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International Journal of Scientific Research in Science, Engineering and Technology IJSRSET

Effect of feeding frequency on the growth, food utilization and survival of African catfish (*Clarias gariepinus*) using locally formulated diet

VO Eyo & A Ekanem

Institute of Oceanography, University of Calabar, P. M. B. 1115, Calabar, Nigeria
e-mail: sirvick2003@yahoo.com

Abstract: A 56-day feeding trial was conducted to determine the effect of different feeding frequency on the growth, food utilization and survival of African catfish (*Clarias gariepinus*) using locally formulated feed. Duplicate group of fish with a mean initial wet weight of 4.18 ± 0.1 g and length of 7.3 ± 0.2 cm were stocked in glass aquaria measuring 96 cm x 50 cm x 29 cm and fed at 5% body weight using locally formulated feed at different frequencies (once/daily, twice/daily and thrice/daily). Growth performance evaluated using weight gain (g), length gain (cm), growth rate, specific growth rate, mean growth rate varied significantly ($P < 0.05$) with feeding frequency. Fish fed twice daily gave the best performance. Food utilization and percentage survival showed no significant ($p > 0.05$) variation in fish fed at different frequencies. It is therefore concluded that to optimize growth performance in *C. gariepinus* using locally formulated feed, feeding frequency of twice daily should be employed and this will also be effective in minimizing water quality deterioration, feed wastage and production cost.

KEYWORDS: *Clarias gariepinus*, formulated feed, feeding frequency, growth, food utilization, survival

Introduction

In Nigeria, consumption and demand for fish protein is increasing due to its affordability. Fish is also a good source of thiamine, riboflavin, vitamins A and D, phosphorus, calcium and iron. Catfishes of the family Clariidae comprise the most commonly cultivated fishes in Nigeria. The African catfish (*Clarias gariepinus*) is one of the most highly demanded freshwater food fish and cultivar species in Nigeria and elsewhere due to its resistance to diseases, ability to tolerate a wide range of environmental conditions and high stocking densities under culture conditions and relative fast growth rate (Hecht *et al.*, 1996; James and Sampath, 2003). It is appreciated by consumers for the quality of its meat (Pruszyński, 2003) and is mostly smoked and used in soups. The African catfish inhabits a wide range of water bodies like swamps, lakes and rivers. They can thrive in harsh environmental conditions like muddy, turbid and oxygen depleted water bodies with the help of their accessory air-breathing organ that allows them to breathe atmospheric oxygen. Generally, they are omnivorous in nature. They feed on insects, plankton, snails and plant matter in the natural water bodies (Ugwumba and Abumoye, 1990). However, this species is highly cannibalistic when substantial differences in size occur (Baras and Jobling, 2002).

Nutritionally well-balanced diets and adequate feeding are the main requirements for successful culture operations. Feed constitute approximately 40 - 60% of the operating costs in intensive fish culture (Agung, 2004). Lack of locally-produced high-quality fish feed is one of the major hindrances to the development of *C. gariepinus* culture in Nigeria. Several researchers have investigated on different methods to reduce the feed cost by increasing the growth performance using suitable feeding strategy in order to maximize utilization of supplied nutrients to cultured fish. Such strategy include mixed feeding schedule of alternating the high and low dietary protein level diet (Roshada, 1994; Ali and Juancey, 2004; Ali *et al.*, 2005; Nandeeshia *et al.*, 2008), optimizing the feeding rate (Dong-Fang *et al.*, 2003) and by incorporating digestive enzymes in the diet (Cavero, 2004).

Feeding frequency is an important factor that can affect growth, survival and fillet composition as well as water quality. Davies *et al.*, (2006) observed that feeding of fish at the optimum frequency can result in tremendous savings in feed cost. However, different species of fish have been shown to have different optimum feeding frequencies; channel catfish- twice a day (Andrews and Page, 1975), common carp- three times a day (Charles *et al.*, 1984), channel catfish- once/day or twice/day (Wang *et al.*, 1998; Webster *et al.*, 2001). Since feeding frequency has been shown to improve the growth of

several fish species, there is a need to establish an optimal feeding frequency that is economically viable for the culture of *C. gariepinus* using locally produced feed. The objective of the study was to investigate the effects of different feeding frequencies on growth performance, survival and food utilisation of African catfish of *C. gariepinus* using locally formulated fish feed.

Data collection and analysis

The 56-day feeding trial was performed at the Institute of Oceanography Hatchery Complex, University of Calabar, Nigeria. A total of 120 *C. gariepinus* fingerlings were randomly stocked in 6 glass aquaria (A1, A2, B1, B2, C1, and C2) measuring 96 x 50x 29 cm³ with 20 fish in each aquarium. The stocked fish were acclimated for one week prior to the start of the feeding trial. During the acclimation period the fish were fed twice daily to satiation. At the start of feeding trial the acclimated fish were starved for 24 hours after which the average initial wet body weight of the fish in each aquarium were taken with an electronic weighing balance to the nearest gram. Also the total length (TL) of the fish in each aquarium was taken with a measuring board to the nearest cm. There were three feeding frequencies (once daily- 8 h, twice daily – 8 and 13 h and thrice daily – 8, 13 and 16 h). Fish in Aquaria A1 and A2 were fed once daily- 8 h, fish in Aquaria B1 and B2 were fed twice daily – 8 and 13 h while fish in Aquaria C1 and C2 were fed thrice daily – 8, 13 and 16 h. Fish were fed at 5% of their body weight. Management of water quality was carried out by replacing water from each aquarium with fresh water once daily at mid-day (12.00hrs) and siphoning unconsumed feed and waste excreta from the aquaria. Physicochemical parameters like dissolved oxygen (DO), pH, ammonia and temperature were measured once weekly.

Diet formulation

Experimental diet (Table 1) was composed of soya bean meal (SBM), fish meal (FM), groundnut meal (GNM), wheat offal (WO), Vitamin C, Bone ash, wheat flour, vitamin premix, palm oil, sodium chloride (NaCl), methionine and lysine. Experimental diet was formulated to contain 45% crude protein using the pearson square method. The different ingredients were mixed according to their calculated percentages. After mixing, the feeds were pelletized then sundried to reduce the moisture content to prevent the growth of mould and thereafter stored off in polyethylene bags.

Table 1: Feed composition of experimental feed

S/N	Feed component	Amount (g)
1	Fish meal (FM)	258.7
2	Soya bean meal (SBM)	258.7
3	Groundnut meal	258.7
4	Wheat offal	163.3
5	Bone ash	5
6	Wheat flour	20
7	Palm oil	10
8	Vitamin premix	10
9	Sodium chloride	5
10	Lysine	5
11	Methionine	5
	Total	1 kg

Determination of growth performance

The following growth performance indices were used:-

- i. *Mean wet weight gain*: $\text{Final weight } (W_2) - \text{Initial weight } (W_1)$
- ii. *Length increment*: $\text{Final length } (L_2) - \text{Initial length } (L_1)$
- iii. *Growth rate*: $(\text{Final weight} - \text{Initial weight}) / (\text{Number of days})$
- iv. *Specific growth rate*: $(\ln \text{final weight}) - (\ln \text{initial weight}) / (\text{Number of days}) \times 100$
- v. *Mean growth rate*: $[(\text{final weight} - \text{Initial weight}) / 0.5(\text{final wt} + \text{initial wt})(\text{Number of days})] \times 1000$
- vi. *% Survival*: $[(\text{Number of fish survived}) / (\text{Number of fish stocked})] \times 100$
- vii. *Feed conversion ratio (FCR)*: $\text{Dry feed fed } (g) / \text{Wet weight gain } (g)$
- viii. *Feed conversion efficiency (FCE)*: $[\text{Wet weight gain } (g) / \text{Dry feed fed } (g)] \times 100$

Statistical analysis

Growth performance and food utilization data like mean weight gain (g), length increment (cm), growth rate (GR), mean growth rate (MGR), specific growth rate (SGR), food conversion ratio (FCR) and %survival were subjected to one way analysis of variance (ANOVA) to determine the significant difference among the feeding frequency. Differences between mean values were assessed by least significant difference (LSD) multiple range tests using PASW windows software program for statistical analysis (version 17.0). Effects with a probability of ($P < 0.05$) were considered significant.

Results

Growth performance

Growth performance indices (Table 2) showed that fish fed twice daily had the highest mean wet weight gain of $78.11\text{g} \pm 2.29$ followed by fish fed thrice daily ($59.05\text{g} \pm 1.96$) while fish fed once daily had the least value of $36.06\text{g} \pm 4.02$. Length gain (cm) also showed the same trend with fish fed twice daily having the highest length gain of $17.2\text{cm} \pm 0.2$ followed by fish fed thrice daily with $14.15\text{cm} \pm 0.85$ while fish fed once daily had the least value of $9.55\text{cm} \pm 0.65$. Growth rate was also highest in fish fed twice daily (1.40 ± 0.05), followed by fish fed thrice daily (1.08 ± 0.02) while fish fed once daily had the least value of 0.64 ± 0.07 . Specific growth rate (SGR) was also highest in fish fed twice daily (5.32 ± 0.05) followed by fish fed thrice daily (4.86 ± 0.04) while fish fed once daily had the least value of 4.04 ± 0.24 . Mean growth rate (MGR) was also highest in fish fed twice daily with value of 32.29 ± 0.06 followed by fish fed thrice daily (31.31 ± 0.09) while fish fed once daily had the least value of 29.41 ± 0.34 .

Food utilization indices evaluated using food conversion ratio (FCR) and food conversion efficiency (FCE) showed that fish fed once daily had the highest value of 1.78 ± 0.09 for FCR followed by fish fed thrice daily with FCR value of 1.55 ± 0.04 while fish fed twice daily had the least FCR value of 1.53 ± 0.01 . For food conversion efficiency (FCE), fish fed thrice daily had the highest value of 62.48 ± 0.25 , followed by fish fed twice daily with FCE value of 61.11 ± 0.15 while fish fed once daily had the least FCE value of 56.47 ± 3.23 .

Percentage survival was highest in fish fed once daily with a mean value of $92.5\% \pm 2.5$, followed by fish fed twice daily with a mean value of $87.5\% \pm 2.5$ while fish fed thrice daily had the least percentage survival with a mean value of 82.5 ± 7.5 .

Table 2: Growth performance, survival and food utilization of *Clarias gariepinus* during the experiment

Growth Performance Indices	Feeding Frequency		
	Once daily	Twice daily	Thrice daily
Initial wet weight (g)	4.19±0.13	4.19±0.01	4.16±0.05
Final wet weight (g)	40.3±3.9	82.3±2.3	63.2±2.0
Mean wet weight gain(g)	36.06 ± 4.02 ^a	78.11 ± 2.29 ^b	59.05 ± 1.96 ^c
Initial length (cm)	7.25±0.25	7.35±0.05	7.3±0.1
Final length (cm)	16.8±0.4	24.6±0.3	21.5±1.0
Length gain (cm)	9.55 ± 0.65 ^a	17.2 ± 0.2 ^b	14.15 ± 0.85 ^c
Growth rate (GR)	0.64 ± 0.07 ^a	1.40 ± 0.05 ^b	1.08 ± 0.02 ^c
Specific growth rate (SGR) (%)	4.04 ± 0.24 ^a	5.32 ± 0.05 ^b	4.86 ± 0.04 ^c
Mean growth rate (MGR)	29.41 ± 0.34 ^a	32.29 ± 0.06 ^b	31.31 ± 0.09 ^c
Food conversion ratio (FCR)	1.78 ± 0.09 ^a	1.53 ± 0.01 ^a	1.55 ± 0.04 ^a
Food conversion efficiency (FCE) (%)	56.47±3.23 ^a	61.11±0.15 ^a	62.48±0.25 ^a
Survival (%)	92.5±2.5 ^a	87.5±2.5 ^a	82.5±7.5 ^a

*Means with the same superscript are not significantly different ($P>0.05$) from each other

Physicochemical parameters

Result of physicochemical measurements is shown in Table 3. In Aquarium A (once daily), mean pH was 7.1±0.4, mean air temperature (29.3±0.1°C), mean water temperature (29.1±0.5°C), mean ammonia (0.008± 0.08mg/L) and mean dissolved oxygen 2.7±0.2 mg/l. In aquarium B (twice daily), mean pH was 7.1±0.6, mean air temperature (29.4 ±0.1°C) mean water temperature (29.0±0.3°C), mean ammonia (0.01±0.01mg/L) and mean dissolved oxygen (2.6±0.2mg/l). In aquarium C (thrice daily), mean pH was 6.5±0.4, mean air temperature (29.3 ±0.2°C), mean water temperature (29.1±0.45°C), mean ammonia level (0.021±0.011mg/L) and dissolved oxygen ranged between 2.5±0.1mg/l.

Table 3: Physicochemical measurement in aquaria during feeding experiment

Parameter	Feeding Frequency		
	Once daily	Twice daily	Thrice daily
pH	7.1±0.4	7.1±0.6	6.5±0.4
Air temperature (°C)	29.3±0.1	29.4 ±0.1	29.3 ±0.2
Water temperature(°C)	29.1±0.5	29.0±0.3	29.1±0.45
Ammonia (mg/l)	0.008± 0.08	0.01±0.01	0.021±0.011
DO (mg/l)	2.7±0.2	2.6±0.2	2.5±0.1

Discussion

In the present study, the experimental fish responded positively to the locally formulated diet as shown in their growth performance. According to De Silva and Anderson (1995), the quality of a feed is a function of how well that feed meets the nutrient requirement of an animal. Also, nutrients must be able to be digested and absorbed in a form that makes them available for providing energy and substrate for growth (bioavailability). Growth response of the experimental fish indicates that the experimental diet contained the correct proportion of bio-available nutrients required by the fish for growth. Growth performance of *C. gariepinus* fingerlings was significantly ($P<0.05$) influenced by feeding which is directly connected to feed ingestion and assimilation. The highest growth performance (final mean wet weight gain, final length gain, growth rate, specific growth rate mean growth rate and food consumption) were recorded in fingerlings fed twice daily followed by thrice daily, while fish fed once showed the lowest growth performance. Results showed that feeding fish with the correct frequency can lead to optimal feed management which will enhance optimal growth as obtained in fish fed twice daily. According to Jobling (1995) and Goddard (1995), the amount of the daily feed intake, frequency and timing of the feedings and presentation of the predetermined ration are the key factors of feed management strategies, influencing the growth and

feed conversion. Since feed is expensive, feed conversion ratio (FCR) or feed conversion efficiency (FCE) are important calculations for the fish to determine if feed is being used as efficiently as possible. Ekanem *et al.*, (2010) reported that the growth and feed conversion ratio of a fish are important tools to compute the acceptability of artificial feed. In the present study, the highest food conversion ratio was recorded for fish fed once/daily (1.78 ± 0.09) but was not-significantly different from other feeding frequency, followed by fish fed thrice/daily while the least FCR value was recorded for fish fed twice/daily (1.53 ± 0.01). This shows that fish fed twice daily had the best FCR. This finding shows that feed utilization efficiency and feed conversion was not influenced by the feed frequency. This could indicate that *C. gariepinus* fed less frequently could utilize more feed than *C. gariepinus* fed more frequently. This is in agreement with Webster *et al.*, (2001) who reported similar FCR values for channel catfish fed once/day or twice/day.

Hepher (1988) stated that feeding frequency had little effect on FCR indicating that food consumption is the growth limiting factor. Results also showed that GR, MGR, and SGR were highest in fish fed twice daily in agreement with Dwyer *et al.* (2002) who reported that both over- and under-feeding may also affect the specific growth rates and the efficiency of feed conversion as these have been observed to be directly related to feed ratio and frequency. Also, Priestley *et al.* (2006) reported that this can be detrimental to the health of the fish and may cause a marked deterioration in water quality, reduced weight, poor food utilization, and increased susceptibility to infection. Therefore being able to determine the most favourable feeding frequency relative to the species and size of fish can be of great economic value in fish culture. Fish that are fed more frequently consume a larger amount of feed; however, when the intervals between meals are short, the food passes through the digestive tract more quickly, resulting in less effective digestion (Liu and Liao 1999). This may be responsible for a lower growth performance reported for fish fed thrice daily when compared to fish fed twice daily. However, feeding fish less frequently for a longer time can lead to increased gut capacity and to hyperhagia (Jobling, 1982 and Rouhani, 1993) because fish try to adapt to such feeding conditions by consuming larger amounts of feed during each meal. The present study is also similar to Davies *et al.*, (2006) who reported a higher percentage weight gains, SGR and average final weight in catfish *Heterobranchus longifilis* fed twice/day compared to fish fed once/day, once on alternate day and twice on alternate day. Feeding frequency required for optimum fish growth depends on factors such as age, size, physicochemical parameters, food quality (Lee *et al.*, 2000) and vary from species to species. In milkfish, *Chanos chanos*, best growth performance was reported in fingerlings fed twice/day than fish fed once/day (Teshima *et al.*, 1984). Results obtained in the present study is similar to Webster *et al.*, (2001) who reported a non-significant growth performance (percentage weight gain and SGR) for channel catfish, *Ictalurus punctatus*, fed once/day and twice/ day.

According to Ng *et al.* (2000), overfeeding disrupts the water quality leading to low dissolved oxygen levels, increased biological oxygen demand, and increased bacterial loads. In the present study, physicochemical parameters including water temperature, pH and dissolved oxygen and ammonia were within the acceptable range for fish growth and health (Boyd, 1979; Goos and Richter, 1996). Results from the present study shows that utilizing the optimum feeding frequency can lead to a proper management of the culture system which will reduce the risk of water pollution, feed wastage and production cost.

In the present study, percentage survival was lowest in fish fed thrice daily ($82.5 \pm 7.5\%$) and highest in fish fed once daily ($92.5 \pm 2.5\%$) ($P > 0.05$). This findings is similar to Marimuthu *et al.* (2010) who reported a higher survival rate in *C. gariepinus* fed once daily than those fed twice daily. This indicates that increasing feeding frequency plays no role in survival and cannibalism rate in *C. gariepinus* rather cannibalism could be attributed to size variation where large individual cannibalize smaller individual.

Conclusion

Locally produced feed can replace expensive commercially imported feed used in catfish farming leading to a better growth performance, reduction of production cost and maximizing profit margin since feed contribute a very significant amount of the total production cost. Feed compounded as indicated in this paper combined with optimal feeding frequency of twice daily is recommended to optimize *C. gariepinus* growth in culture. This will also result in optimal water quality condition and minimal feed wastage,

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