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The effect of different feeding rates and restriction on the growth performance of *Clarias gariepinus*

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Introduction

Fish is a primary source of protein for many persons in the world (Rameshguru *et al*., 2011). However increase population pressure not adequately matched with fish production has caused more demand pressure on the fisheries sector. Hence, there is a need to increased aquaculture production to solve this problem associated with the market demands of fish and fish products (Aydin *et al*., 2011). The species of high yield potential for aquaculture production in Africa are the Nile tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*) and African catfish (*Clarias gariepinus*) (FAO, 2008). Production of these species has been with the addition of organic manures to pond water so as to stimulate the growth of natural food organism (Robinson and Li, 1999). However, supplementary feeding has become widely practiced in modern aquaculture in the quest for improving productivity. Feeding now accounts for above 60% of the total cost of fish production in Africa, hence, determining the viability and profitability of fish farming enterprise (Jamu and Ayinla, 2003). Commercial diets commonly used are very expensive and fed to fish at different self-determined rate and feeding frequencies so as to break even. Fish farmers also prepare on-farm feed using alternative feedstuffs which are locally available, cheap and usually unconventional so as to reduce the cost of production and maximize profit.

Determining optimum feeding rate can ensure a successful aquaculture operation (Yuan *et al*., 2010). Optimum feeding rate differs according to the fish species, size, and rearing system (Cho *et al*., 2003). Knowledge of the optimum feeding rate, therefore, affect the usage of the nutrients in the feed (Mihelakakis *et al*., 2002), improve feed efficiency and consequently results in better growth performance (Cho *et al*., 2003; Eroldogan *et al*., 2004). It is also important to note that optimizing feeding rate helps to prevent water quality degradation which overfeeding causes (Mihelakakis *et al*., 2002; Webster *et al*., 2002; Eroldogan *et al*., 2004). Over or under-feeding could result in increased fish disease and mortality (Deng *et al*., 2003). Hence, it is important to investigate and design a proper and applicable feeding regime so as to optimize the growth of cultured fish. This is because inadequate food supply directly affects production costs and water quality of the culture system (Ng *et al*., 2000; Mihelakakis *et al*., 2002; Silva *et al*., 2007). Feeding restriction has been reported to cause compensatory growth in many fish species (Ali *et al*., 2003; Nikki *et al*., 2004); however, there is little or no data for such feeding management for the African catfish. This study to our knowledge, represent the first designed to investigate the growth performance of *C. gariepinus* fed diet at different rates and restricted times.

Materials and methods

This study was conducted at the North core Fish hatchery of the Fisheries and Aquaculture Department, University of Agriculture, Makurdi, Benue state, Nigeria. Benue lies between latitude 7.44^{o}E and longitude 8.32^o at an elevation of 97m above sea level. A total number of 260 *C. gariepinus* fingerlings (10.02±0.03g) were obtained from University fish farm in the south core and transported to the fish hatchery in North-Core. They were acclimatized for two (2) weeks before the start of this experiment. The feeding trial was carried out using twelve (12) plastic bowls of thirty-five (35) liter capacity each and filled to the twenty (20) liter mark with de-chlorinated water (Bowls represent replicates of the treatment in this study). Twenty (20) fingerlings were distributed into each plastic bowl at random.

The experimental fish were fed with 2mm commercial floating fish feed (Coppens®) throughout the period of the experiment. The experimental unit consists of fingerlings fed at 5%, 10% and 15% body weight every day and every other day. The amount of feed fed were adjusted after the weekly weighing using the Philips electronics Kitchen scale (Type HR 2385/A).

Growth performance was estimated as stated below.

(a) Mean Weight Gain (MWG)= Mean final weight – Mean initial weight

(b) Feed conversion ratio (FCR)= $\frac{dry\ feed\ intake}{wet\ weight\ gain}$

(c) Specific Growth Rate (%/day)= $\frac{\log_e(wt_2) - \log_e(wt_1)}{t_2 - t_1}$

Where Wt_1=Initial weight gain

Wt_2=Final weight gain

T_2-T_1=Duration (in days) considered between Wt_2 and Wt_1

(d) Protein efficiency ratio= $\frac{wet\ weight\ gain}{protein\ fed}$

Where Protein fed $= \frac{\%protein\ in\ diet \times total\ diet\ consumed}{100}$

(e) % survival rate= $\frac{total\ number\ of\ fish\ mortality}{total\ number\ of\ fish} \times 100$

Water quality parameters monitored during the study includes Dissolved Oxygen (DO), Temperature, pH, TDS, and Conductivity. Proximate compositions of the fish (before and after the study) were determined according to standard methods by AOAC (2000). However, Nitrogen free extracts in samples were determined by difference. The analyses were conducted in triplicate and all reagents were of analytical grade.

The data obtained from the study were analyzed using Gen stat® discovery edition 4 and Minitab® 14. Descriptive statistics were done and mean gotten were subjected to analysis of variance. Where significant differences existed (p<0.05), means were separated using Duncan's least significant difference (LSD).

Results and discussion

Result of the present study showed that feeding African catfish at 5% body weight every other day in a static system gave the best performance in growth and nutrient utilization (Table 1 and 2), while fingerling fed every other day at all feeding rate in the flow through system performed better (Table 3 and 4). Navarro and Gutierrez (1995) had stated that fish employ various behavioural, physiological and structural responses to mobilize energy reserves to cover their metabolic requirements during starvation or feed restriction. These may include allowing overall condition factor to decrease or exhibiting changes in lipid content and blood metabolites, and/or muscle and organ mass (Navarro and Gutierrez, 1995). Hence decreased growth are observed, however, when feeding resumes, fish exhibit an exceptionally fast growth rates, known as compensatory (catch up) growth (Ali *et al*., 2003). Though this phenomenon is not fully understood, scientist, however, predicts hyperphagia (increase in appetite) (Ali *et al*., 2003; Nikki *et al*., 2004), rapid protein synthesis (Quinton and Blake, 1990), and replenishment of energy reserves as causes of rapid growth. Contrary to the observation of better growth recorded in fingerlings fed 5% body weight every other day in static system and every other day at all feeding rate in the flow through system, the reduction in growth of fish fed at rates beyond 10% body weight every other day in the static system may be due to bad water quality (Table 5). This is likely as a result of uneaten feed which probably stress the fish and nullifying the compensatory growth effect of starvation or feed restriction. Kasi *et al*. (2011) had earlier reported poor performance of *C. gariepinus* feed 2% and 5% body weight. Also fish species such as Bagrid catfish juveniles (*Mytus nemurus*), Europian sea bass (*Dicentradus carbrax*), Channel catfish (*Ictalurus punctatus*) and Pecu (*Plaractus mesopotamocus*), has been reported to grow better when fed higher feeding rates than lower rates. (Borghetti and Canzi, 1993; Robinson and Li, 1999). Optimum feeding rate has also been described for other fish species in earlier studies. For instance,

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5% body weight was best for *Channa striatus*, (Qin and Fast, 1996) growth; 6% was recommended for *C. fuscus* (Anderson and Fast, 1991), while 10% was recommended for Tambaqui, *Colossoma macropomum* (Silva *et al*., 2007). Also, in the case of juvenile snakehead, Qin and Fast (1996) found that feeding rate greater than 5% per day could even reduce growth, apparently due to increased surfacing and swimming activities. It important to note that optimum feeding rate differs according to the fish species, size and rearing system (Cho *et al*., 2003).

Table 1: Growth performance and nutrient utilization of *Clarias gariepinus* fingerlings fed at different feeding rate in static system.

Parameters	5%ED	5%EOD	10%ED	10%EOD	15%ED	15%EOD	P-Value
Mean Int. Wt	10.14 ± 0.58	10.48 ± 0.02	10.84 ± 0.53	10.49 ± 0.15	10.04 ± 0.03	10.55 ± 0.53	0.635
Mean Final Wt	34.61 ± 1.82^b	37.49 ± 0.67^a	30.48 ± 0.03^d	32.23 ± 0.25^c	32.48 ± 0.03^c	30.33 ± 0.05^d	0.04
Mean Wt gain	24.47 ± 2.40^b	27.01 ± 0.1^a	19.64 ± 0.55^d	21.73 ± 0.10^c	22.64 ± 0.55^c	19.74 ± 0.55^d	0.01
Growth Rate	0.45 ± 0.04^b	0.48 ± 0.01^a	0.40 ± 0.01^{cd}	0.42 ± 0.001^c	0.41 ± 0.01^c	0.38 ± 0.01^d	0.02
SGR	2.28 ± 0.19	2.31 ± 0.04	2.26 ± 0.10	2.27 ± 0.01	2.25 ± 0.10	2.22 ± 0.10	0.743
Feed Fed	71.00 ± 2.31^d	27.39 ± 0.08^e	121.8 ± 0.85^b	82.31 ± 0.11^d	143.1 ± 0.85^a	104.8 ± 0.85^c	0.001
FCR	2.69 ± 0.16^d	1.02 ± 0.02^e	2.38 ± 0.10^d	4.54 ± 0.02^b	3.38 ± 0.10^c	5.38 ± 0.10^a	0.001
FCE	37.22 ± 2.18^c	98.61 ± 2.28^a	42.05 ± 1.70^b	22.43 ± 0.12^d	22.05 ± 1.70^d	19.25 ± 1.70^e	0.001
PER	0.588 ± 0.05	0.650 ± 0.02	0.531 ± 0.01	0.500 ± 0.00	0.453 ± 0.01	0.403 ± 0.01	0.192
%Survival	95.0 ± 5.00^a	97.5 ± 2.50^a	90.0 ± 0.00^c	85.0 ± 0.00^b	75.0 ± 0.00^c	55.0 ± 0.00^c	0.01

Mean in the same row with different superscripts differ significantly ($p<0.05$)
Keys:- ED=Every day; EOD= Every other day

Table 2: Carcass analysis of *Clarias gariepinus* fingerlings fed in static system before and after the experimental period.

Parameters	Initial	5%ED	5%EOD	10%ED	10%EOD	15%ED	15%EOD	P-Value
Moisture	70.15 ± 0.05^a	69.36 ± 0.03^a	59.31 ± 0.02^e	68.72 ± 0.02^c	69.05 ± 0.05^b	65.05 ± 0.05^d	68.12 ± 0.01^c	0.001
Ash	2.63 ± 0.05	2.51 ± 0.15	2.61 ± 0.05	2.55 ± 0.15	2.24 ± 0.04^g	2.42 ± 0.02^d	2.29 ± 0.02^f	0.341
Fat	4.99 ± 0.05^f	7.23 ± 0.05^c	8.12 ± 0.02^e	7.11 ± 0.05^b	7.99 ± 0.02^e	8.00 ± 0.02^a	7.54 ± 0.02^d	0.001
Fibre	1.72 ± 0.01	1.92 ± 0.02	1.85 ± 0.04	1.75 ± 0.05	1.92 ± 0.01	1.88 ± 0.02	1.90 ± 0.02	0.902
Protein	14.07±0.15^d	17.00 ± 0.01^c	19.96 ± 0.02^a	18.29 ± 0.03^b	17.21 ± 0.01^c	19.99 ± 0.02^a	18.59 ± 0.05^b	0.001
CHO	6.44 ± 0.05^b	2.34 ± 0.02^d	8.15 ± 0.01^a	1.58 ± 0.05^e	1.59 ± 0.02^b	2.66 ± 0.02^c	1.56 ± 0.02^e	0.001

Mean in the same row with different superscripts differ significantly ($p\leq0.05$)
Keys:- ED=Every day; EOD= Every other day

Table 3: Growth performance and nutrient utilization of *Clarias gariepinus* fingerlings fed at different feeding rate in flow through system.

Parameters	5%ED	5%EOD	10%ED	10%EOD	15%ED	15%EOD	P-Value
Mean Int. Wt	10.11 ± 0.58	10.48 ± 0.02	10.49 ± 0.15	9.84 ± 0.53	9.98 ± 0.53	10.04 ± 0.53	0.635
Mean Final Wt	36.61 ± 1.82^d	37.01 ± 0.67^{cd}	37.23 ± 0.25^{cd}	38.40 ± 0.03^{bc}	40.48 ± 0.03^{ab}	42.19 ± 0.03^a	0.04
Mean Wt gain	26.50 ± 1.10^b	26.53 ± 0.1^d	27.74 ± 0.01^{cd}	28.56 ± 0.25^c	30.54 ± 0.55^b	32.14 ± 0.55^a	0.01
Growth Rate	0.47 ± 0.04^e	0.48 ± 0.01^e	0.54 ± 0.001^d	0.58 ± 0.01^c	0.62 ± 0.01^b	0.66 ± 0.11^a	0.02
SGR	2.29 ± 0.19	2.28 ± 0.04	2.26 ± 0.01	2.14 ± 0.10	2.14 ± 0.10	2.14 ± 0.10	0.743
Feed Fed	72.10 ± 0.11^e	37.13 ± 0.08^f	112.11 ± 0.01^c	99.18 ± 0.15^d	153.8 ± 0.35^a	120.8 ± 0.25^b	0.001
FCR	2.69 ± 0.16^a	1.92 ± 0.02^f	2.41 ± 0.02^b	2.12 ± 0.10^d	2.38 ± 0.10^c	2.08 ± 0.10^e	0.001
FCE	49.30 ± 1.23^f	78.61 ± 2.32^e	67.01 ± 0.22^d	69.05 ± 1.70^c	79.54 ± 1.70^b	82.23 ± 1.70^a	0.001
PER	0.61 ± 0.05	0.670 ± 0.02	0.74 ± 0.00	0.79 ± 0.01	0.83 ± 0.01	0.95 ± 0.01	0.192
%Survival	95.0 ± 5.00	97.5 ± 2.50	95.0 ± 0.00	90.0 ± 0.00	93.0 ± 0.00	95.0 ± 0.00	0.231

Mean in the same row with different superscripts differ significantly ($p <0.05$)
Keys:- ED=Every day; EOD= Every other day

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Table 4: Carcass analysis of *Clarias gariepinus* fingerlings fed in flow through system before and after the experimental period.

Parameters	Initial	5%ED	5%EOD	10%ED	10%EOD	15%ED	15%EOD	P-Value
Moisture	70.15 ± 0.05^a	69.36 ± 0.03^a	69.31 ± 0.02^a	67.72 ± 0.02^b	59.05 ± 0.05^c	58.05 ± 0.05^c	50.05 ± 0.05^d	0.001
Ash	2.63 ± 0.05^a	2.11 ± 0.05^b	1.21 ± 0.05^e	2.05 ± 0.15^c	1.04 ± 0.04^g	1.32 ± 0.02^d	1.12 ± 0.02^f	0.001
Fat	4.99 ± 0.05^f	6.01 ± 0.05^c	5.28 ± 0.02^e	7.05 ± 0.05^b	5.22 ± 0.02^e	10.94 ± 0.02^a	5.99 ± 0.02^d	0.001
Fibre	1.72 ± 0.01^b	2.02 ± 0.02^a	2.04 ± 0.04^a	2.05 ± 0.05^a	2.02 ± 0.02^a	2.05 ± 0.02^a	2.10 ± 0.02^a	0.011
Protein	14.07±0.15^f	17.12 ± 0.01^e	18.26 ± 0.02^d	17.99 ± 0.03^e	22.01 ± 0.01^b	19.17 ± 0.02^c	25.23 ± 0.05^a	0.001
CHO	6.44 ± 0.05^d	3.37 ± 0.02^g	4.92 ± 0.01^f	5.05 ± 0.05^e	10.66 ± 0.02^b	7.32 ± 0.02^c	14.59 ± 0.02^a	0.001

Mean in the same row with different superscripts differ significantly ($p\leq0.05$)
Keys:- ED=Every day; EOD= Every other day

Table 5: Water quality parameters within the experimental units.

Parameters	Flow though system	Static system						
		5%ED	5%EOD	10%ED	10%EOD	15%ED	15%EOD	P-Value
Temperature	28.6 ± 0.48^a	25.6 ± 0.48^b	26.0 ± 0.49^b	26.1 ± 0.50^b	25.9 ± 0.47^b	25.4 ± 0.47^b	24.9 ± 0.47^b	0.012
TDS	415.33 ± 3.84	415.33 ± 3.84	337.0 ± 32.4	348 ± 152	332.7 ± 122	390.2 ± 28.5	402.7 ± 21.5	0.869
pH	7.5 ± 0.13^a	7.0 ± 0.13^b	6.9 ± 0.10^b	6.5 ± 0.29^c	6.0 ± 0.23^d	6.1 ± 0.11^d	5.7 ± 0.18^e	0.05
Conductivity	847.3 ± 22.3	827.3 ± 22.3	789.3 ± 61.1	817.3 ± 87.3	815.0 ± 64.0	856.0 ± 64.0	803.0 ± 64.0	0.156
DO	5.2 ± 0.14^a	4.8 ± 0.18^b	5.0 ± 0.12^a	3.6 ± 0.32^c	2.7 ± 0.15^d	3.1 ± 0.01^{cd}	2.9 ± 0.11^c	0.001

Mean in the same row with different superscripts differ significantly ($p<0.05$)

The observed similarity in specific growth rate and protein efficiency ratio among the treatments is consistent with the argument that the effect of feeding frequency on feed utilization is usually small (Sogbesan and Ugwumba, 2008; Adewumi and Olaleye, 2011; Aderolu *et al*., 2011). This, however, suggested that the fish had efficiently converted feed consumed to growth. The ability of an organism to utilize nutrients especially protein will positively influence its growth rate (Aderolu *et al*., 2011). Fish are not completely efficient feed converters (i.e. with FCR's of 1.0 and FCE's of 100%). When fed a given weight of feed, fish cannot exhibit the same amount of growth in weight because some of the energy from the feed is firstly used for metabolic activities that keep the system running. This includes digestion, respiration, nerve impulses, salt balance, swimming and other life activities (Craig and Helfrich, 2009). Hence, there is a significant reduction in the amount of feed converted to flesh. In the present study, the FCR (i.e. <2.0) and FCE (i.e. >50%) values obtained in fish fed 5% body weight every other day and in all feeding rate feed every other day in the flow through system indicate good growth for the fish (Tables 1 and 2). Also, there was a general decrease in FCR and increase in PER of this fish compared to other treatments. Although Pechsiri and Yakupitiyage, (2005) had stated the fact that FCR decreases while PER increases with increased feeding rate, compensatory growth phenomenon associated with starvation and feeding restriction however, must have contributed to the better growth observed in this study. The underlining consequent of a decreased FCR is that it would require less feed to get a fish to 1kg by feeding at 5% body weight every other day in the static system and at all feeding rate in flow through system. Research by workers in some major feed companies has indicated that the FCR of some fish species can be as low as 0.8 (FEAP-Aquamedia, 2010). From a practical perspective, exploitation of the compensatory growth response is recommended as a way to increase the productivity of finfish aquaculture. Hence, feeding programs can be designed to limit rations of feed for fishes while still achieving acceptable long-term growth trajectories for the fish, and as a result minimizing feeding cost. This study has shown that catfish farming can make more profit feeding African catfish at 5% body weight every other day in static system and up to 15% feeding rate in flow through system, hence taking advantage of compensatory growth response.

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