

Full Length Research Paper

The outcome of cyclic feed scarcity on growth and economic limit of commercial feed-based in-door grow-out of *Clarias gariepinus* (Burchell, 1822)

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Growth, feed utilization, and economic limit of commercial pelleted feed use were compared between daily-fed and feed deprived groups of *Clarias gariepinus* (Burchell, 1822) raised under low density culture. Groups of *C. gariepinus* were fed daily (Treatment 1) or on alternate days (Treatment 2) for 5½ months, with 45% crude protein commercial pellets. Feeding was at a rate of 6% body weight per day which was considered satiation feeding. Cost and revenue were determined on the basis of feed cost and revenue from fish sales respectively. Treatment 1 yielded profits up to a mean weight of 64±8 g at feed conversion ratio 1.0±0.08 and 4.71% loss at mean weight of 105±10 g and feed conversion ratio (FCR) 2.1±0.7. Treatment 2 was profitable up to harvest mean weight of 264±10 g. Feed conversion ratio, mean weight, and total weight, were significantly higher in Treatment 1 ($p<0.05$). Cost-benefit ratio and percentage profit were significantly higher in Treatment 2 ($p<0.0001$). Thus the economic limits were 2 months at mean weight of 105±10 g; and 5 months at mean weight 264±10 g; in Treatments 1 and 2 respectively. The skip-a-day feeding strategy adopted in Treatment 2 was effective in extending the economic limit of conventional feeding using commercial pelleted feed in low density commercial catfish culture. The limits established in this study could serve as an advisory to farmers on the appropriate time to switch from the expensive commercial pelleted feeds usually fed at the early stage of grow-out to farm-made feeds.

Key words: *Clarias gariepinus*, economic limit, low density, feed deprivation, satiation feeding, growth, feed utilization.

INTRODUCTION

The major problems impeding the profitability of aquaculture production in Nigeria have been the cost of commercial pelleted feed, and the purchasing power of the public. Consequently, it is difficult to convert the advantage of higher biological production obtained from pelleted feeds into economic gains when fed fish are fed following conventional practices. Some of the strategies

used by farmers in an attempt to deal with this challenge include mixed feeding alternating commercial pellets with farm-made feeds. Commercial pelleted feeds are usually fed at the early stage (Akinwole and Faturoti, 2007), while farm-made are fed for the rest of culture. Studies (Ofor and Unyime, 2010; Miller and Atanda, 2011) report this feed management approach to still be in practice. There

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are no guides as to when this switch may best be made, as the economic limits of the commercial pelleted feed have not been experimentally determined.

Fish can undergo partial or full growth compensation when subjected to feed denial. The potential of feed denial to improve production efficiency of farmed species has been recognised (Joblin, 2010). These species include *Phoxinus phoxinus* and *Gasterosteus aculeatus* (Zhu et al., 2001), gibel carp (*Carassius auratus gibelio*) and Chinese longsnout catfish (*Leiocassis longirostris*) (Zhu et al., 2004). The potential has also been reported for individually housed and grouped fish (Ali et al., 2003); hybrid tilapia *Oreochromis mossambicus* x *Oreochromis niloticus* (Wang et al., 2000); and barramundi (*Lates calcarifer*) (Tian and Qin, 2003). However, Eroldogan et al. (2006) reported only partial compensation by *Sparus aurata*.

In these studies, fish were subjected to a long unbroken period of feed deprivation, followed by a long unbroken period of re-feeding, which can be repeated in the culture period. The disadvantage of this procedure is that on full compensation fish revert to the growth and feed utilisation characteristics of continuously-fed groups. The test procedure in this study is aimed to prevent this by keeping fish on perpetual compensation. Also, the feeding habit of *C. gariepinus* differs from that of the tested species. The objectives of this study therefore are to determine the economic limits of conventional use of commercial pelleted feed, and the effect of short-term cyclic feed denial on this limit, in the low density culture of *C. gariepinus*.

MATERIALS AND METHODS

Two groups of *C. gariepinus* of mean weight 4.6 ± 0.2 g were subjected to different feeding regimes. In Treatment 1, fish were fed daily. In Treatment 2, fish were fed at one day intervals (one day feeding, one day non-feeding). Treatment 1 served as control. Feeding was with a commercial pelleted feed of 42% crude protein, 13% ether extract, 1.8% crude fibre, and 7.5% ash content. Feeding was at the rate of 6% fresh body weight daily, or in feeding days in Treatment 2. This was considered satiation feeding. The feed was dispensed in three instalments of 2% each. Experimental units were plastic tanks stocked at the rate of 86 fish of 0.39 kg total weight/m³. Each treatment was replicated thrice. Fish were weighed at monthly intervals and feed weight adjusted according to the new fish weight. The experiment lasted for 170 days (5½ months). Feeding was stopped 24 h before sampling and commenced 24 h after restocking. Sampling was done monthly, during which fish were weighed. Dissolved oxygen (mg/L), pH, temperature (°C), ammonia (mg/L), and nitrite (mg/L) of culture water were measured. Feed and fish weight data were used to calculate mean weight, specific growth rate (%/day), feed conversion ratio, profit, revenue, and feed cost during culture and at harvest.

SGR was calculated as (Goda et al., 2007):

$$SGR = \left(\frac{\ln FBW - \ln IBW}{\text{Days}} \right) \times 100$$

Where FBW is the mean weight at harvest (g), IBW is the initial or

stocking mean weight (g), and ln is the natural logarithm. Feed conversion ratio (FCR) was calculated as:

$$FCR = \frac{\text{Dry weight food fed (g)}}{\text{Weight gain (g)}}$$

Cost-benefit ratios of the two treatments were compared at each sampling during culture, and at harvest. Feed cost was the only cost item considered. The prevailing pelleted feed retail price of US\$2.23 (1 US\$=157 Naira) per kg of 2-4 mm pellet size was used as feed cost. Likewise, the only benefit considered was revenue derived from sale of fish. The prevailing catfish retail price of US\$ 3.8 (600 Naira) per kg, was used to calculate revenue. At the end of culture, mean weight, total weight, SGR, FCR, percentage profit, cost-benefit ratios, revenue, feed cost, and physico-chemical parameters were compared using the student's t-test.

RESULTS

Sampling was done on the 34th, 70th, 104th, 139th, and 170th days of age respectively corresponding to the 1st, 2nd, 3rd, 4th and 5th months respectively. Feed fed was partially taken up in Treatment 1 while it was completely taken up by fish in Treatment 2. Total feed weight fed in Treatment 2 amounted to 31.1% of feed weight in Treatment 1. Total weight recorded in Treatment 2 amounted to 61% of the total weight in Treatment 1. Results of comparison of total weight, mean weight, SGR, FCR, percentage profit, cost-benefit ratios, revenue, and feed cost are given in Table 1. Profit was highest in Treatment 2 while Treatment 1 operated at a loss. SGR (% day⁻¹) was not significantly affected by treatment ($p > 0.05$). Survival, FCR, mean weight, and total weight were significantly affected by treatment ($p < 0.05$). The trend of variation of biological and economic production indices are presented in Figures 1 to 7. Both treatments recorded profits and consequently cost-benefit ratios above 1 up to the second month. In subsequent months Treatment 1 recorded losses and cost-benefit ratios less than 1, while Treatment 2 remained profitable, with cost-benefit above 1. Mean monthly levels of physico-chemical parameters of culture water are given in Table 2. Treatment 1 generated significantly higher levels of ammonia and nitrite.

DISCUSSION

Feed is the single highest cost component in commercial, pelleted feed-based fish culture, accounting for 50 to 70% of production costs (Rana et al., 2009). Improvement of feed management practices is therefore important for successful catfish culture. Commercial pelleted-based culture of the Clariidae is known to be unprofitable if pelleted feed is used for the entire period of grow-out. Because of this, farmers use commercial feed in the

Table 1. Production parameters survival (%), total weight (g), mean weight (g), specific growth rate (%/day), feed conversion ratio, revenue (US\$ per ton), cost:benefit ratio, profit (% feed cost), and feed cost (US\$/ton)(g) of *Clarias gariepinus* (Burchell, 1822) fed daily (treatment 1) and at one-day intervals (treatment 2) at the end of 5 ½ months culture at the rate of 6% fresh body weight, with commercial pelleted feed of 42% crude protein content, 13% ether extract, 1.8% crude fibre, and 7.5% ash content.

Parameter	Survival	Mean weight	Total weight	SGR	FCR	Revenue	C:B	Profit	Feed cost
Treatment 1	67±17 ^a	295±14 ^a	1114±240 ^a	2.4±0.05 ^a	2.94±0.1 ^a	4259±916 ^a	0.60±0.03 ^b	-40±2.5 ^b	7097±1785 ^a
Treatment 2	45±4 ^u	264±10 ^u	678±56 ^u	2.3±0.13 ^{ca}	1.2±0.01 ^u	2590±213 ^u	1.51±0.13 ^{ca}	51±13.3 ^{ca}	1732±281 ^u

Values are means (±SEM) of three replicates per treatment. Means in the same column with different superscript letters are significantly different (p<0.05). 1US\$=157 Naira.

initial phase of grow-out, and farm-made feed which is presumed to be cheaper, for the rest of grow-out (Akinwole and Faturoti, 2007; Miller and Atanda, 2011). The appropriate point to switch from commercial pelleted feed to farm-made feed has not been well defined and farmers are not properly guided. This is because the switch-over point has not been experimentally established, to determine the full extent to which commercial pelleted feed can be used. In this study, the biological characteristics of this point have been defined as shown in Figures 1, 2, and 3. The resulting economic characteristics have been described as shown in Figures 4 to 7. It seems that pelleted feed can be utilized profitably in the culture of *C. gariepinus* for as far as FCR is maintained between values of 1 and 2. This is because FCR of 1.01 yielded a profit (% feed cost) of 89%, while the FCR of 2.1 placed the system close to break-even at mean weight 64±8 and 105±11 g respectively. These points were attained for commercial feed, at the 2nd and 3rd months of culture respectively. The economic limit of FCR is defined as the point at which extra feed fed is paid for by the extra weight gained (Hepher, 1988; De Silva and Davy, 1992). Consequently, it is recommended that the switch from commercial pelleted feed to farm-made feeds be made at the point of attainment of an

FCR value marginally less than 2, since at FCR of 2.1 yielded a profit of -4.71% (Figure 2). The cost of feed can be reduced by an improvement in its utilization. Treatment 2 recorded a lower FCR than Treatment 1 indicating superior feed utilization in Treatment 2 (Table 2). This is inherent in the feeding procedure adopted in Treatment 2 and led to a significant reduction in feed cost. Treatment 2 thus consistently made profit for the entirety of the culture period, due to a combination of improved feed conversion, and the growth compensation of fish subjected to feed denial.

Fish exhibit catch-up growth when abundant food is given following a period of deprivation. Feed deprivation can be short-term or long term and repeated in cycles, over the culture period, in order to avoid starvation. This study has shown that this phenomenon can be exploited for economic benefits. The growth rate of fish during the catch-up phase is higher than that of individuals who have been constantly exposed to feed (Jobling, 1994). The importance of this mechanism for achieving increased growth rates in aquaculture has been noted by Hayward et al. (1997). Fish subjected to various levels of fasting have been known to partially, fully, or over-compensate, for lost growth when full feeding is restored (Ali et al., 2003). According to Wang et

al. (2000) tilapia deprived of feed for 1 week in 8 week experimental period were of comparable weight than those that had been fed continuously, while fish that were deprived for 2 and 4 weeks had significantly lower weight than fish fed continuously. According to Xie et al. (2000), gibel carp (*Carassius auratus gibelio*) starved for 1 and 2 weeks respectively in 5 week feeding period, fully compensated for the deprivation in 2 weeks of re-feeding. Likewise, Kim and Lovell (1995) reported that Channel Catfish deprived of feed for three weeks weighed as much after 18 weeks as controls fed continuously, requiring only 3 weeks to catch up with the controls. According to Reigh et al. (2006), 15- and 30-day fasted *Ictalurus punctatus* had no significant differences in weight gain and FCR in comparison with fish fed continuously for the 72 days feeding period. In this experiment, this phenomenon resulted in the use of much less feed to produce much more fish per unit weight of feed, than was the case when fish were subjected to continuous feeding. Because re-feeding after days of fasting in this study was done at satiation rates, the mechanism for compensation in Treatment 2 may have been both hyperphagy (Ali and Wootton, 2001) as indicated by the complete consumption of feed given, and improved feed utilisation, as seen by the very low FCR values in Treatment 2.

Table 2. Water quality parameters of tanks used in the grow-out of *Clarias gariepinus* fed with a 45% crude protein commercial pellet at the rate of 6% body weight daily or at one-day intervals (Treatments 1 and 2 respectively).

Parameter	Temp (°C)	pH	DO (mg/L)	Ammonia (mg/L)	Nitrite ((mg/L)
Treatment 1	27.1±1.9 ^a	6.7±0.4 ^a	4.1±0.3 ^a	0.04±0.01 ^a	0.05±0.01 ^a
Treatment 2	26.8±2.4 ^a	6.8±0.1 ^a	4.2±0.5 ^a	0.02 ^b	0.02 ^b

Values are means (±SEM) of triplicate measurements per treatment taken before monthly water change for monthly sampling. Means in the same column with different superscript letters are significantly different (p<0.05).

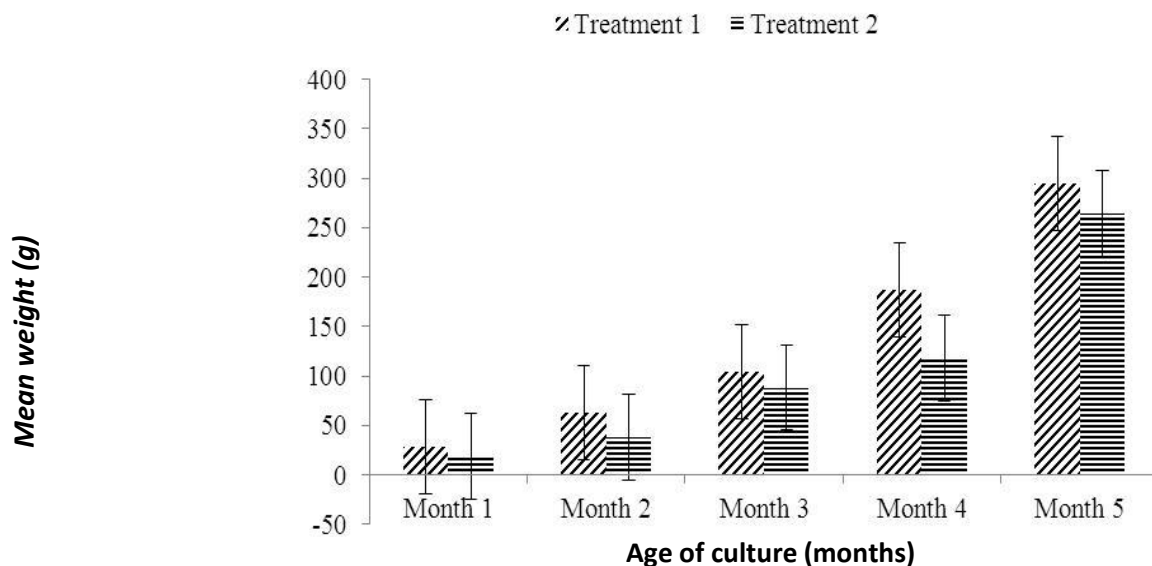


Figure 1. Mean weight (g) of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatment 2), during a 5 ½ month grow-out period at the rate of 6% fresh body weight with commercial pelleted feed of 42% crude protein content. Data points are means (±SE) from three replicates.

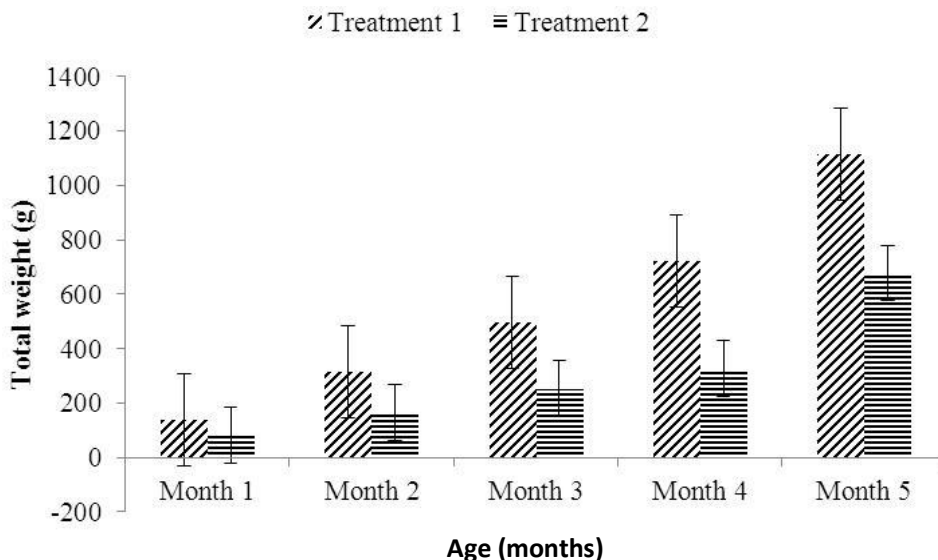


Figure 2. Total weight (g) of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatment 2), during a 5 ½ month grow-out period at the rate of 6% fresh body weight with commercial pelleted feed of 42% crude protein content. Data points are means (±SE) from three replicates.

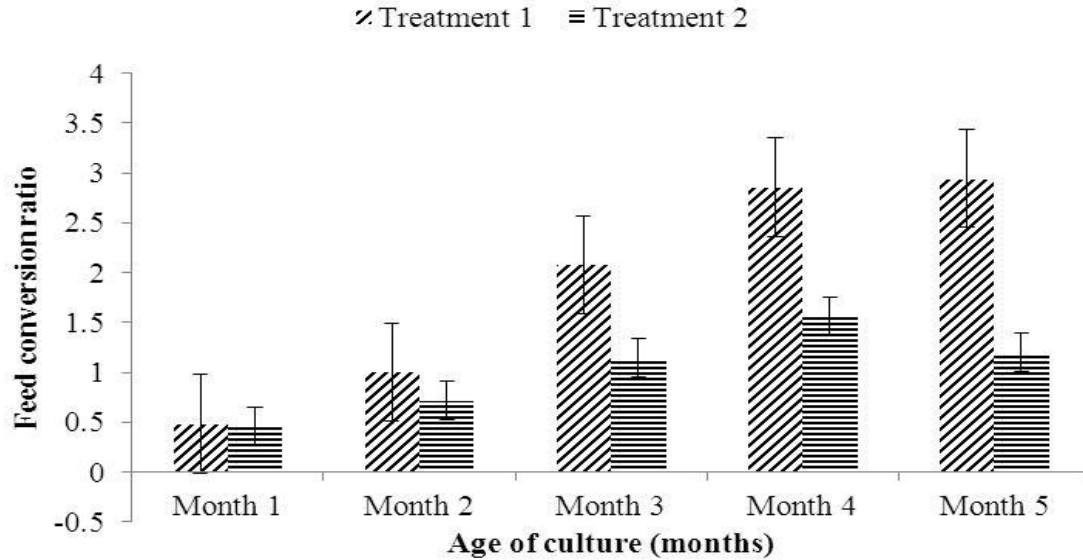


Figure 3. Feed conversion ratio of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatment 2) during 5 ½ months of culture at the rate of 6% fresh body weight, with commercial pelleted feed of 42% crude protein content. Data points are means (\pm SE) from three replicates.

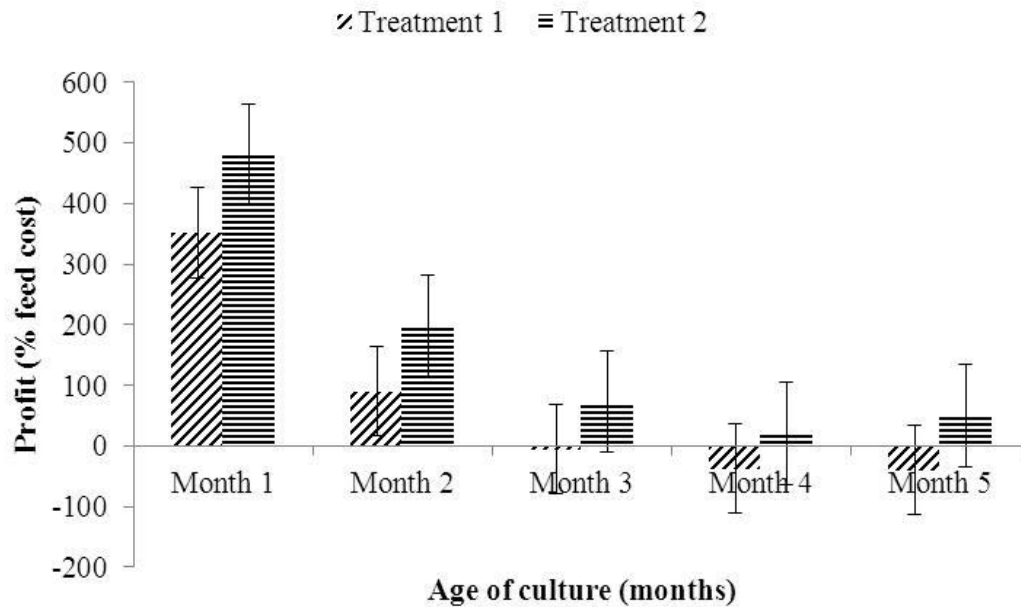


Figure 4. Profit (% feed cost) (US\$/ton) of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatment 2) during 5 ½ months of culture at the rate of 6% fresh body weight with commercial pelleted feed of 42% crude protein content. Data points are means (\pm SE) from three replicates.

The deprivation and re-feeding approach adopted in this study contrasts with the usual approach of a relatively long period of denial followed by a long period of re-feeding. The approach in this study was aimed at

preventing a situation where fish reverts to the growth and feed utilisation trajectories of the continuous fed treatment, on full compensation.

Treatment 1 generated significantly higher levels of

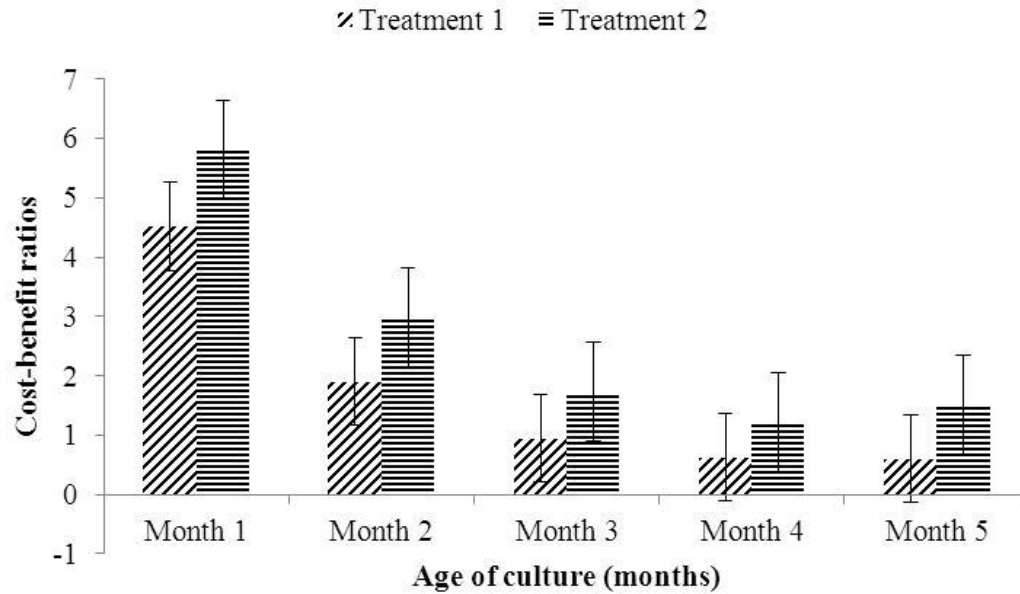


Figure 5. Cost-benefit ratios of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatment 2) during 5 ½ months of culture at the rate of 6% fresh body weight with commercial pelleted feed of 42% crude protein content. Data points are means (\pm SE) from three replicates.

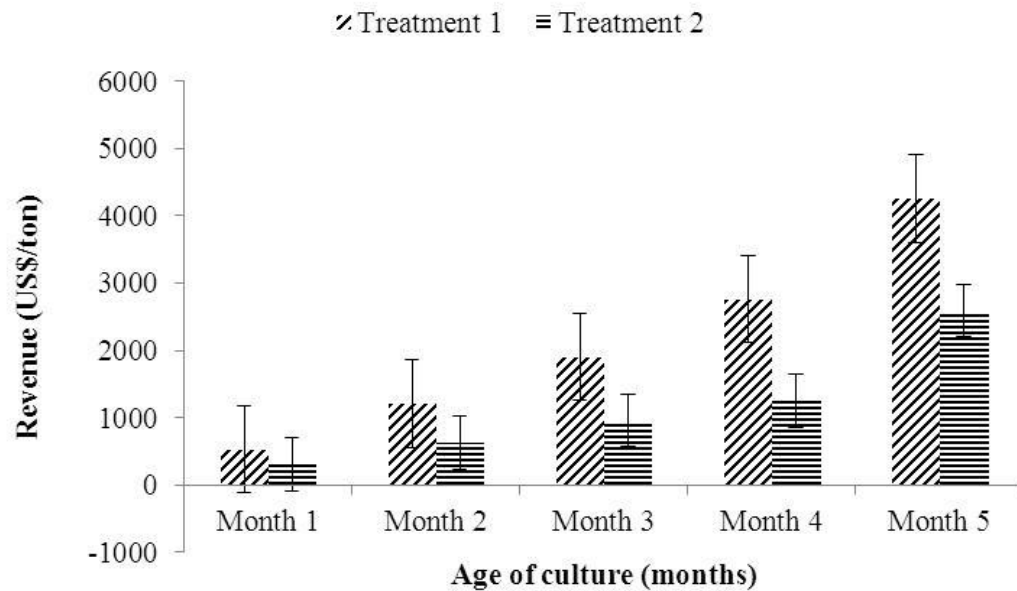


Figure 6. Revenue (US\$/ton) of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatment 2) during 5 ½ months of culture at the rate of 6% fresh body weight with commercial pelleted feed of 42% crude protein content. Data points are means (\pm SE) from three replicates.

nitrite and ammonia than Treatment 2. Ammonia and nitrite levels were within the tolerance range for fish culture in Treatment 1, but within the optimal range in Treatment 2. These metabolites are usually kept at

optimal levels for good growth of fish. Under field conditions, their elimination may necessitate a higher water exchange rate and cost in Treatment 1 than Treatment 2.

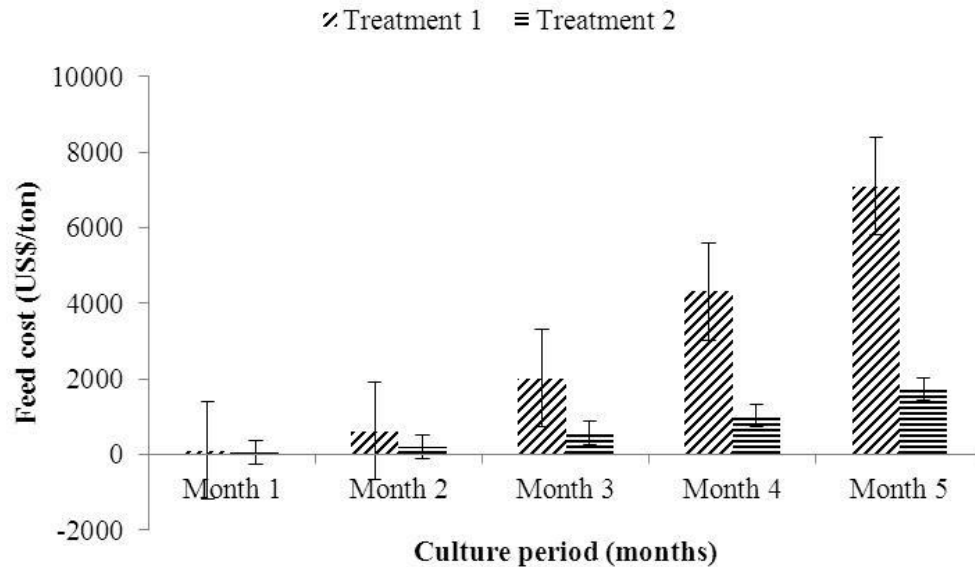


Figure 7. Feed cost (US\$/ton) of *Clarias gariepinus* (Burchell, 1822) fed daily (Treatment 1) and at one-day intervals (Treatments 2) during 5 ½ months of culture at the rate of 6% fresh body weight with commercial pelleted feed of 42% crude protein content. Data points are means (\pm SE) from three replicates.

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