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Research Article
Studies on the Effects of Feeding Levels on Growth Response and Nutrient Utilization of *Heteroclarias* (Hybrid Catfish)

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Abstract

Background and Objective: Feeding level depends on the weight of the fish as well as being influenced by variables such as temperature of the water, dissolved oxygen, time of day, season and other physico-chemical parameters. The growth response, survival and feed utilization of hybrid catfish (*Heteroclarias*) under different feeding levels were evaluated for 12 months. **Methodology:** The experiment was carried out at the Department of Fisheries and Aquatic Environmental Management, University of Uyo, Nigeria using 9 tarpaulin tanks of 1 M^3 volume. The study employed completely block design with three feeding levels (FL), 1.0% Fresh Body Weight (FBW) of fish (FL1), 1.5% FBW (FL2) and 2.0% FBW (FL3) as treatments. These were replicated three times at a stocking density of 75 fish m^{-2}. The feeding rate was adjusted monthly with increase in body weight. Sampling of fish was done monthly by draining whole water from all tarpaulin tanks. **Results:** Result shows that, there was no significant difference ($p>0.05$) for mean final weight, mean weight gain, specific growth rate and daily weight gain for FL1, FL2 and FL3, respectively. Feed conversion ratio at FL1 was significantly different ($p<0.05$) from FL2 and FL3. However, protein efficiency ratio showed no significant ($p>0.05$) difference among the feeding levels. Survival rate showed significant difference ($p<0.05$) among the feeding levels and the values increased with increasing feeding levels. **Conclusion:** On the basis of growth response and nutrient utilization data obtained, feeding hybrid catfish (*Heteroclarias*) at 1.5% body weight per day is recommended for raising hybrid catfish at reduced cost of production.

Key words: *Heteroclarias*, hybrid catfish, feeding level, growth performance, nutrient utilization, survival

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Aquaculture is the rearing of fish and other aquatic organisms in man-made ponds, reservoirs, cages or other enclosures in lakes and coastal waters[1]. Due to increasing protein demand in Nigeria, fish farming practices have elevated tremendous over the last five decades. Aquaculture in Africa has come a long way since it was first introduced. However, aquaculture production in Africa is still minor at the global level. It accounted for only 2.32% of total global aquaculture level in 2014 according to FAO[2] report. Similarly, Nigeria accounted for 0.42% of global aquaculture production[2] in 2014. Feeding is one of the most important aspects of aquaculture which a farmer cannot do without, mainly when fish are raised under intensive or semi-intensive system[3]. Fish farmers have the desire to produce table-sized fish within the shortest possible time[4], thus, the choice of species to culture is critical in the realization of this goal. In Africa, especially Nigeria, the species most cultured are *Clarias gariepinus*, *Heterobranchus* spp. and their hybrids[5]. Feeding level or otherwise known as feeding rate is the quantity of feed given to fish per day. Feeding level depends on the weight of the fish as well as being influenced by variables such as temperature of the water, dissolved oxygen, time of day, season and other physico-chemical parameters. Growth of fish can be influenced by availability of space, adequate feed and other environmental factors. Fish feed constitute a major limiting factor for large scale aquaculture as the cost of feed is high and this reduces the profitability in the overall production[6].

Aquaculture with emphasis to *Heteroclarias* has become an important sector in terms of its potentials for contributing to food and family income. It is very profitable as a result of its high resistance against diseases and environmental stress[7]. The blending of high survival rate and fast growth rate in the hybrid catfish (*Heteroclarias*) offers higher production prospects. *Heteroclarias* is an inter-specific hybrid of *Clarias gariepinus* and *Heterobranchus bidorsalis* which transfer or combine desirable traits of the two species[8,9]. The hybrid catfish (*Heteroclarias*) is derived when two pure lines of African catfishes are crossed (male/female of *H. bidorsalis* and the female/male of *C. gariepinus*). Heteroclarias fish culture in ponds started in Nigeria in 1973 and the fish combines the fast growth traits of *Heterobranchus* species and early maturing traits of *C. gariepinus*[10]. Adeogun *et al*.[10] reported 58% internal rate of return (IRR) on investment using this technology. The hybrid of *H. bidorsalis* and *Clarias gariepinus* is a voracious omnivore, feeding on a wide range of food from live animal prey through aquatic plants to plankton organisms[11]. The *C. gariepinus* possesses early maturity traits, while *Heterobranchus* spp. are fast growers. In order to combine these traits in a culturable species, *Heteroclarias* was developed. *Heteroclarias* are in high demand by most farmers due to their hardness and fast growth[12].

Studies on *Heteroclarias* have been carried out with respect to stocking densities[6,13-14], haematology[15-16], inclusion levels of various feedstuff[12,17] and feeding frequency[3,18-19]. There are reports on the effect of feeding levels on growth performance and nutrient utilization of other catfish species including Ng *et al*.[20], Marimuthu *et al*.[21], Andem[22], Ashley-Dejo *et al*.[23], Odedeyi and Ademeso[24] and Tippayadara *et al*.[25]. However, there is dearth of information regarding the effects of feeding levels on the growth response and nutrient utilization of *Heteroclarias*. The study was put forward to tackle this.

The optimum ration for hybrid catfish is yet to be clearly defined and this has led to uncertainty in the feeding pattern used by many farmers. The objective of the study was to evaluate the comparative effect of different feeding levels on the growth performance, survival and nutrient utilization of *Heteroclarias* (hybrid catfish) in tarpaulin tanks.

MATERIALS AND METHODS

Experimental area: The experiment was carried out at the Fish Hatchery complex of the Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo, Nigeria. This area is between latitudes 4°52' S and 4°51' N and longitudes 7°54' W and 8°03' E. Nine tarpaulin tanks of 1 M^3 volume were utilized for the study which lasted 52 weeks (May, 2015-June, 2016).

Experimental design and procedures: The study used Completely Block Design (CRD). Nine tarpaulin tanks measuring $1\times1\times1$ m^3 were used. Each was designed with an outlet for easy drainage and was filled with 0.25 m^3 of water. The study had three Feeding Levels (FL), 1.0% Fresh Body Weight (FBW) of fish (FL1), 1.5% FBW (FL2) and 2.0% FBW (FL3) as treatments. These were replicated three times. The fingerlings used was derived from a breeding exercise using two broodstock females (*C. gariepinus*) and two broodstock males (*H. longifilis*) according to method narrated by Ngugi *et al*.[26]. The fingerlings were acclimated for 2 weeks and fed with commercial feed (38% crude protein)

before the experiment. The fingerlings were stocked at 75 fish m^{-2} before the start of the experiment. They were then starved for 24 h in order to empty the gut and prepare them for the feeding trial and the mean initial weight (2.05±0.05 g) measured. The fish were fed three times daily (8.00, 13.00 and 18.00) using commercial feed (Coppens) of 38% crude protein. The fish were fed at 1.0, 1.5 and 2.0% FBW, respectively. The feeding rate was adjusted monthly as fish increased in body weight.

Water quality assessment: Water in each tank was changed at 100% daily by using a partial flow through mechanism. The various water quality parameters were monitored at monthly intervals. Temperature was determined using a mercury thermometer calibrated 0-50°C which was dipped in the various tanks and read off after 2 min, pH using a pen type pH meter (pH-009 111) and dissolved oxygen using dissolved oxygen meter (HI 9461).

Growth and nutrient data evaluation: Sampling of fish was done monthly by draining whole water from all tarpaulin tanks. Fish from each tank were collected with a plastic filter basket and then weighed to nearest 0.01 g using an electronic weighing balance (TD6002A). At the end of the experiment, results from weight as well diet data were used to determine growth performance parameters such as Mean Final Weight (MFW), Mean Weight Gain (MWG), Daily Weight Gain (DWG), Specific Growth Rate (SGR), Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and Survival Rate (SR) using the equation below:

- Mean weight gain (g) (MWG):

$$MWG = MFW\text{-}MIW$$

Where:

MFW = Mean final weight
MIW = Mean initial weight

- Daily weight gain (g/day) (DWG):

$$DWG = \frac{MFW - MIW}{\text{Rearing period in days}}$$

- Specific growth rate (%/day) (SGR)[27]:

$$SGR = 100 \times \frac{\ln(MFW) - \ln(MIW)}{\text{Rearing period in days}}$$

- Feed conversion ratio (FCR)[27]:

$$FCR = \frac{\text{Dry weight of feed given (g)}}{\text{Wet weight gain of fish (g)}}$$

- Protein efficiency ratio (PER)[28]:

$$PER = \frac{\text{Wet weight gain of fish (g)}}{\text{Protein intake (g)}}$$

Where:

$$\text{Protein intake} = \frac{\text{Protein in feed} \times \text{Total weight (g) of diet consumed (\%)}}{100}$$

- Survival rate (SR) (%):

$$SR = \frac{100 \times \text{Total number of fish that survived}}{\text{Total number of fish stocked}}$$

Statistical analysis: Growth, nutrient and water quality parameters were subjected to one-way analysis of variance (ANOVA) to evaluate mean differences at 0.05 significant levels. Results with $p \leq 0.05$ were considered significantly different[29]. Duncan multiple range test was used to compare significant difference among the treatments. The statistical analyses were done using IBM SPSS Inc. (Windows version 20).

RESULTS

Water quality assessment: Table 1 showed water quality at different feeding levels during the experiment. Temperature showed significance ($p<0.05$) at 1.0%. Dissolved oxygen and pH had no significance ($p>0.05$) among the feeding levels.

Growth response and nutrient utilization: Table 2 showed the growth performance and feed utilization of hybrid catfish to different feeding levels. Result showed that, there was no significant difference ($p>0.05$) for mean final weight, mean weight gain, specific growth rate, daily weight gain and protein efficiency ratio values. Feed conversion ratio and survival rate showed significant difference ($p<0.05$) among the feeding levels.

Table 1: Water quality parameters monitored during the experiment

	Mean±SE		
Parameters	FL1	FL2	FL3
Temperature (°C)	28.26±0.20[b]	28.77±0.09[a]	28.70±0.09[a]
Dissolved oxygen (mg L^{-1})	5.21±0.09[a]	5.06±0.05[a]	5.03±0.06[a]
pH	7.62±0.15[a]	7.50±0.14[a]	7.63±0.14[a]

Means with different superscripts along the same row are significantly different $p<0.05$

Table 2: Growth response and nutrient utilization parameters during the experiment

	Mean±SE		
Parameters	FL1	FL2	FL3
Mean initial weight (MIW) (g)	2.03±0.04[a]	2.06±0.03[a]	2.06±0.08[a]
Mean final weight (MFW) (g)	768.63±139.15[a]	889.80±37.79[a]	833.86±68.74[a]
Mean weight gain (MWG) (g)	766.60±139.18[a]	887.73±37.75[a]	831.80±68.69[a]
Specific growth rate (SGR) (%/day)	0.71±0.02[a]	0.72±0.00[a]	0.72±0.00[a]
Daily weight gain (DWG) (g/day)	2.15±0.39[a]	2.49±0.11[a]	2.34±0.19[a]
Feed conversion ratio (FCR)	1.31±0.16[b]	1.71±0.08[a]	1.58±0.04[ab]
Protein efficiency ratio (PER)	1.89±0.26[a]	1.40±0.07[a]	1.50±0.02[a]
Survival rate (SR) (%)	48±3.92[b]	42±0.88[b]	61±3.52[a]

Means with different superscripts along the same row are significantly different $p<0.05$

DISCUSSION

The physico-chemical parameters of water observed during the experimental period were within the range recommended for culture of warm water fishes[30]. The range of water quality parameters (28.26-28.77°C, 5.03-5.21 mg L^{-1} and 7.50-7.63 for temperature, dissolved oxygen and pH, respectively) in the present study was not affected by the feeding levels and they were within tolerable range for the culture of hybrid catfish. Results in the current study were similar to those found by Ashley-Dejo *et al.*[23] for *Clarias gariepinus* and Afia *et al.*[31] for hybrid catfish. However, water quality parameters were higher than reports of Marimuthu *et al.*[21], Andem[22] and Odedeyi and Ademeso[24] for catfish species. These results highlighted that, feeding *Heteroclarias* with FL1, FL2 and FL3 did not cause significant deterioration of water quality parameters as well as influencing growth negatively provided water was exchanged at regular intervals.

In fish culture practices, studies on the quantity and rate of feeding are aimed at identifying the optimum level/ration. Increased feed digestibility and increased water quality are the benefits of using the best feeding level[23]. Studies conducted on other fish species have shown that feed consumption and growth generally increased with feeding level up to a given limit[23,32,33]. These agreed with findings of the present study that feeding level influenced growth response and nutrient utilization of *Heteroclarias* up to a given limit. Growth and nutrient data seemed to increase with increase in feeding level up to 1.5% body weight. However, further increase in feeding level did not result in significant increase in growth or feed utilization. Similar findings were reported by Ng *et al.*[20], at 2.5% body weight for *Mystus numerus* fingerlings, Andem[22], at 8.0% for *Clarias gariepinus* fingerlings, Ashley-Dejo *et al.*[23], at 5.0% body weight for *C. gariepinus* fingerlings and Odedeyi and Ademeso[24], at 5.0% body weight for *C. gariepinus* broodstock. Growth data parameters are great tools for evaluating the effect of feed and its value composition on fish species[34,35]. Fish like other animals, require essential nutrients for metabolic activities like growth, reproduction, repairs, etc. In the current study, hybrid catfish responded positively to all feeding levels as observed in their growth performance parameters. Growth response indices from the study showed that, Mean Final Weight (MFW), Mean Weight Gain (MWG), Specific Growth Rate (SGR) and Daily Weight Gain (DWG) of *Heteroclarias* fed 1.0, 1.5 and 2.0% body weights did not differ significantly ($p>0.05$). However, numerically, FL2 had superior values for MFW, MWG, SGR and DWG. This is in consonance with reports of Ng *et al.*[20], Marimuthu *et al.*[21], Andem[22], Ashley-Dejo *et al.*[23] and Odedeyi and Ademeso[24] who observed better growth performance as feeding level increased. The differences in numerical values of MFW, MWG, SGR and DWG from previous studies was due to differences in species, culture medium, stocking density and dissimilar feeding levels (previous authors employed higher feeding levels).

In the study of fish nutrition, the quantity of feed consumed is crucial for calculating Feed Conversion Ratio (FCR)[35]. The FCR is hence an important tool for evaluating the effectual use of feed considering the high cost fish feed. The proper understanding of FCR help the farmer to feed the fish to satiation and when fish are fed exactly the quantity of feed required, they are not stressed and they provide high quality meat for human consumption[36]. In order to maximize profit, FCR should never go above 2 for commercial culture. Results from the present study indicated significant difference ($p<0.05$) in FCR for hybrid catfish fed 1.0%, 1.5 and 2.0% body weights with best FCR observed for fish fed FL1. The FCR for all feeding levels were within range for commercial aquaculture (1.5-2.0). Similarly, best PER was observed in hybrid catfish fed FL1 but no significant difference ($p>0.05$). There was significant difference ($p<0.05$) observed in the survival rate of hybrid catfish to FL1, FL2 and FL3. Survival rate was poor in the present study and significantly higher

in FL3 than FL1 and FL2. This may be attributed to the high stocking density and prolonged period of culture which favoured cannibalism as FL1 and FL2 may not have been enough for them, as a result, they preyed on each other. Cannibalism is common in catfishes even with higher feeding levels. Survival rate was lower than reports of Marimuthu *et al.*[21], Andem[22], Ashley-Dejo *et al.*[23] and Odedeyi and Ademeso[24]. This may be due to differences in stocking density, culture period and feeding level. The study recommended further research employing greater feeding levels for *Heteroclarias*, this can serve as an effective tool for comparing the survival rate.

CONCLUSION

Feeding levels did not show a significant effect on all the growth performance parameters but it did for feed conversion ratio and survival rate. Both growth rate and nutrient utilization improved with the increase in the feeding levels; further increases in feeding level above 1.5% did not result in significant growth of hybrid catfish. On the basis of growth response and nutrient utilization data obtained, feeding hybrid catfish (*Heteroclarias*) at 1.5% body weight per day is recommended for raising hybrid catfish at reduced cost of production.

SIGNIFICANCE STATEMENT

Feeding fish at 3.0% body weight or higher uses much feed, hence, the need for lower feeding levels. It is obvious that feeding level is one of the main limiting factors for growth of fishes. This research discovered that, employing lower feeding levels gave similar growth performance and feed utilization when compared with previous studies that utilized higher feeding levels, hence, cost of feeding can be reduced when raising this fish. Fish culturists must understand the relationship between growth response and feeding level of this fish. The study is helpful to fish farmers as they can culture hybrid catfish in lower feeding level with accompanying better growth response and feed utilization. This study will also serve as a useful information for future researches on feeding level and growth studies of *Heteroclarias*.

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