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Effect of restricted and re-feeding regime on feeding cost, growth performance, feed utilization and survival rate of mixed sex Nile tilapia *Oreochromis niloticus* cultured in tanks

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Abstract
Feed is the most expensive item in captive fish production frequently amounting to more than 50% of the total variable costs depending on the intensity of culture. Feeding costs can be significantly reduced by using proper feeding regimes. Mixed sex *Oreochromis niloticus* with initial mean weights (± standard error) of 3.97 ± 0.35 g were randomly fed twice daily (G1), starved for one day (G2) and two days (G3) in three replicates so as to evaluate feeding cost, growth performance, feed utilization and survival rate for eight weeks in tanks. The results showed that, feed restriction had a significant effect in reducing feed cost ($F = 180.291$, $p = 0.001$). Lowest feed cost was obtained in *O. niloticus* starved for two days compared to those starved for one day ($p = 0.005$) and fed twice daily ($p = 0.001$). Feeding cost was reduced by 10 and 20% in *O. niloticus* restricted to feed for one and two days respectively compared to those fed twice daily. During re-feeding growth performance and feed utilization were significantly higher in *O. niloticus* starved for two days than those starved for one day and fed twice daily ($p < 0.05$). The current study revealed that, feeding cost can be reduced to 10 and 20% by depriving *O. niloticus* to feed for one and two days respectively without affecting growth performance, feed utilization efficiencies and survival rate.

Keywords: feeding regime, deprivation, compensatory growth, hyperphagia.

1. Introduction
Feed is the most expensive component of aquaculture enterprise accounting for 40-60% of the operating cost depending on the intensity of production [1, 2]. Successful cultured fish production therefore requires availability of running cost and optimal feeding practices to ensure best growth rates and feed efficiencies [3]. Nile tilapia, *Oreochromis niloticus*, one of the most popular and widely cultured species globally is in a similar situation. Its feeding usually involves two or more meals per day which further increases the feeding cost. Unfortunately, many *O. niloticus* farmers especially in developing countries lack enough incomes and knowledge of feeding their fish. This scarcity of incomes coupled with low price of the cultured *O. niloticus* in the local markets have weakened the development of its production.

An important approach to reduce feeding costs and thus increasing profits in *O. niloticus* culture is to develop proper feeding management [4]. Efforts have been made to reduce feeding cost, while increasing growth rate and maximizing feed utilization by including digestive enzymes in the diet [5]. Other methods tested include the use of mixed feeding timetable of varying high and low dietary protein levels in feed [6, 7] and optimizing the feeding rate [8, 9]. However, poor fish farmers find these methods difficult to apply and expensive to achieve. Feeding regime using restriction and re-feeding strategy has been shown in other species as a simple, easy, practically applicable and affordable means of reducing feeding cost [10-12]. Under restricted feeding regime, some fishes convert a greater portion of feed to body weight without any adverse effect on their growth and nutrient utilization than they do under unrestricted daily feeding ration regime [13].

Feed restriction and re-feeding has been described for many groups of fishes including Cyprinids [14], Gadoids [11], Pleuronectids [15], Molatids [16], Cichlids [17], Ictalurids, [18],

Salmonids [19] and Clariids [20]. Many previous studies using restriction feeding and re-feeding in *O. niloticus* has concentrated on hybrids and none has focused on mixed sex [17, 21, 22]. However, most fish farmers in developing countries practice farming of mixed sex *O. niloticus*. Moreover, there are limited studies that have investigated the effect of restricted feeding and re-feeding on feeding cost, growth performance, feed utilization and percentage survival of mixed sex *O. niloticus.*

The present study was designed to assess the effect of restricted and re-feeding regime in mixed sex *O. niloticus*. The objective was to evaluate the cost of feeding, growth performance and feed utilization as well as percentage survival under three feeding regimes i.e. fed twice daily, restricted to feed for a day and two days. In addition, the study compared the growth performance and nutrient utilization during re-feeding period in the three regimes.

2. Materials and methods

2.1 Experimental set up

A total of 9 concrete tanks measuring 1x1x1 m^3 were used for the experiment. Twenty fingerlings of initial mean body weight (± SE) of 3.57 ± 0.35 g were randomly stocked in each tank of group one (G1), group two (G2) and group three (G3) in three replicates. G1 were fed twice daily (control), G2 were fed every other day (restricted to feed for one day) and G3 were fed on a third day (restricted to feed for two days).

Fingerlings were obtained from the Department of Aquatic Sciences and Fisheries of the University of Dar es Salaam at Kunduchi campus and acclimatized for one week before the start of the experiment. During acclimatization fingerlings were hand-fed twice daily using a pelleted feed containing 196.20 g kg^{-1} protein, 50.50 g kg^{-1} lipid, 564 g kg^{-1} NFE, fiber 51.20 g kg^{-1} and 138.10 g kg^{-1} ash of dry feed. The feed was purchased from Education and Training Agency - Mbegani Campus situated in Bagomoyo, Coast Region at a cost of 1.87 USD kg^{-1} dry feed.

The eight weeks of the experiment were divided into two periods. The first period involved feeding G1 fingerlings with the above feed at 5% of their average body weight twice daily. During this period, G2 and G3 fingerlings were fed every other day (restricted to feed for one day) and G3 were fed on a third day (restricted to feed for two days) respectively. On the day of feeding G1, G2 and G3 were fed twice daily between 0900 and 1000 hrs in the morning and 1500 and 1600 hrs in the evening. The second period involved a re-feeding period from the sixth week to the end of the experiment. During re-feeding period, all test groups were fed twice daily. Feed was spread equally in all parts of the experimental tanks. The amount of feed given was adjusted every two weeks after determination of new total *O. niloticus* weights in each tank.

2.2. Data collection

All the experimental *O. niloticus* were taken from each tank for individual weight and length measurements every 14 days. Individual *O. niloticus* weight was measured using an electronic weighing balance (model number YP5001N, made in China) to nearest 0.01 g. The length was measured using a ruler to the nearest 0.01 cm from the tip of the snout to the end of the tail, with mouth closed and the tail lobes pressed together. After the measurements, *O. niloticus* were released back to their respective treatment tanks.

2.3 Feeding cost evaluation

The amount of feed used every fortnightly and the cost of feed per kilogram were used to estimate the feeding cost. The cost was obtained by multiplying the total feed used and the cost per kilogram dry feed.

2.4 *O. niloticus* growth performance and feed utilization

The weight data were used to calculate relative growth rate (RGR), daily weight gain (DWG), specific growth rate (SGR) and percentage weight gain (PWG). Weight and feed data were used to estimate feed conversion ratio (FCR), feed efficiency ratio (FCE) and protein efficiency ratio (PER). The following formulae were used.

i. $$\text{RGR}\ (\%\ \text{g day}^{-1}) = \left[\frac{\text{Wf} - \text{Wi}}{\text{Wi x T}}\right] \text{x } 100$$

where W_f =Final weight and W_i = Initial weight and T = time in days.

ii. $$\text{DWG}\ (\text{g day}^{-1}) = \frac{\text{Wf} - \text{Wi}}{\text{T}}$$

iii. $$\text{PWG}\ (\%) = \left[\frac{\text{Wf} - \text{Wi}}{\text{Wi}}\right] \text{x } 100$$

iv. $$\text{SGR}\ (\%\ \text{day}^{-1}) = \left[\frac{\ell\text{nWf} - \ell\text{nWi}}{\text{T}}\right] \text{x } 100$$

where $\ell n\, W_f$ = Natural logarithm of final weight and $\ell n\, W_i$ = Natural logarithm of initial weight.

v. $$\text{FCR} = \frac{\text{TFG}}{\text{TWG}}$$

where TFG = Total feed given to *O. niloticus* and TWG = Total weight gained by *O. niloticus.*

vi. $$\text{FCE} = \frac{\text{TWG}}{\text{TFG}}$$

The number of fingerlings stocked at the start of the experiment and those that remained after eight weeks were used to determine percentage survival (SV, %) using the formula:-

vi. $$\text{SV} = \frac{\text{NFf}}{\text{NFi}} \text{ x } 100$$

where NFf and NFi = Number of *O. niloticus* at the end and start of the experiment respectively.

2.5 Statistical analyses

All data are presented as means ± standard error of the mean and tested for homogeneity of variances using Levene's test. After confirming homogeneity of variances, one-way analysis of variance (ANOVA) was applied to determine the differences in feeding cost, growth of *O.*

niloticus, feed utilization efficiencies and percentage survival among the feeding regimes. When significant differences were detected, Tukey's post hoc test was performed to determine specific differences among the treatments. Percentage data were arcsine-transformed prior to ANOVA and reversed afterwards for reporting purposes. All statistical analyses were performed using SPSS Version 20 (SPSS, Inc.). Values were considered statistically different at p value of less than or equal to 0.05 [23].

3. Results

3.1 Feeding cost

Feed restriction had a substantial effect on feed cost during the experiment (Figure 1). The cost of feed between the control and restricted groups was significantly different at the end of the experiment ($F = 180.291$, $p = 0.001$). Tukey post hoc test revealed that, the feed cost was significantly lowest in G3 *O. niloticus* (0.40 ± 0.003 USD) as compared to G2 (0.45 ± 0.005 USD) ($p = 0.005$) and G1 (0.50 ± 0.002 USD) ($p = 0.001$). The cost was also significantly lower in G2 compared to G1 ($p = 0.005$; Figure 1). Feeding cost was reduced by 10 and 20% in *O. niloticus* restricted to feed for one and two days respectively compared to those fed twice daily.

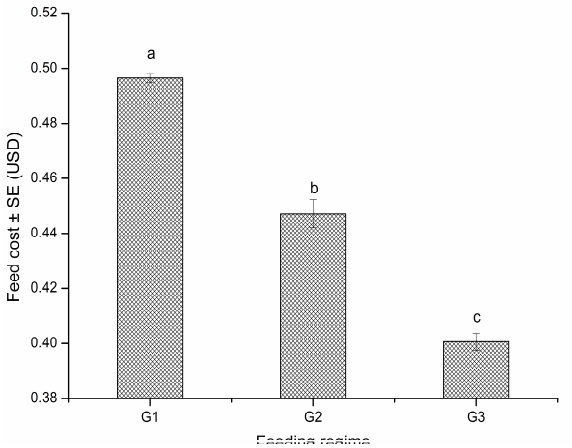


Fig 1: Feed cost for *Oreochromis niloticus* fed the three feeding regimes during the experiment. Different letters above the bars indicate significant difference ($p < 0.05$) and vertical bars indicate standard error (SE) of the mean.

3.2 Growth performance

Feed restriction had no significant effect on mean body weight increase (Figure 2). The mean weight increase did not differ significantly among the three feeding regimes ($F = 0.387$, $p = 0.683$). Final mean body weight of *O. niloticus* (G1 = 11.09 ± 0.30, G2 =11.20 ± 0.07 and G3 = 11.39 ± 0.14; Figure 2) was similar in all groups ($F= 0.615$, $p = 0.597$). The growth parameters in the current study indicated that *O. niloticus* performed equally well under all the three feeding regimes ($p > 0.05$).

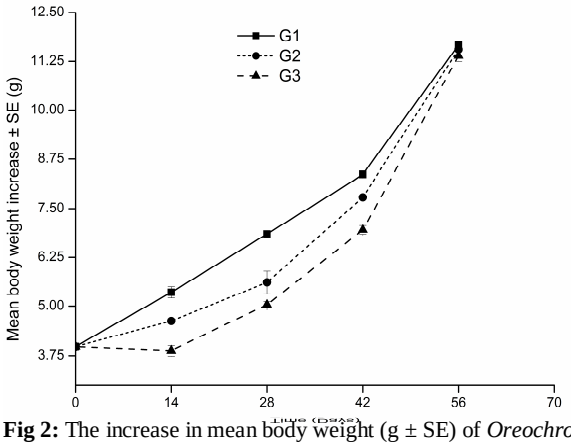


Fig 2: The increase in mean body weight (g ± SE) of *Oreochromis niloticus* during the experimental time (days). Vertical bars indicate standard error (SE) of the mean.

Interestingly, during the last two weeks (42 – 56 days) of re-feeding, SGR increased significantly in G3 than G1 and G2 ($F = 11.404$, $p = 0.040$) (Figure 3).

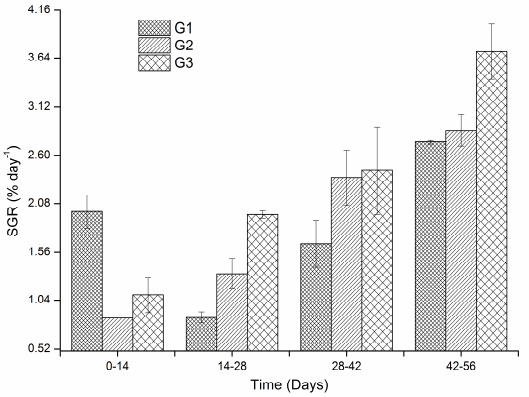


Fig 3: Variation of SGR (% day^{-1}) for *Oreochromis niloticus* during the experimental period. Vertical bars indicate standard error (SE) of the mean.

Tukey multiple comparisons showed that, SGR was significantly higher in G3 than G1 ($p = 0.043$) but similar in G1 and G2 ($p = 0.067$; Table 1). Similarly, DWG and RGR were significantly higher during the same period in G3 than G1 and G2 ($F = 27.355$, $p = 0.012$). Results of Tukey multiple comparisons test showed significantly higher values of DWG and RGR in G3 than G1 ($p = 0.011$) and G2 ($p = 0.030$; Table 1).

Table 1: Growth performance parameters of *Oreochromis niloticus* during the last two weeks of re-feeding.

Growth parameter	G1	G2	G3
SGR (% day^{-1})	2.48 ± 0.05^{a}	2.68 ± 0.15^{a}	3.71 ± 0.30^{b}
DWG (g day^{-1})	0.19 ± 0.02^{a}	0.24 ± 0.00^{a}	0.32 ± 0.02^{b}
RGR (% g day^{-1})	2.33 ± 0.16^{a}	2.99 ± 0.08^{a}	4.56 ± 0.34^{b}
PWG (%)	32.57 ± 2.18^{a}	$47.63 \pm 6.74^{a,b}$	63.84 ± 4.72^{b}

Values in the same row with different superscripts are statistically significant.

3.3 Feed utilization efficiencies

A similar trend as in growth performance was obtained in feed utilization efficiencies. Overall, the study did not find significant differences in feed utilization among the feeding regimes ($p > 0.05$). However, in the last two weeks, FCE and PER were significantly highest in G3 as compared to G1 and G2 ($F = 27.355$, $p = 0.012$ and $F = 10.127$, $p = 0.046$) respectively (Figure 4). Tukey test showed that FCE was higher in G3 than G1 ($p = 0.011$) and G2 ($p = 0.03$). Similarly, PER was higher in G3 than G1 ($p = 0.041$). Furthermore, FCR was significantly different among fish in G3, G1 and G2 ($F = 11.774$, $p = 0.038$). The FCR value was significantly lower in G3 than G1 ($p = 0.035$; Table 2).

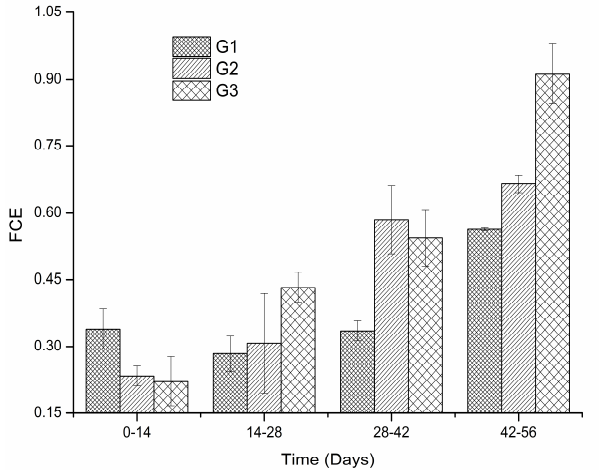


Fig 4: Variation of FCE for *Oreochromis niloticus* during the experimental period. Vertical bars indicate standard error (SE) of the mean.

Table 2: Variation of feed utilization efficiencies of *Oreochromis niloticus* during the two weeks of re-feeding.

Feed utilization	G1	G2	G3
FCE	0.46 ± 0.03^{a}	0.60 ± 0.02^{a}	0.91 ± 0.07^{b}
FCR	2.16 ± 0.14^{a}	$1.50 \pm 0.21^{a,b}$	1.10 ± 0.08^{b}
PER	2.37 ± 0.16^{a}	$3.47 \pm 0.49^{a,b}$	4.65 ± 0.34^{b}

Values in the same row with different superscripts are statistically significant ($p < 0.05$).

3.4 Percentage survival

Percentage survival of the cultured *O. niloticus* was generally higher in all feeding regimes. It ranged from $92.50 \pm 2.50\%$ in G3 to $97.5 \pm 2.50\%$ in G1 and G2. There was no significant difference in percentage survival among the different feeding regimes ($F = 1.333$, $p = 0.385$).

4. Discussion

The present results have shown lower feed cost in *O. niloticus* fed on restricted regimes than the control. These results are supported by [3] who indicated that, restriction feeding has the potential to lower feeding cost. This is because the amount of feed given in an aquaculture system is determined by the feeding frequency and rate as well as average weight and number of fish present. Since the feeding rate, average weight and number of *O. niloticus* were the same, the significant difference in feed cost obtained is due to feeding restriction. *O. niloticus* restricted to feed consumed less amount of feed than unrestricted ones. Consequently, the cost of feed was lowest in *O. niloticus* fed on a third day followed by those fed every other day and was highest in those fed twice daily.

It is apparent from the current results that, the discriminate restriction to feed for one or two days offers an opportunity to protect fish farmers against unfavourable situations such as feed shortages or high cost of feed. This strategy provides a chance for *O. niloticus* farmers to reduce the cost of production. *O. niloticus* farmers can surely derive more income from their aquaculture activities if the amount of money spent on feeds is reduced considerably. Therefore, the current study indicates that, feeding cost can be reduced by depriving *O. niloticus* to feed for one and two days.

Feed restriction did not affect mean body and final weights as well as growth performance of *O. niloticus* in the present study. These results are in agreement with those obtained by [22] who reported non-significant differences in weight between fish deprived of feed for 1, 2 and 3 days per week. This is due to compensatory growth, defined as a period of unusually fast growth shown by individuals encountering abundant food following a period of food deprivation [16, 24]. Compensatory growth represents readjustments of growth rate to minimize the discrepancy between achieved and desired growth rate caused by a period of under-nutrition [25]. Thus, feeding regime did not cause alteration of growth performance among *O. niloticus* in the current study.

The study has indicated significant increase in growth parameters (SGR, DWG, RGR and PWG) during the last two weeks of re-feeding. Earlier studies have revealed increased growth efficiency during re-feeding in Sunfish hybrids [16], gibel carp [26] and three-spined sticklebacks [24]. Similar results have been obtained by [27] using hybrid tilapia *Oreochromis mossambicus* x *O. niloticus* and [3] on *Oreochromis niloticus*. The fast growth during the period of re-feeding is due to hyperphagia (an increase in appetite) and improved growth efficiency [25]. Hyperphagia is a rapid rate of food consumption shown by fish restricted to feed than those accessing feed continuously [11, 13]. The increased appetite resulted in *O. niloticus* consuming more feed as a response to overcome or compensate the difficult period they encountered during feed restriction [24]. In the present study, hyperphagia was vivid in the last two weeks both the restricted *O. niloticus* after re-feeding. This observation indicates that *O. niloticus* on the restricted feeding regimes used hyperphagia to consume more feeds following a period of deprivation resulting in fast growth rate.

The results showed higher FCE and PER and lower FCR in *O. niloticus* restricted to feeding for two days than those restricted for a day and fed twice daily continuously during the last two weeks of re-feeding. Increased feed efficiency during re-feeding has been observed in previous studies involving sockeye salmon [28], rainbow trout [29], European minnow [30] and gibel carp [31]. The higher conversion efficiencies is due to improved feed conversion efficiency during the re-feeding period as a consequence of starvation [17, 26]. Studies have shown that, during fasting period, basal metabolic rate of animals usually decreases [32-34]. The

decreased metabolic rate is not immediately regulated when feed is available. This makes a larger portion of the ingested feed being utilized for tissue growth instead of basal metabolism which improves feed conversion efficiency. The *O. niloticus* starved for one day and two days showed higher capabilities of nutrient utilization in the last two weeks. This indicates improved feeds conversion to growth due to feed restriction period.

It is apparent from the current results that, increased growth performance and feed utilization during re-feeding regime require a certain length of prior starvation period and occurs after defined times. In both cases, the improved response was evident in *O. niloticus* experiencing the longer period of starvation (2 days) and at an extended period of time (last two weeks [42-56 days] of re-feeding. The present results are supported by the recommendation given in [24] that the increased response reflects the length of the period prior to starvation. Studies have indicated that, time is required to re-establish effective digestive processes in the stomach following a period of feed deprivation [3, 35, 36]. This elucidates on the fact that deprived fish eat more feed after adapting new feeding regimes than normally fed fish when daily feeding is resumed resulting in improved growth and feed utilization [27].

The current study has shown similar percentage survival between the restricted and non-restricted groups of *O. niloticus*. Similar results were obtained by [17] who depicted percentage survival of hybrid tilapia between 95% and 100% per tank during feed restriction and re-feeding period respectively. The existence of similar percentage survival in all groups indicates that *O. niloticus* can be cultured by restricting feeds for one to two days and re-feeding during the last 25% of culture period towards harvesting without affecting the desired survival rate. Thus, restricting *O. niloticus* to feeds for one or two days and re-feeding does not affect their percentage survival.

5. Conclusion

The current study indicated that, feeding cost can be reduced by 20% through depriving *O. niloticus* to feed for two days and then re-feeding during the last 25% of the culture period without affecting growth performance, nutrient utilization and survival rate. Thus, feed restriction can be used as a management tool to reduce feeding cost, improve growth rates and feed utilization when properly planned.

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7. References

1. Marimuthu K, Cheen AC, Muralikrishnan S, Kumar D. Effect of different feeding frequency on the growth and survival of African catfish (*Clarias gariepinus*) fingerlings. Adv Environ Biol 2010; 4(2):187-193.
2. El-Sayed A-FM. Alternative dietary protein sources for farmed tilapia, *Oreochromis* spp. Aquaculture 1999; 179:149-168.
3. Gao Y, Lee J-Y. Compensatory responses of Nile tilapia *Oreochromis niloticus* under different feed-deprivation regimes. Fish Aquat Sci 2012; 15(4):305-311.
4. Lovell RT. Nutrition and Feeding of Fish. 2nd Edition ed. Boston, London, UK: Kluwer Academic Publishers. 1998.
5. Kaleeswaran B, Ilavenil S, Ravikumar S. Growth response, feed conversion ratio and antiprotease activity of *Cynodon dactylon* (L.) mixed diet in *Catla catla* (Ham.). J Anim Vet Adv 2011; 10(4):511-517.
6. De Silva SS. Performance of *Oreochromis niloticus* (L) fry maintained on mixed feeding schedules of differing protein content. Aquac Fish Manag 1985; 16:331-340.
7. Gabriel UU, Inko TMB, Allison ME, Davies OA. Growth of *Heterobranchus bidorsalis* fingerlings fed varying dietary protein and energy rations. Int J Agric Environ Biotech 2000; 2(1-2):35-41.
8. Qin J, Fast AW. Effects of feed application rates on growth, survival and feed conversion of juvenile snakehead (*Channa striatus*). J World Aquacult Soc 1996; 27:52-56.
9. Dong-Fang D, Koshio S, Yokoyama S, Bai SC, Shao Q, Cui Y, Hung SSO. Effects of feeding rate on growth performance of white sturgeon (*Acipenser transmontanus*) larvae. Aquaculture 2003; 217:589-598.
10. Oh S-Y, Noh CH, Cho SH. Effect of restricted feeding regimes on compensatory growth and body composition of Red Sea Bream, *Pagrus major*. J World Aquacult Soc 2007; 38(3):443-449.
11. Jobling M, Meløy OH, Dos Santos J, Christiansen B. The compensatory growth response of the Atlantic Cod: effects of nutritional history. Aquacult Int 1994; 2(2):75-90.
12. Oh S-Y, Kang R-S, Myoung J-G, Kim C-K, Park J, Daniels HV. Effect of ration size restriction on compensatory growth and proximate composition of dark-banded Rockfish, *Sebastes inermis*. J World Aquacult Soc 2010; 41(6):923-930.
13. Ali M, Nicieza A, Wootton RJ. Compensatory growth in fishes: a response to growth depression. Fish Fish 2003; 4:147-190.
14. Russell NR, Wootton RJ. Appetite and growth compensation in the European minnow, *Phoxinus phoxinus* (Cyprinidae) following short term food restriction. Environ Biol Fishes 1992; 34:277-285.
15. Paul AJ, Paul JM, Smith RL. Compensatory growth in Alaska yellowfin sole, *Pleuronectes asper*, following food deprivation. J Fish Biol 1995; 46:442-448.
16. Hayward RS, Noltie DB, Wang N. Use of compensatory growth to double hybrid sunfish growth

rates. Trans Am Fish Soc 1997; 126(2):316-322.
17. Wang Y, Cui Y, Yang Y, Cai F. Compensatory growth in hybrid tilapia, *Oreochromis mossambicus* x *O. niloticus*, reared in seawater. Aquaculture 2000; 189:101-108.
18. Gaylord TG, Gatlin DM. Dietary protein and energy modifications to maximize compensatory growth of channel catfish (*Ictalurus punctatus*). Aquaculture 2001; 194:337-348.
19. Johansen SJS, Eko M, Stagnes B, Jobling M. Weight gain and lipid deposition in Atlantic salmon *Salmo salar*, during compensatory growth: evidence for lipostatic regulation? Aquacult Res 2001; 32:963-974.
20. Hussein MS. Effect of various feeding frequencies on growth performance and previously starved fingerlings and juveniles of African catfish (*Clarias gariepinus*). Egypt Aqua Biol and Fish 2012; 16(2):145-152.
21. Essa MA. The effects of feeding methods and regimes on performance of hybrid tilapia, *Oreochromis niloticus* x *O. aureus*, reared in cages. Egypt Aqua Biol and Fish 2000; 4(1):67-84.
22. Abdel-Hakim NF, Abo State HA, Al-Azab AA, El-Kholy KF. Effect of feeding regimes on growth performance of juvenile hybrid Tilapia (*Oreochromis niloticus* x *Oreochromis aureus*). World J Agric Sci 2009; 5(1):49-54.
23. Zar JH. Biostatistical Analysis. 5th edition ed. New Jersey, USA: Prentice Hall Inc. 2010.
24. Zhu X, Cui Y, Ali M, Wootton RJ. Comparison of compensatory growth responses of juvenile three-spined stickleback and minnow following similar food deprivation protocols. J Fish Biol 2001; 58(4):1149-1165.
25. Xie S, Zhu X, Cui Y, Wootton RJ, Lei W, Yang Y. Compensatory growth in the gibel carp following feed deprivation: temporal patterns in growth, nutrient deposition, feed intake and body composition. J Fish Biol 2001; 58(4):999-1009.
26. Qian X, Cui Y, Xiong B, Yang Y. Compensatory growth, feed utilization and activity in gibel carp, following feed deprivation. J Fish Biol 2000; 56:228-232.
27. Wang Y, Cui Y, Yang Y, Cai F. Partial compensatory growth in hybrid tilapia *Oreochromis mossambicus*·x *O. niloticus* following food deprivation. J Appl Ichthyol 2005; 21:389-393.
28. Bilton H, Robins G. The effects of starvation and subsequent feeding on survival and growth of Fulton channel sockeye salmon fry (*Oncorhynchus nerka*). Journal of the Fisheries Research Board of Canada 1973; 30(1):1-5.
29. Dobson S, Holmes R. Compensatory growth in the rainbow trout, *Salmo gairdneri* Richardson. J Fish Biol 1984; 25(6):649-656.
30. Russell NR, Wootton RJ. Appetite and growth compensation in the European minnow, *Phoxinus phoxinus* (Cyprinidae), following short periods of food restriction. Environ Biol Fishes 1992; 34(3):277-285.
31. Qian X, Cui Y, Xiong B, Yang Y. Compensatory growth, feed utilization and activity in gibel carp, following feed deprivation. J Fish Biol 2000; 56(1):228-232.
32. Fu S-J, Xie X-J, Cao Z-D. Effect of fasting and repeat feeding on meabolic rate on Southern Catfish *Silurus meridionalis* chen. Mar Freshwat Behav Physiol 2005; 38(3):191-198.
33. Rosen DAS, Trites AW. Changes in metabolism in response to fasting and food restriction in the Steller sea lion (*Eumetopias jubatus*). Comp Biochem Physiol B: Biochem Mol Biol 2002; 132:389-399.
34. Wang T, Hung CCY, Randall DJ. The comparative physiology of food deprivation: From feast to famine. Annu Rev Physiol 2006; 68:223-251.
35. Ali M, Cui Y, Zhu X, Wootton RJ. Dynamics of appetite in three fish species (*Gasterosteus aculeatus*, *Phoxinus phoxinus* and *Carassius auratus gibelio*) after feed deprivation. Aquacult Res 2001; 32:443-450.
36. Zhu X, Xie S, Zou Z, Lei W, Cui Y, Yang Y, Wootton RJ. Compensatory growth and food consumption in gibel carp, *Carassius auratus gibelio*, and Chinese long snout catfish, *Leiocassis longirostris*, experiencing cycles of feed deprivation and re-feeding. Aquaculture 2004; 241:235-247.