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Effect of Feeding Frequency on Feed Consumption, Growth and Feed Conversion of *Clarias gariepinus* ♂ X *Heterobranchus longifilis* ♀ Hybrids

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Abstract: The effect of feeding frequency on feed consumption, growth and feed conversion efficiency of *Clarias gariepinus*♂ X *Heterobranchus longifilis*♀ hybrids was investigated in the laboratory over a period of 12 weeks (3 months). Fish fed once daily consumed a lower quantity of feed (40.70±0.58 g) than fish fed at higher frequencies. The highest feed consumption was observed in fish fed 5 times daily (54.43±0.24 g), with a significant difference (P< 0.05) in feed consumption at the different feeding frequencies. However, no significant difference was observed in the amount of feed consumed at the once daily twice daily (42.50±0.24 g) and thrice daily (44.77±0.20 g) feeding frequencies. There was a significant difference (P< 0.05) in fish length between these feeding frequencies. For weight values, feeding frequency A (once daily) had the lowest final mean weight (21.40 g) while feeding frequency E (five times daily) had the highest mean weight value (30.41 g) starting from 4.12 g ab initio. Mean weight values for other feeding frequencies (B-D, i.e. twice, thrice and four times daily) ranged increasingly between the two extremes. There was also a significant difference (P< 0.05) in final weight values at the different feeding frequencies. The highest length increment (7.90±0.08 cm) was observed in feeding frequency E and the lowest value (6.36±0.02 cm) was observed in frequency A. Similarly, the highest weight increment (26.29±0.10 g) was recorded at the highest feeding frequency (E) and the lowest value (17.28±0.11 g) was recorded at the lowest feeding frequency (A). The fish fed at frequencies of once daily had the highest feed conversion ratios and least feed conversion efficiencies (2.35, 42.45%) and the ones fed twice and thrice daily had the lowest feed conversion ratios and highest feed efficiencies (1.95, 1.91 and 51.28%, 52.36%) respectively. A statistical comparison of the feed conversion ratios in the five feeding frequencies, using ANOVA, revealed a significant difference (P<0.05) among the feeding frequencies, but non (P>0.05) specifically, between feeding frequencies B and C (i.e. between twice and thrice daily feeding). It was concluded that feeding *Clarias gariepinus*♂ X *Heterobranchus longifilis* ♀ hybrids more than once a day increased growth performance and the feed conversion ratio was better in twice and thrice daily feeding than feeding the fish once or more than thrice daily.

Key words: Feeding · Efficiency · Ratios · Conversion · Frequency · Growth · Fish · Hybrids

INTRODUCTION

Fish require food to supply the energy they need for movement and all other activities in which they engage and the "building blocks for growth." The gross energy (or gross calorific value) of food, GE, is the total energy contained in the food and is essential for their proper body conformation [1]. According to these authors, the food requirement of different species vary in quantity and quality according to the nature of the animal, its feeding habitats, its size, its environment, its reproductive state, etc.

Good nutrition in animal production systems is essential to economically give a healthy product. It has been posited that in fish farming, nutrition is critical because feed represents 40-50% of the production cost; fish nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal fish growth and health [2]. The development of new species-specific diet formulations supports the aquaculture (fish farming) industry as it expands to satisfy increasing demand for affordable, safe and high-quality fish and seafood products [2]. Aquaculture has been accepted, the world over, as a

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means for increasing fish production and a developing country like Nigeria with her immense resources offers tremendous possibilities for fish culture [3]. Aquaculture expansion has been a slow process as private sector fish farmers face major constraints such as lack of seed and quality feed [4].

Catfish, family Clariidae, is very popular in Nigeria due to its culture characteristic, which has endeared it to many fish farmers. Ninety percent of the catfish supply in sub-Saharan Africa in the year 2000 occurred in Nigeria [5]. *Clarias gariepinus* and *Heterobranchus* species are species of high aquaculture importance in Nigeria. They are widely cultured owing to their high market price, fast growth rate and ability to withstand adverse pond conditions especially low oxygen content [6]. *Clarias gariepinus* X *Heterobranchus longifilis* hybrids (Commonly referred to as *Heteroclarias*) grow faster and attain bigger sizes than their genetic parents, *Clarias* and *Heterobranchus* which mature earlier and are highly adaptable [7]. It has also been reported that inter-specific fish hybrids transfer desirable traits of two species into a single group of fishes [8]. The hybrids of *Heterobranchus* and *Clarias* exhibit the fast growing quality of *Heterobranchus* reaching up to 1.0 kg under eight months in ponds and resistant to disease These are obviously very attractive qualities for aqua culturists [7-9].

In Nigeria, getting fast growing fish seed has been a major problem to farmers targeting high yields. Hybridization of clariid catfish has increased rapidly in the last few years and apparently market demand for these hybrids is still increasing [4]. Nigeria is one of the largest importers of fish in the developing world, importing some 600,000 metric tons (mt) annually. To solve the country's high demand for fish, Nigerians must turn to their underutilized inland waters for improved fish production and Aquaculture. It has been noted that the largest mature *Clarias gariepinus* would usually give the best spawn weight in induced breeding but there is no mention in any literature available as to whether the fish with best spawn would equally give the best fry survival and growth performance [10]. Research has shown that there are variations in the sizes of fingerlings produced from the same clariid brood stock at the same time and that the variation in sizes of the fingerlings might be related to the variation in sizes of their eggs [11].

Some workers in Nigeria and other parts of the world have studied the effects of feeding frequency on food consumption and growth of fish [12-14]. They observed that channel catfish fed daily (high frequency) consumed more feed with a resultant very high production when compared with fish that were fed "every other day"[12].

Investigations were carried out on the effect of feeding frequency and feeding rate on the growth and feed efficiency of juvenile milkfish, *Chanos chanos* and suggested that more frequent feeding over a wider spread of time would be a more efficient strategy for feeding milkfish in ponds[14].

So far, no work has been carried out on the effect of feeding frequency on food consumption and growth of the *Clarias gariepinus*♂ X *Heterobranchus longifilis*♀ hybrids.

This Research Was Therefore Aimed At:

- determining the effect of feeding frequency on food consumption by the *Clarias gariepinus*♂ X *Heterobranchus longifilis*♀ hybrids in the laboratory.
- determining the effect of feeding frequency on feed conversion efficiency and growth in length and weight of the studied fish in the laboratory.
- Suggesting an aquaculture practice that will minimize losses and maximize profit in rearing these fish.

MATERIALS AND METHODS

Fingerlings of the fish hybrids obtained from the University of Calabar fish farm (mean weight, 4.12 g; mean total length, 3.50 cm) were stocked (10 each) in glass aquaria of 54,000 cm^3 cubic capacity labeled A, B, C, D and E after a one day acclimation period and fed with dry Copene feed at the rate of 5% fish body weight for three months. The fishes in the different aquaria were fed at different feeding frequencies. Those in aquarium A, B, C, D and E were fed once, twice, thrice, four times and five times a day, respectively.

Before new feeds were given, old uneaten feeds were removed using a small scoop net. The left- over feed were dried at a temperature of 40°C for 24 hours to the initial feed moisture content of 45% in an incubator. These left over feed were then weighed in order to determine the amount of feed eaten by the experimental fish.

Mean daily consumption of feed (g) by each fish fingerling per feeding frequency was estimated by subtracting the weight of the uneaten feed from the total weight of feed given to the fish in each aquarium and dividing it by the total number of fingerlings in that aquarium. These values were then summed up to determine the mean weekly feed consumption per feeding frequency.

Because of the small sizes of the fingerlings, 5 fingerlings were put in a Petri dish and weighed collectively on a weighing balance. The average weight in grammes was calculated to represent the weight of each individual fingerling. The lengths (Total length and Standard length) of each fingerling were measured to the nearest 0.1 mm using a meter rule.

Measurements of weights and lengths of the fingerlings was done once every week throughout the experimental period.

Based on the length and weight increments, the food conversion ratios of the fish at different feeding frequencies were calculated from the formula:

$$FCR = \frac{\text{diet fed (g)}}{\text{weight gain (g)}}$$

The feed conversion efficiency (%) was also calculated from the formula:

$$FCE = \frac{\text{weight gain by fish(g)}}{\text{diet fed(g)}} X\ 100$$

RESULTS

Feed Consumption: The mean total feed consumed per fish per feeding frequency during the study (g) by *Clarias gariepinus*♂ X *Heterobranchus longifilis*♀ hybrids, during the study period, is shown in table 1. Fish fed once daily consumed a lower quantity of feed (40.70±0.58 g) than fish fed at higher frequencies. The highest feed consumption was observed in fish fed 5 times daily (54.43±0.24 g). There was a significant difference ($P< 0.05$) in feed consumption at the different feeding frequencies. However, no significant difference was observed in the amount of feed consumed at the twice daily (42.50±0.24 g) and once daily as well as the twice daily and thrice daily (44.77±0.20 g) feeding frequencies. The weekly pattern of mean daily feed consumption by the fish at different feeding frequencies is illustrated in figure 1.

Length and Weight Measurements: The mean weekly values of fish lengths and weights at each feeding frequency are shown in tables 2 and 3. Fish length increased from an initial value of 3.50 cm to final values of 9.86 cm in feeding frequency A and 11.40 cm in feeding frequency E. Other feeding frequencies (B-D) had length values intermediate between the two extremes. There was a significant difference ($P< 0.05$) in length values between these feeding frequencies. For weight values, feeding frequency A had the lowest final mean weight (21.40 g) while feeding frequency E had the highest mean weight value (30.41 g) starting from 4.12 g weight, ab initio. Mean weight values for other feeding frequencies (B-D) ranged progressively between the two extremes. There was also a significant difference ($P< 0.05$) in final weight values at the different feeding frequencies. Final mean length and mean weight increments per feeding frequency at the end of the study period are shown in figure 2.

Table 1: Mean total feed consumption per study fish at each feeding frequency during the study period

Feeding frequency		Total feed consumed /fish /feeding frequency during the study period (g±SE).
A.	Once daily	40.70±0.58
B.	Twice daily	42.50±0.24
C.	Thrice daily	44.77±0.20
D.	Four times daily	49.48±0.21
E.	Five times daily	54.43±0.24

Table 2: Mean weekly length measurements of fish per feeding frequency

Feeding Frequency (Tanks A-E)	Initial length (cm)	Weekly length measurements (cm) Weeks 1	2	3	4	5	6	7	8	9	10	11	12
A. Once daily	3.50	3.60	4.02	4.21	4.58	5.30	6.00	6.45	6.56	7.01	7.63	8.25	9.86
B. Twice daily	3.50	3.62	3.88	4.25	4.72	6.08	6.30	6.68	7.10	7.50	8.02	8.66	10.42
C. Thrice daily	3.50	3.25	3.45	4.00	4.25	4.50	5.60	7.11	7.87	8.27	9.00	9.64	10.77
D. Four times daily	3.50	3.50	3.65	4.01	4.30	5.00	6.00	7.00	8.46	8.84	9.25	10.15	11.20
E. Five times daily	3.50	3.55	4.00	4.21	4.45	5.60	6.80	8.85	9.50	9.70	10.10	10.28	11.40

Table 3: Mean weekly fish weights per feeding frequency

Feeding Frequency (A-E)	Initial weight (g)	Weekly mean weights (g) of the studied fish — Weeks 1	2	3	4	5	6	7	8	9	10	11	12
A. Once daily	4.12	4.15	4.83	5.00	5.71	7.62	9.11	10.62	13.40	15.66	17.84	19.00	21.40
B. Twice daily	4.12	4.16	5.03	6.26	7.00	8.12	11.77	13.00	17.93	19.46	21.22	23.41	25.86
C. Thrice daily	4.12	4.18	5.80	6.96	7.90	10.14	12.90	16.29	18.11	20.62	23.90	25.80	27.62
D. D. Four times daily	4.12	5.07	6.40	7.12	8.40	11.47	15.92	17.40	19.63	22.73	24.25	26.41	28.74
E. Five times daily	4.12	5.95	6.96	7.87	10.12	12.68	16.93	18.27	20.61	23.43	25.86	27.96	30.41

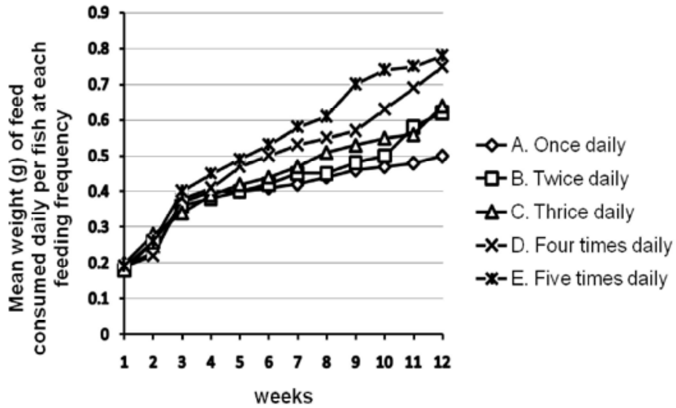

Fig. 1: Weekly pattern of mean daily feed consumption by the fish at different feeding frequencies

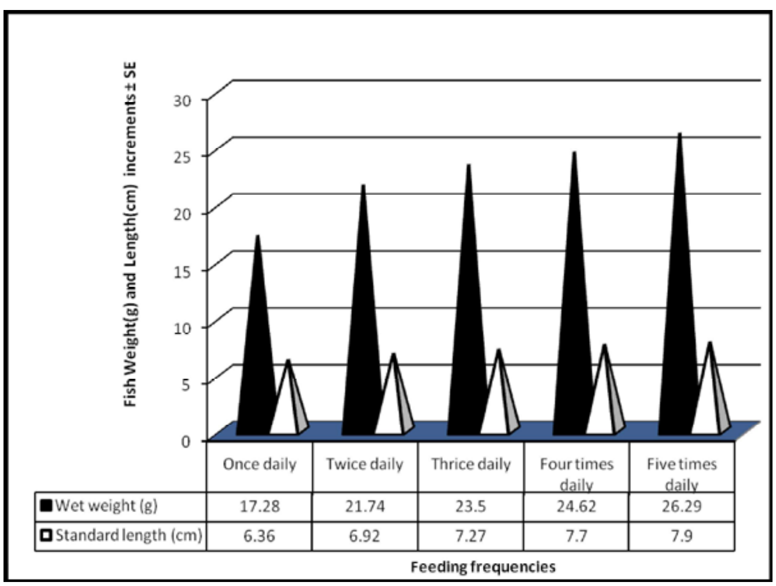

Fig. 2: Total weight (g) and length (cm) increments in the studied fish at the end of the study period.

The highest length increment (7.90±0.08 cm) was observed in feeding frequency E and the lowest value (6.36±0.02 cm) observed in frequency A. Similarly, the highest weight increment (26.29±0.10 g) was recorded at the highest feeding frequency (E) and the lowest value (17.28±0.11 g) was recorded at the lowest feeding frequency (A).

Food Conversion Ratio and Food Conversion Efficiency: The Biological Feed Conversion Ratios for the studied fish at the various feeding frequencies during the study period are shown in figure 3. The fish fed at frequencies of once daily (A) had the highest feed conversion ratio (2.35) and the ones fed twice and thrice daily (B and C) had the lowest feed conversion ratios of 1.95 and 1.91,

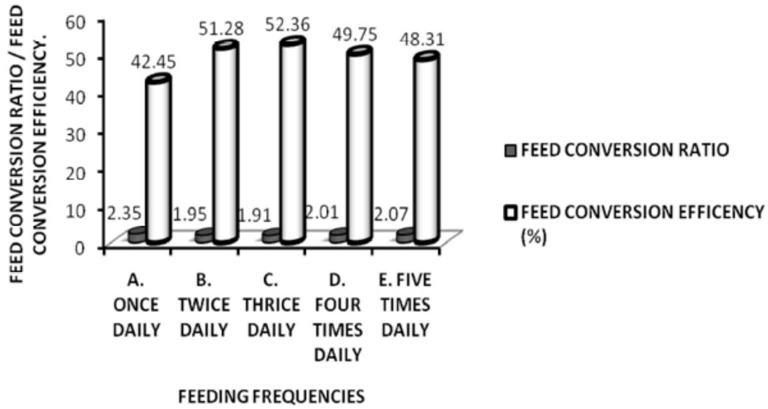

Fig. 3. Feed conversion ratios and feed conversion efficiencies of the studied fish at different feeding frequencies.

respectively. A statistical comparison, using ANOVA, of the feed conversion ratios in the five feeding frequencies revealed a significant difference (P<0.05), generally, among the feeding frequencies but non, specifically, between feeding frequencies B and C (i.e. between twice and thrice daily feeding).

Accordingly, the Feed Conversion Efficiencies were a reflection of the feed conversion ratios as seen in figure 3. The highest feed conversion efficiency was exhibited by fish fed thrice daily (52.36%) and the least (42.45%) seen in fish fed once daily.

DISCUSSION

Feeding and feeding frequencies are key factors that determine the growth and survival chances of fish. The hybrids of *Clarias gariepinus* and *Heterobranchus longifilis* were subjected to different daily feeding frequencies. In this investigation, it was observed that the highest quantity of feed was consumed by fishes fed the greatest number of times (5 times) daily, while the least amount was consumed by fishes fed once daily. Although statistical analysis using ANOVA showed that there was a significant difference in the amount of feed consumed at the different feeding frequencies (P< 0.05), there was however, no significant difference in the amounts consumed at the twice daily and thrice daily feeding frequencies. The basic principle in feeding is that fish should be fed exactly to satiation [15]. If they are fully fed, the fish are not stressed and they provide high quality food for human consumption. This requires the farmer to have the skills to judge precisely how much feed to give. Feeding rates and feeding frequencies are, in part, a function of fish size. Small larval fish and fry, such as the ones used in the present investigation, need to be fed a high protein diet frequently and usually in excess. Small fish have a high energy demand and must eat nearly continuously and, therefore, must be fed almost hourly. Studies on some fish species have shown that the highest weight gain was obtained (P<0.05) by feeding the fish frequently (three times daily), providing more feed [16]. The studies showed that a higher growth rate depended on both higher and more frequent feed supply.

Fish length and weight increments in the present study were highest in the fish fed the highest number times (5 times) daily and the lowest increment was observed fishes fed the least number of times (once) daily. There was,however, no significant difference in the growth increment between fish fed twice and those fed thrice daily. Investigations have considered the effect of feeding rate on the growth and feed efficiency of juvenile milk fish (*Chanos chanos*) and found that, regardless of the feeding rate, increasing the feeding frequency from four (4) to eight (8) times per day significantly increased growth and feed efficiency of this fish by 20% [14]. These authors suggested that more frequent feeding over a long period would be an efficient strategy for feeding *Chanos chanos* in ponds. In the present study, feeding the *Heteroclarias* hybrid fingerlings up to 5 times daily showed a significant weight increment (P<0.05) over feeding it three times or less daily. There is no serious consequence in this since feeding small fish in excess is not as much of a problem as over feeding larger fish because small fish require only a small amount of feed relative to the volume of water in the culture system [2].

The feed conversion ratio (FCR) in the present study was calculated from the amount of feed used to produce a given weight of the fish (in grams). The Biological feed conversion ratio was considered in this investigation. This differs from the Economic FCR which usually takes into account all the feed used, the effect of feed losses and fish mortalities. The feed conversion ratio was highest in the fish fed once daily (2.35) followed by the fish fed five (5) times and four (4) times daily (2.07 and 2.01, respectively). The fish fed twice and thrice daily had the least FCR values (1.95 and 1.91 respectively) with no statistically significant difference between the latter two frequencies (P>0.05). The values obtained for Feed Conversion Efficiency (FCE) were a reflection of the FCR values since the FCE is the reciprocal of the FCR expressed as a percentage. The highest FCE was observed in the feeding frequency C (Three times daily. 52.36%) and the least was in feeding frequency A (once daily, 42.45%). There was an observed decrease in the feed conversion efficiency as the feeding frequency increased above the thrice daily level. Because feed is expensive, feed conversion ratios or feed conversion efficiencies are important calculations for the fish grower which can be used to determine if feeds are being used as efficiently as possible [17]. FCR's of 1.5-2.0 are considered "good growth" for most fish species. Accordingly, FCE's greater than 50% are also considered " good growth". Farms reporting low FCR's normally have good management practices in place, with no over feeding and very low, if any, mortalities. 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 they must use some of the energy in feed for metabolic heat, digestion, respiration, nerve impulses, salt balance, swimming and other life activities [2]. Feed conversion ratios will vary among species, sizes and activity levels of fish as well as the environmental conditions and culture systems used. In the present study, the FCR (<2.0) and FCE (>50%) values obtained in fish fed twice and thrice daily indicate good growth for the fish fed at these feeding frequencies.

Feed conversion, growth and feeding rates are the major variables for the commercial aquaculture enterprise. An understanding of the relationships between these is fundamental in optimizing the feeding of the fish. Unfortunately, the maximum growth and the lowest feed conversion ratio do not coincide at the same feeding rate. The lowest feed conversion ratios (FCR's) occur at feeding rates (quantity of feed supplied per body weight of fish) which are below those at which maximum growth occurs. In the present study, the lowest FCR values were obtained at the twice daily and thrice daily feeding frequencies, whereas the highest weight and length increments were obtained at the four times daily and five times daily feeding frequencies. Similar findings have been reported by other workers with other fish species [17, 18]. It is, therefore, evident that there is a range of possible feeding (rates/frequencies) choices which depend on whether maximum growth, optimal feed conversion or a balance between the two is sought. A high feeding rate (Feed per body weight) and frequent feeding (number of times the fish are fed per day) lead to the best performance [19].

In conclusion, these investigations have shown that feeding *Clarias gariepinus*♂ X *Heterobranchus longifilis*♀ hybrids more than once a day increased growth performance. Feed conversion ratio of this fish was better in twice and thrice daily feeding than feeding the fish once or four times and five times daily.

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). It, therefore, means that there is further room for fish farming to become even more productive without compromising the environmental or welfare standards.

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