Influence of feeding regimen on growth parameters of African Catfish (*Clarias gariepinus*, Burchell 1822)

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Abstract

An experiment was conducted using 270 African catfish fingerlings to evaluate the effects of different feeding regimen on growth performance of the fish. The fish were hatched and reared to 12 weeks under similar condition before the commencement of the experiment that lasted for 40 days. Feeding regimens included equally shared feed based on recommended of 5% body weight, and equally spaced feed allocation at 6, 8 and 12 hourly intervals. Each of the three treatment groups comprised of six replicates of 15 fish per plastic tank. Body weight, and two linear measurements (total and standard length) were taken twice weekly on each of the fish in all the tanks and the respective length-weight relationship and condition factor (K) were computed. Weekly gain, final weight, average daily gain, absolute, relative, specific and mean growth rates for the three groups were evaluated and compared. Results showed that all parameters studied except final total length were significantly ($P < .05$) affected by feeding regimen. The coefficient of determination for all ANOVA had variable values for all growth parameter; Final Weight (83.11%), Absolute Growth Rate (79.19%), Final Total Length (61.30%), Final Standard Length (60.87%), Relative Growth Rate (38.68%), Specific Growth Rate (35.57%), Mean Growth Rate (32.23%) and Condition Factor (12.83%). The 6-hourly treatment group mostly had the highest values across all the parameters studied but was not statistically different ($P > .05$) from the values obtained in the 8-hourly group.

Keywords: Growth parameters, feeding regimen, fish rearing, Aquaculture

Introduction

African catfish (*Clarias gariepinus*) is becoming increasingly popular in Africa as a result of its wide acceptability across ethnic, cultural and religious divides. It is a veritable source of animal protein. Its relative ease of culturing in artificial tanks, hardiness and omnivorous attributes makes it a preferred specie in aquaculture (Adebayo and Fagbenro, 2004). As at 2010, Nigeria accounted for 62.65 percent of the total production of clariid catfish in Africa (FAO, 2012) and artificial culture of the species has since been on the increase. *Clarias gariepinus* is ideal for culture because of its tolerance to low dissolved oxygen, rapid growth rate, acceptability of varieties of feed resources and ability to

withstand stress associated with its handling. Market demand for catfish also continues to increase over years for its delicious taste and relatively affordable price (Zidni *et al.*, 2013; Hecht, 2013). Four major production challenges have been identified to confront profitable and sustainable aquaculture (George *et al.*, 2010), and feeding remains the biggest threat to fish rearing, with regards to the quality and quantity of feed on one part and its availability and affordability on the other part. It has been reported that feed represents 40-50% of production cost, and fish nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal fish growth and health (Craig,

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2002). Thus, to improve on the culture of *Clarias gariepinus*, there is need to produce quality table size fish within the shortest possible time and at minimum cost to ensure optimal return on investment (Booth *et al.*, 2008 and Ndome *et al.*, 2011). Aquaculturists typically report growth using absolute (g/d), relative (% increase in body weight), and specific growth rates (%d) and each of these rates is a numerical representation of growth which assumes a specific relationship between size and time (Hopkins, 1992). Fish growth is influenced by feed availability and intake, genetics, age and size, environment and nutrition, and feed intake is perhaps the most prominent factor affecting growth rate of fish (Li *et al.*, 2004). In a bid to overcome the inadequacy of feeding, there is the need to strike a balance between rapid fish growth and optimum use of supplied feed by recommending the optimal feeding frequency to reduce wastage and its attendant economic losses. Such problems can be solved by avoiding the twin traps of overfeeding and underfeeding, which are both detrimental to the health of the fish and may cause marked deterioration in water quality, reduced weight, poor food utilization, and increased susceptibility to infections (Priestley *et al.*, 2006). It may also affect the specific growth rates and the efficiency of feed conversion as these have been observed to be directly related to feed ration and frequency. When fish are fed at optimal feeding frequency, growth and survival rates are expected to improve because this regulate their feed intake in relation to their energy demand (Schnaittacher *et al.*, 2005), and times of feeding and feeding frequency have been reported to affect feed intake and growth performance in fishes (Ali *et al.* 2005). This study aims to investigate the growth performance of *Clarias gariepinus* fed at three different equal intervals of 6, 8 and 12

hours per day as expressed by their weekly gain, mean, absolute, relative and specific growth rates. Thus, the objective of this study was to make comparative analysis of the weekly growth rate and other growth parameters under the three differing feeding regimes, and recommend the optimal feeding frequency for the African catfish rearing.

Materials and methods

The study site

The study was entirely conducted at the Lagos State University, along Badagry Expressway, Ojo, Lagos State at latitude 6° 28.226' N and longitude 3° 12.019' E, with an average annual rainfall of 1693mm and average temperature of 27.0°C. The first part of the experiment was set up at the Hatchery of the Department of Fisheries, while subsequent rearing was at the Department of Zoology laboratory. The Hatchery has an indoor flow through system with several concrete tanks and the fry were raised in plastic tanks of equal size and dimensions.

Experimental unit

Four brood stocks comprised of three females and one male, with each female weighing 645g, 525g and 525g, respectively while the male weighed 2,325g, were procured from a reputable commercial fish farm along Badagry Expressway, Lagos State, Nigeria. The fish were separated by sex and left for some time to acclimatize, before the females were induced with artificial hormone (Ovaprim). Egg stripping was done 8 hours after by gently pressed the abdomen with a thumb started from the area of the chest, moved towards the genital papillae into a clean bowl. The male was sacrificed with its testes removed and kept in a clean bowl. Milt was collected by maceration of the testes and mixed saline solution. Thereafter, the milt was added to the egg

and mixed by gently shaking the bowl and the fertilized eggs were spread on wire mesh inside the breeding tank. After about 22 hours, hatchlings were noticed swimming around the mesh net, carrying their yolk, the mesh was removed a day after hatching, and dead eggs were siphoned out. Feeding commenced on the third day after absorption of yolk and fry were fed with artemia for three weeks, before introduction of Coppens commercial fish feed of varied sizes depending on the stage of development as described by Abanikannda *et al* (2019). The fingerlings were kept and reared under same conditions for 12 weeks when the fingerlings were strong enough to withstand the rigors of handling during measurements.

Experimental design

Two hundred and seventy 12-week old fingerlings weighing between 5.00g – 14.96g were randomly selected and randomly assigned to three different and independent treatment groups (6, 8 and 12 hourly regimen), each with 90 fingerlings per treatment. The fingerlings were fed at the recommended 5 percent of their body weight and the feed was apportioned into 4, 3 or 2 parts daily for each feeding regimen. There were six replicates per treatment with each plastic tank, measured 30cm x 48cm x 29cm each holding 15 fingerlings. A preliminary statistical analysis of the mean weights across all the 18 tanks at the commencement of the experiment was fairly uniform and not different ($P>0.05$). Fingerlings assigned to treatment A were fed four times daily at 6 hourly intervals at 12am, 6am, 12pm and 6pm while treatment B were fed three times daily at 8 hourly intervals at 12 am, 8am, and 4pm respectively, and treatment C were fed twice daily at 12 hourly intervals at 12am and 12pm daily. Irrespective of the treatment group, the fingerlings were fed daily with 3mm Coppens commercial feed

at 5% of their body weight throughout the experimental period, and the tank water was changed every two days to maintain good water quality.

Measurements and data collection

Individual body weight (g), total length (cm) and standard length (cm), of each fish were taken twice a week using digital balance for the body weight and meter rule for total and standard length and feed offered was measured using digital balance sensitive to 0.00g. Data collected were transcribed and entered onto Excel Worksheet comprising columns indicating Tank ID, Weight, Total Length and Standard Length at specified intervals.

Data preparation and statistical analyses

Aside from the weight, total length and standard length recorded at the commencement of the experiment which was defaulted to initial values, further recordings were made at intervals spanning a period of 40 days. Each recording was appropriately tagged and weekly measurements were computed as the difference between the current and prior week recordings. Other parameters such as Absolute Growth Rate (AGR), Specific Growth Rate (SGR), Relative Growth Rate (RGR) and Mean Growth Rate (MGR) were computed by methods of Brown (1957), Ricker (1975), Bagenal (1978), and Varela *et al*, (2010) as follows:

$$AGR = \left(\frac{W_f - W_i}{t} \right)$$

$$SGR(\%) = \left(\frac{\ln W_f - \ln W_i}{t} \right) \times 100$$

$$RGR(\%) = \left(\frac{W_f - W_i}{W_i} \right) \times 100$$

$$MGR(g/day) = \left(\frac{W_f - W_i}{0.5(W_f + W_i)t} \right) \times 100$$

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Where W_f was final weight (g), W_i was initial weight (g), t was time (days), and $\ln$ is natural logarithm.

Indices such as length weight relationship and Fulton's condition factors were estimated using the formula of Tesch (1968) and Fulton (1904) as described by Abanikannda *et al.* (2019) as follows:

$$W = aL^b$$

which was transformed as $\log W = \log a + b \log L$. The Fulton's Condition Factor was given as;

$$K = \left(\frac{W \cdot 100}{L^3} \right)$$

where W = Weight in gram, L = length in (cm), a = a constant being the initial growth index, and b = growth coefficient. K is the condition factor.

Preliminary exploratory analyses were done to check data validity, assess for outlier values and test for normality. The General Linear Models of ANOVA was used to test for differences between treatments for the three measurements studied (weight, total length and standard length) and the computed indices (weekly gain, length-weight relationship, condition factor, absolute, specific, relative and mean growth rates). The statistical model used in the final analyses is given as;

$$Y_{ijk} = \mu + \alpha_i + \beta_j + e_{ijk}$$

Y_{ijk} = Observed measure for each variable

μ = Overall mean

α_i = Effect of feeding regime (i = 6 hourly, 8 hourly and 12 hourly)

β_j = Initial reading as Covariate

e_{ijk} = Residual error

Results

Measured variables

The mean $\pm$ SE initial weight at the commencement of the experiment was 7.15 ± 0.17 g, 7.05 ± 0.17 g and 7.17 ± 0.17 g, respectively for the three treatments (6, 8 and 12 hourly), while the overall mean

across the three treatments was 7.13 ± 0.10 g. There was no statistical difference ($P > 0.05$) in the initial weight across the three treatments and all were fairly homogenous.

The weekly gain in weight across the three treatments is presented in Figure 1. There was difference ($P < 0.05$) amongst treatments in all the weekly weight gain except for the 5th week that was not significant ($P > 0.05$). Also, the 6 hourly regimen mean was consistently superior throughout the study except for the first week, whereby the 8 hourly regimen mean was highest.

The effect of treatment on final weight was highly significant ($P < 0.01$) and the model ascribed 83.1 percent of variation in final weight to the combined effects of initial weight and treatment group (Table 1). The 6-hourly treatment had the highest final weight gain of 32.33 ± 1.39 g which was not significantly ($P > 0.05$) different from 30.54 ± 1.42 g recorded in the 8-hourly regimen but both values were significantly ($P < 0.05$) higher than the 29.27 ± 1.34 g recorded for the 12-hourly regimen.

Total length

The overall ($n=270$) mean of initial total length in the study was 12.49 ± 0.06 cm with respective means for the three treatments (6, 8, and 12 hourly) as 12.48 ± 0.09 cm, 12.47 ± 0.11 cm and 12.51 ± 0.10 cm. There was no statistical difference ($P > 0.05$) in the treatment means all through the study except for second week where the 6-hourly regimen had significantly ($P < 0.05$) higher values than the other two treatments. Weekly gain in total length is presented in Figure 1.

There was no statistical ($P > 0.05$) difference in the final total length recorded in the study (Table 1) which was respectively 9.92 ± 0.20 cm, 9.41 ± 0.22 cm and 9.57 ± 0.21 cm for the 6, 8 and 12-hourly regimen, while the overall mean total length was 9.63 ± 0.12 cm. The model accounted for 61.3 percent of variation in final total length across the three treatments.

Table 1: General Linear Models ANOVA Table of Growth Parameters of *Clarias gariepinus*

Sources of Variation	Degrees of Freedom	Final Weight	Final Total Length	Final Standard Length	Condition Factor	Specific Growth Rate	Absolute Growth Rate	Relative Growth Rate	Mean Growth Rate
Initial Weight	1	47278.3***	1062.39***	902.83***	0.24***	34.99***	25.25***	1174283***	11.84***
Treatment	2	234.5**	4.12 ^{ns}	8.22*	0.03*	1.31**	0.16**	46967**	0.43*
Error	266	36.4	2.55	2.23	0.01	0.26	0.03	7527	0.10
*** = P < 0.001		** = P < 0.01		* = P < 0.05		^{ns} = P > 0.05			

Standard length

There was no significant difference ($P > .05$) in the initial mean standard length across the three treatments nor in the weekly recordings across the five weeks (Figure 1). The overall mean initial standard length was $10.85 \pm .05$ cm, while it was $10.82 \pm .08$ cm, $10.82 \pm .09$ cm and $10.90 \pm .09$ cm for the 6, 8 and 12-hourly regimen, respectively.

However, there was significant ($P < .05$) difference in the final standard length across the three treatments (Table 1) and the coefficient of determination of the model was 60.87 percent. The overall final standard length was $8.81 \pm .12$ cm, but the 6-hourly regimen had the highest value of $9.21 \pm .19$ cm, which was statistically ($P < .05$) higher than $8.53 \pm .21$ cm recorded in the 12-hourly regimen, but the $8.70 \pm .20$ cm recorded in the 8-hourly regimen was intermediate between the other two treatments and was not statistically ($P > .05$) different.

Computed Indices

Length weight relationship: Logarithmic transformation of the weight and length of the fish resulted in the regression equations

presented in Table 2. It was observed that the growth coefficient (b) in the 6-hourly treatment has positive allometry ($b > 3$) while the other two treatment groups had negative allometry ($b < 3$).

Condition Factor (K)

This is a measure of the health of the fish, and feeding regimen exerted significant ($P < .05$) influence on this parameter (Table 1). Surprisingly, the 8-hourly treatment group had the highest values while the 12-hourly group had the least (Table 3), which is an indication of improved wellness and health of the 8-hourly group compared to other treatment groups. The model for condition factor had the least coefficient of determination of all parameters studied which was 12.83 percent.

Specific Growth Rate (SGR)

Effect of feeding regimen was a highly significant ($P < .01$) source of variation in specific growth rate (Table 1) and the model explained 35.57 percent of variation in specific growth rate. Mean values from 6-hourly regimen was significantly ($P < .05$) higher than values obtained in the 12-hourly treatment group, but the 8-hourly group was intermediate between the two extreme values (Table 3).

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Figure 1: Weekly distribution of weight gain (g), total length (cm) and standard length (cm) across the three different feeding regimens

It is worthy of note that the coefficient of determination for the three regression equations revealed that the 8-hourly

treatment had a better fit of 79.3% while the 6-hourly treatment had the lowest R^2 value of 73.8% which is below the average of the three treatments.

Table 2: Regression of Log Weight on Log Length across Treatments

Treatments	N	a	b	R ²
6-hourly	90	-2.62	3.10	73.8
8-hourly	90	-2.27	2.85	79.3
12-hourly	90	-2.37	2.91	77.9
Combined	270	-2.39	2.93	77.0

R² = Coefficient of Determination

Table 3: Growth Parameters of *Clarias gariepinus*

Treatments	N	SGR (%)	AGR	RGR	MGR	CF
6-hourly	90	4.37±.06 ^a	0.85±.04 ^a	437.5±10.7 ^a	3.56±.03 ^a	0.48±.01 ^{ab}
8-hourly	90	4.24±.08 ^{ab}	0.80±.04 ^a	418.0±12.8 ^{ab}	3.48±.04 ^{ab}	0.50±.01 ^a
12-hourly	90	4.14±.06 ^b	0.77±.04 ^b	393.2±10.8 ^b	3.43±.04 ^b	0.47±.01 ^b
Combined	270	4.25±.04	0.81±.02	416.3±6.71	3.49±.02	0.48±.01

Means with different superscript within the same column are statistically different (P<0.05)

Absolute Growth Rate (AGR)

The 6-hourly group had the highest value for absolute growth rate (Table 3) and influence of group was significant (P<.05) amongst the three treatments studied (Table 1). The coefficient of determination for the model was 79.19 percent due to initial weight and treatment.

Relative Growth Rate (RGR)

Effect of feeding regimen was a highly significant (P<.01) source of variation in RGR (Table 1), with the 6-hourly treatment recording the highest values and 12-hourly regimen had the least (Table 3). The 8-hourly treatment group had intermediate values between the two extreme values and was not statistically (P>.05) different from the other two values (Table 1). The model was able to explain 38.68 of variation in relative growth rate using only the initial weight and feeding regimen as sources of variation.

Mean Growth Rate (MGR)

The model explained 32.23 percent of variation in mean growth rate and feeding regimen was a significant (P<.05) source of variation in mean growth rate (Table 1). There was a 3.79 percent superiority of the 6-hourly group mean on the 12-hourly group, while the difference between the 8-

hourly group and the other two treatments was marginal (Table 3).

Discussion

Initial Weight: There was similarity in the initial weight of the three groups because the random selection and assignment had averaged out the likely variation that could have inherently existed between the groups. Aside from the nearly equal mean values of initial weight between the groups, the variability within the three groups was very similar with coefficient of variation of 23.02, 22.58 and 22.66 percent respectively for the 6, 8 and 12-hourly treatment groups.

Weekly Weight Gain

The 8-hourly treatment group had the highest gain in week 1 which is almost 26 percent higher than gain recorded by the 12-hourly treatment group and 17 percent higher than the 6-hourly group (Figure 1). In subsequent weekly weight gain recordings, the 6-hourly group consistently had the highest values for the remaining four weeks, albeit there was no difference in the 5th week weight gain between the groups. The greatest difference in weekly weight gain between the highest and lowest mean was recorded in week 4 (2.58g) between the 6-hourly group and the 12-

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hourly group, while the least was in week 1 (0.15g). This weekly difference in weight gain is in consonance with earlier reports (Ruhohen *et al.*, 1998; Ibiyo *et al.*, 2007; Aderolu *et al.*, 2010; Marimuthu *et al.*, 2010; Asuwaju *et al.*, 2014 and Jamabo *et al.*, 2015) who all worked on *Clarias* under similar conditions as this study.

The 6-hourly treatment that feeds four times daily had the best gains across the weeks but such values were not statistically different from the values obtained in the 8-hourly group that feeds only thrice. Although feeding at optimum frequency result in noticeable reduction in feeding cost as suggested by Davies *et al.*, (2006), it must be borne in mind that the additional cost of labour for more frequent feeding must be taken into consideration before adoption of the method.

Final Weight Gain

At the end of the study, the 6-hourly group gained 10.45 percent more than the 12-hourly group (Figure 2), but a meagre 5.86 percent more than the 8-hourly group. It should be noted that while there was a huge statistical difference between the 6 and 12-hourly groups, there was no significant difference between the 6 and 8-hourly groups which is in consonance with submission of Bascinar *et al* (2007) who worked on Black Sea Trout in Turkey, that feed consumption and growth generally increase with feeding frequency to a given limit.

The significant difference in weight gain recorded in this study is in close agreement with the reports of Asuwaju *et al* (2014) who also worked on *Clarias gariepinus* in their 49-day study.

Figure 2: Histogram of final weight gain (g), final total length (cm) and final standard length (cm) across the three different feeding regimen

Total Length

Total length mean did not follow any consistent pattern throughout the study, and the effect of treatment group on total length at the end of the study which was not different between groups. This implies that despite the numerical differences in the total length, the within group difference is so large not to allow the between group difference significant.

Standard Length

Effect of treatment group on standard length followed a similar trend as that of total length all through the study except at the final standard length. The 6-hourly group had the highest final standard length (Figure 2) and it was 7.97 percent higher than the 8-hourly group which had the least. This may be attributed to higher increase in size and weight of this treatment group. The relationship between weight and standard length is direct and as such impact the standard length.

Length-Weight Relationship

The positive allometry of the 6-hourly group is indicative of the superiority of this group in terms of weight prediction based on length (Table 2). This implies that better responses are recorded on weight as a consequence of unit change in length of the fish in the 6-hourly group. However, the lower coefficient of determination of the model suggest that some other salient factors might have contributed to this observation. This observation supports the report of Panase and Mengumphan (2015) who worked on hybrid catfish in net cages and the difference in b-values may be due to differences in feeding regimen (Wooton, 1990).

Condition Factor

This is a measure of the wellness and health of the individual fish in a population (Stevenson and Woods, 2006), and the 8-hourly group had the best value of 0.50, while the least of 0.47 was recorded in the

12-hourly group. This difference among the three groups, supported earlier reports on the same specie (Panase and Mengumphan, 2015; Haruna *et al.*, 2014; Ayoade, 2011 and Ekelemu, 2010). Although, Kasiri *et al.*, (2015) reported that feeding frequency did not affect condition factor in the Angel Fish (*Pterophyllum scalare*) they studied in Iran.

Absolute Growth Rate

The difference in absolute growth rate is a reflection of the daily gain across the three treatment groups. However, the values decreased with decreasing number of times the fish were fed, with the highest values recorded in the 6-hourly and the least in the 12-hourly group. This indicate that whilst the daily gain was statistically different in itself, the large difference in the final weight is then attributable to the frequency of feeding and absolute growth rate of the fish.

Specific Growth Rate

The 5.56 percent increase in the specific growth rate of the 6-hourly group over the 12-hourly group is an indication of better growth and feed utilization in that treatment group. Although the 8-hourly group was intermediate between the other two (6 and 12 hourly) treatments. This observation is in line with various reports on effect of feeding frequency of *Clarias* on specific growth rate (Omodu *et al.*, 2017; Okwuosa *et al.*, 2016; Orire and Ozoadibe, 2015; Orire *et al.*, 2013; Aderolu *et al.*, 2010 and Amisah *et al.*, 2009).

Relative Growth Rate

The 6-hourly treatment group had mean values that was 11.27 percent higher than the 12-hourly group that recorded the least (Table 3). The 8-hourly group was intermediate between the two extreme values of the other treatments. This corroborates the observations of Pantazis and Neofitou (2003), Emmanuel and Solomon (2013), Jamabo *et al.*, (2015) and Omodu *et al.*, (2017) in their respective

studies on growth characteristics of catfish.

Mean Growth Rate (MGR)

The superiority of the 6-hourly group over the other two treatments is a reflection of better feed utilization within the group since feeding was well spaced, thereby reducing wastages. This is in alliance with the reports of Okwuosa *et al.* (2016), Liu and Liao (1999) and Robinson *et al.* (1995), who all worked on catfishes.

Conclusions

The study showed that differences in growth parameters of *Clarias gariepinus* is as a result of the different feeding regimen. It has established that when fish are fed correctly, growth rates are good and uniform across the population, FCR are low and pond water quality is optimized; In order to minimize wastages and inefficient feed utilization, optimum feeding regimes should be established and adopted in different stages of fish growth and development.

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