demonstrating a lower FCR with channel catfish fed less frequently.

Seven days treatment had the highest nominal value and invariably worst utilization of feed. However, FCR within the treatments increase with feeding time until the end of the experiment. The less fed groups obviously utilized feed more efficiently than the most fed group. There were no significant difference between treatments at 4 and 6 weeks but 5 and 7 days treatments differ significantly at 2nd and 8th week. In this study, 5 days treatment utilized feed most efficiently. Feed efficiency decreased as feeding rate increase when feeding rate is above the maintenance level of the fish (Storebakken and Austreng 1987a, Hung et al., 1989, Du et al., 2005). FCR increases with increasing weight of fish. Similar results were observed by Hafedh (1999) in *Oreochromis niloticus* fed with varying degrees of protein diet.

4.1.4. Blood Analysis

Red Blood Cells (RBC)

The values were within the range of normal RBC for *Oreochromis niloticus* of 0.7 to 28 x 10^6µL as reported by Bittercourt et al. (2004). RBC tends to increase with increasing number of feeding days but statistically, no differences exist between 5, 6 and 7 days treatments.

Hematocrit (HCT)

The values seem to increase with increasing number of feeding days although only 7 days treatment was statistically different. 5 days treatment had the lowest HCT values of 29.45±0.636. All the values were normal for *Oreochromis niloticus* as reported by Bittercourt et al. (2004). The normal range of HCT is from 15-45 %.

4.1.5. Proximate analysis

Moisture content to some extent indicated a decreasing trend with increasing number of weekly feeding days. Seo et al. (2008) had similar results with juvenile rockfish (*Sebastes schlegeli*).

Body fat of juvenile fish showed an increasing trend with increasing numbers of feeding days per week with the highest value at 7 days treatment. Whole-body lipid content of fish in this study showed a tendency toward increase with increasing feeding frequency. Similar findings were observed by Storebakken and Austreng (1987a) in Atlantic salmon fry and fingerlings, Seo et al. (2008) in juvenile rockfish *Sebastes schlegeli*, Ozório et al. (2009) in juvenile Blackspot Seabream *Pagellus bogaraveo* and Du et al. (2006) in juvenile grass carp *Ctenopharyngodon idella*.

Crude protein values showed a decreasing trend from 4, 5 and 7 days treatment. Six days value was highest. Seemingly, there was an inverse relationship between protein and fat deposition with increasing number of feeding days per week. Adebayo and Quadri. (2005) observed same relationship in Hybrid Clariid Catfish, *Clarias gariepinus* x *Heterobranchus bidorsalis* fed with different percentages of protein. All treatments were statistically different except for initial and 5 days treatment.

Ash content showed a decreasing trend with increased number of feeding days per week although values of 6 were higher than that of 4 and 5 days treatment as seen in table 14. Seven days treatment had the least fat content. Zhou et al. (2003) obtained similar results when juvenile gibel carp

(*Carassius auratus gibelio*) were fed on 5 different frequencies. Four and 5 days treatment differs significantly from 6 and 5, and 6 days treatment differ from 7 days treatment.

4.2. Compensatory growth experiment

4.2.1. Net mean weight gain

From the results shown in Table 15 and 17, it was observed that juvenile Nile tilapia demonstrate compensatory growth as the most starved group with the lowest mean weight prior to start of CG experiment grew and caught up with that of least starved group of 7 days treatment. When favourable conditions are restored (feeding to satiation 3 times daily) after a period of growth depression (deprivation of feed), there was a phase of accelerated growth as depicted in Table 17. Ali et al. (2003) had similar views in his review of compensatory growth as a response to growth depression. Compensatory growth had been demonstrated in fishes after growth depression had been induced by complete or partial food deprivation. In this study, it took 24 days of feed deprivation for full or complete compensatory growth in juvenile Nile tilapia. CG has been reported within 3 weeks of refeeding in 1-2g minnows (*Phoxinus phoxinus*) after 16 days deprivation, in 16-120g rainbow trout after a 3 week deprivation and partial compensation in 4.34g hybrid tilapia (*Oreohromis mossambicus* x *O. niloticus*) after 2-4 weeks of deprivation followed by 4 weeks of refeeding (Wang et al., 2000).

There was a tendency for both feed intake and growth percentage net mean weight gain to increase with the length of feed deprivation (Table 16 and 17). The magnitude of CG tends to be dependent on the severity of under nutrition (Wang et al., 2000). Hyperphagia could be a major contributor to the high growth rates during CG. Compensatory growth is a response to hyperphagia when rates of food consumption are higher than those in fish that have not experienced growth depression (Wang et al., 2000, Xie et al., 2001, Ali et al., 2003).

4.2.2. Specific growth rate (SGR)

There was decreasing trend from the previous most starved group of 4 days feeding per week to the least starved group of 7 days feeding per week. The values range from 0.87±0.025 of 4 days feeding to 0.54±0.167 of 7 days weekly feeding. Cui et al. (2006) had same results for juvenile gibel carp following 4 weeks deprivation and 4 weeks refeeding.

4.2.3. Feed conversion ratio (FCR)

Feed conversion ratio was highest with the least starved groups of 7 days which had the worse feed efficiency. It turns to show an increasing trend though 4 days treatment was higher than 5 and 6 but lower than the former least starved group of 7 days feeding per week (Table 18). The result is in conformity with Wang et al., (2000), Ali et al., (2003) and Mambrini et al., (2004) who reported improved feed efficiency with compensatory growth.

4.2.4. Blood analysis

Red blood cell (RBC)

Despite the fluctuating trend, all treatments had normal values as reported by Bittercourt et al. (2004)

Hematocrit (HCT)

Values were all normal as reported by Bittercourt et al. (2004)

4.2.5. Proximate analysis

There was increasing lipid levels from the least formerly starved group of 7 days treatment as compared to the other treatments. The increasing crude fat levels were also reported by Ali et al. (2003). Periods of feed deprivation induces changes in the storage reserves, particularly of lipids of fish. Apart from the strong evidence for the restoration of somatic growth trajectories, CG is a response to restore lipid levels.

V. CONCLUSION

Effects of different feeding regimes on the growth and compensatory growth of juvenile Nile tilapia were tested. From the results obtained, it was concluded that adopting weekly feeding regimes that will reduce production cost are very essential in increasing economic gains for the fish farmer. Besides the increased economy of scale, the fish farmer can spare some time to carry out other economic activities.

The best feeding strategy to optimized gains is 5 days feeding per week. This was evident after comparing all the growth parameters used in this study. Statistically, there was no significant difference between 5, 6 and 7 feeding days per week for weight gain and specific growth rate. For the 5, 6 and 7 feeding days per week, 5 days treatment had the lowest FCR and invariably, the best feed efficiency. Blood analysis was within the normal range for Nile tilapia and although differences exist in proximate analysis, the protein content remains reasonably high for all the treatments.

At the 8th week, 6 days feeding per week had the highest weight thus the farmer could consider skipping a day or two when feeding juvenile Nile tilapia to optimized profit margins resulting from feed wastage.

Juvenile Nile tilapia equally demonstrated compensatory capacity. The compensatory growth was full or complete after 24 days of feed deprivation, and refeeding ad libitum for 4 weeks. The least fed group (4 days feeding per week) grew and caught up with that of 7 feeding days per week group. Although there were slight differences in numerical values in weight gain, statistically there was no significant difference amongst the treatments.

Both results of growth and compensatory experiment could be of relevance in terms of saving feed and labour cost and invariably maximizing profits margins for the fish farmer.

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