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Comparative study of growth parameters of African Catfishes as panacea for food security

[*1]Abanikannda, O.T.F., [2]Jimoh, A.A., [1]Abagun, A.A. and [2]Badmus, L.A.

[1]*Department of Zoology and Environmental Biology, Lagos State University, Ojo – Lagos, Nigeria*
[2]*Department of Fisheries, Lagos State University, Ojo – Lagos, Nigeria*

[*]***Corresponding Author**: otfabanikannda@hotmail.com* ***Phone Number**: +234 802 312 8376*

***Target audience:** Fish farmers, Scientists, Government policy makers*

Abstract

Aquaculture assist in bridging the wide gap by meeting demands for fish and provision of less expensive animal protein in Nigeria. Clarias gariepinus and Heterobranchus bidorsalis are generally acceptable important species of catfish, and highly priced because of their high biological values in terms of protein retention, assimilation and low cholesterol content, necessitating the need to evaluate their potentials. Fingerlings of Clarias gariepinus (purebreed) and Clariabranchus (hybrid) were grouped according to their weights, assigned to two tanks each and fed 5% of their body weight daily. Measurements of body weight (g), total length (cm) and standard length (cm) were taken weekly on each fish. At the commencement of the experiment, there were 281 fishes comprising 150 pure breed and 131 hybrids. By the end of the study some died or were outliers. A total of 224 fishes comprising 108 pure breed and 116 hybrids were finally evaluated. Indices computed included Length-Weight Relationship (LWR), Fulton's Condition Factor (K), Absolute Growth Rate (AGR), Specific Growth Rate (SGR), Relative Growth Rate (RGR) and Mean Growth Rate (MGR). The coefficient of the LWR was respectively 2.42 and 2.82 for the pure breed and hybrids. Effect of breed was highly significant (P<0.01) on all variables studied and the hybrid consistently outperformed the pure breed except in exception of condition factor which is a measure of wellness of the fish. The superiority of the hybrid over the pure breed in all variables studied except one, is indicative of its potential as a better feed converter, thus it is more efficient in feed utilization, and it is recommended for commercial fish producers for maximum yield and higher profit. The study provides a veritable platform for further research on the potentials of interspecific hybridization with a view to minimize production cost engendered by high cost of feed.

***Key words**: Catfish, Clarias gariepinus, Heterobranchus bidorsalis, Growth traits, interspecific hybridization, Aquaculture*

Description of Problem

Nigeria's population, estimated in 2018 to be around 194,615,054, with an estimated annual increase of 2.67% amounting to 5,055,552 million people more than the projection in the previous year. This implies that the Nigerian population is among the fastest growing populations of the world with a consequential significant increase in food demand as a result of the population growth (1).

The significant growth in population with its attendant increased demand and consumption of fish has been on increase in the recent past, since fish is one of the cheapest and readily available source of animal protein in the country (2). Fish is the most easily affordable source of animal protein in every average Nigerian family home and in the world at large with reports showing that fish account for more than forty percent (40%) protein diet for about two-third of the global population (3).

The Federal Department of Fisheries estimated that the current annual aquaculture production hovers around 0.62 million metric tons with small scale fish farming supplying the greatest percentage of the Nigerian annual fish production output (4). However, the production level has been hampered due to high cost of feeding fish coupled with the exorbitant cost of protein as feed ingredient and high demand of fish as food.

To surmount these twin problems of high demand for fish and high cost of common animal protein diets, aquaculture, simply known as aquatic farming is the best option in bridging the wide gap between satisfaction of human demands for fish and provision of less expensive domestic aquatic products in most part of the country (5).

Prior to the discovery of oil in the 1970's, Nigeria was a leading nation in fish production within Africa but suddenly became a major fish importing nation since the government neglected agriculture in general and aquaculture in particular. However, it is only this abandoned sector that would revive Nigeria from its woes of food insecurity and meeting the unending demand for fish by humans (6). The 1996 World Food Summit defined food security as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious foods that meets their dietary needs and food preferences for a healthy life (3).

In general, aquaculture plays a major role in the economic sector of developing countries of Africa like Nigeria by producing fish on a large-scale basis in and out of season ensuring regular supply to meet the food demands of the increasing Nigerian population (7). It is the fastest growing food production sector in the country with an average annual rate of about 8.8% accounting for 47% of Nigeria's fish supply (8).

Due to the reckless fishing methods and destruction of the natural environment which has led to the low supply of fish, there is need to artificially propagate fish seeds. Fish culture has become an innovative technology aimed at producing large quantities of fish for food thus solving the issues of food insecurity affecting the ever-increasing human population in Nigeria. Fish Culture or pisciculture involves the raising of fishes commercially in tanks or enclosed water bodies usually for food or commercial sale. It is the principal form of aquaculture (9) and with increasing interest in the development of fish culture, the search for suitable species of fish for culture becomes important. In recent years fish production in Nigeria has not been consistent hence, there is need to tackle the problems of over exploitation, inefficiency of fisheries management policy and obnoxious fishing methods as these challenges affects fisheries development in Nigeria.

Genetic techniques are needed to ensure the production of fish breed with faster growth rate, high feed conversion, shorter production cycle as well as a greater tolerance for poor water conditions. Since one single specie may not have all these attributes, it then becomes necessary to cross amongst different species. Hybridization studies in fish are very scanty and very few reports are available. However, there are reports on artificial hybridization between catfishes viz; *Clarias gariepinus*×*Hetrobranchus longifilis* and *Clarias gariepinus* × *Heterobranchus bidorsalis* (10). Generally, hybridization entails formation of new organism either naturally or by human intervention by combining the genes of two different parental species or subspecies. Fish hybridization occurs when two different species, genera or families are crossed, backcrossed or outcrossed to give hybrids of desired qualities. It is one of the genetic techniques which helps to remove undesirable characteristics from cultured species while retaining only the desirable ones and it is a major and important prospect of fish culture (11, 12 and 13).

Clarias gariepinus (14) and *Heterobranchus bidorsalis* (15) species of fish are genus of the African catfish belonging to the family *Clariidae*. Due to their fast growth rate, high feed conversion ratio and utilization, high resistance to stress and disease, desirability as food, acceptability of artificial diets and feeds over a wide range of diets, they are widespread and have been identified in the African aquatic ecology (16). Growth, the irreversible increase in size (length, volume, mass and body composition) of an organism over time is influenced by many factors such as temperature, turbidity, dissolved oxygen, photoperiodism and stocking density (13, 17 and 18). 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 (19). 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 (20).

They are highly priced globally and in Nigeria due to their tremendous contribution towards ameliorating food insecurity coupled with their high biological values in terms of protein retention, assimilation and low cholesterol content. Their high quality and better taste of flesh makes them highly demanded, hence there is a need to increase the local production of both species (5).

The study of both species of the African catfish, *Clarias gariepinus* and *Heterobranchus bidorsalis* is to assess both species and formulate an important tool in differentiating and comparing these closely related species of organisms having huge similarities. Thus, this study is focused mainly on establishing relationships and differences between pure *Clarias gariepinus* and *Clarias gariepinus* x *Heterobranchus bidorsalis* hybrid of the African catfishes using various measurements and computed indices of some growth parameters. The objectives of this study therefore are to examine potentials across purelines and hybrid juveniles of the African catfish (*Clarias gariepinus*) with a view to evaluate the growth parameters of the two lines and compare their performances.

Materials and Methods

Study site: The experiment was conducted at the hatchery of the Department of Fisheries, Lagos State University, Ojo between November 2018 and March 2019. It is located 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.

Figure 1: The African Catfishes studied *Heterbranchus bidorsalis* and *Clarias gariepinus* (Source Wikipedia)

Experimental Units: Pure lines of male and female brood stocks of both *Clarias gariepinus* (14), and *Heterobranchus bidorsalis* (15) are obtained from two different reputable commercial fish farms in Badagry and Ikorodu axis of Lagos to minimize chances of relatedness and inbreeding and transferred to the earthen pond at the hatchery to acclimatize them for one week before breeding.

Anatomically, both species have little or no difference (Figure 1) except in the maturation age and growth rate, they both belong to the same family *Clariidae*. (Table 1). They both possess well developed sensory organs and a hearing apparatus called the swim bladder serving as their inner ear. They are hardy and as such survive a wide range of extreme aquatic conditions and their possession of accessory breathing lungs complement their gills which enables them live several hours outside water bodies.

Table 1: Taxonomical Classification of Clarias *Gariepinus* and *Heterobranchus Bidorsalis**

Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Super class	Osteichthyes	Osteichthyes
Class	Actinopterygii	Actinopterygii
Order	Siluriformes	Siluriformes
Family	Clariidae	Clariidae
Genus	Heterobranchus	Clarias
Species	*Heterobranchus bidorsalis*	*Clarias gariepinus*

* = (Burchell, 1822) and (Geoffroy Saint-Hilaire, 1809)

Table 2: Mean ± Standard Error of Variables at different stages of Measurement

	Initial Measurements		Second Measurements		Final Measurements	
Variable	**N**	**Mean ± SE**	**N**	**Mean ± SE**	**N**	**Mean ± SE**
Body Weight (g)						
Hybrid	123	^{a} 4.15±.21	123	^{a} 10.61±.50	116	^{a} 13.49±.67
Pure breed	117	^{a} 4.04±.16	117	^{b} 6.39±.25	108	^{b} 9.74±.33
Combined	240	4.09±.13	240	8.55±.31	224	11.68±.40
Total Length (cm)						
Hybrid	123	^{a}10.08±.18	123	^{a} 10.88±.18	116	^{a} 12.02±.21
Pure breed	117	^{b}8.04±.12	117	^{b} 9.05±.13	108	^{b} 10.43±.15
Combined	240	9.08±.13	240	9.99±.13	224	11.25±.14
Standard Length (cm)						
Hybrid	123	^{a} 8.82±.16	123	^{a} 9.44±.16	116	^{a} 10.36±.18
Pure breed	117	^{b} 7.22±.11	117	^{b} 7.99±.11	108	^{b} 9.19±.13
Combined	240	8.04±.11	240	8.73±.11	224	9.80±.12

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

Behaviourally, both are very active at night and often referred to as nocturnal animals, and are omnivorous and bottom feeders exhibiting predatory behaviors and cannibalism. In captivity, reproduction isn't natural hence artificial propagation is often adopted for their reproduction (21).

Experimental design

Brood stocks (two males ♂ and two females ♀) used in the production of new hatchlings for the experiment were obtained based on their external morphological characteristics: gravid and distended abdomen in females and reddish colour on genital papillae tip in males.

Fingerlings Production

Prior to breeding, the circular tanks in the hatchery were thoroughly washed, disinfected and prepared for the process of fertilization and hatching of fries. Breeding process commenced by artificially inseminating the female *Clarias gariepinus* and *Heterobranchus birdosalis* by injecting intraperitoneally with a single dose of hormone (Ovaprim) at 22:00 hours. Both female fishes were hand stripped for eggs after a latency period of eight hours, then the eggs were collected in a bowl. Milt extraction was done by dissecting the testes after sacrificing males of both breeds. Few eggs from the female specie of *Clarias* brood stock was mixed with the milt of the male *Heterobranchus* and vice versa to get fertilized eggs of hybrids *Heteroclarias* and *Clariabranchus*. Subsequently the remaining eggs from the female *Clarias* specie and *Heterobranchus* were mixed with milt from their respective males to get pure lines of both *Clarias gariepinus* and *Heterobranchus bidorsalis* respectively.

The resultant eggs and milt were mixed to produce four lines, which were gently stirred with a plastic spoon, rinsed with distilled water and introduced into circular tanks with continuous water flow- through system for incubation.

Eggs were carefully laid on a mesh inside the circular tanks to monitor hatching processes 22-24 hours later, eggs of pure lines of *Clarias gariepinus* and *Heteroclarias* hatched forming larvae while eggs of the second hybrid line (*Clariabranchus*) and that of the pure *Heterobranchus birdosalis* line got infected and died off.

Larvae of both hatched breeds were allowed to absorb their yolks for three days while still incubating in the circular tanks. Larvae developed into frys and were fed with Artemia twice daily for the first three weeks and subsequent feeding is as earlier described (22).

Measurements and Data Collection

Fingerlings of both breeds were grouped according to their body weights into two tanks for each line based on their body weight to minimize cannibalism during the rearing period over a period of 4 months within the hatchery.

Measurements including weight (g), total length (cm) measured from the maxilla to the end of the caudal fin, and standard length (cm) measured from the maxilla to the end of the caudal peduncle were taken weekly for both lines. 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 weekly intervals spanning a period of 21 days. Fish weights were taken using a professional digital scale sensitive to 0.00 grams. Data collected included body weight and linear body measurements using a ruler and digital Vernier caliper.

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) are computed by different methods (23, 24, 25 and 26) as follows:

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

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

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

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

Where W_f is final weight (g), W_i is initial weight (g), t is time (days), and Ln is natural logarithm.

Indices such as length weight relationship and Fulton's condition factors were estimated using the appropriate formula (27 and 28) as earlier described (22) as follows:

$$W = aL^b$$

which is transformed as $Log\ W = Log\ a + b\ Log\ L$. And the Fulton's Condition Factor is given as;

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

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.

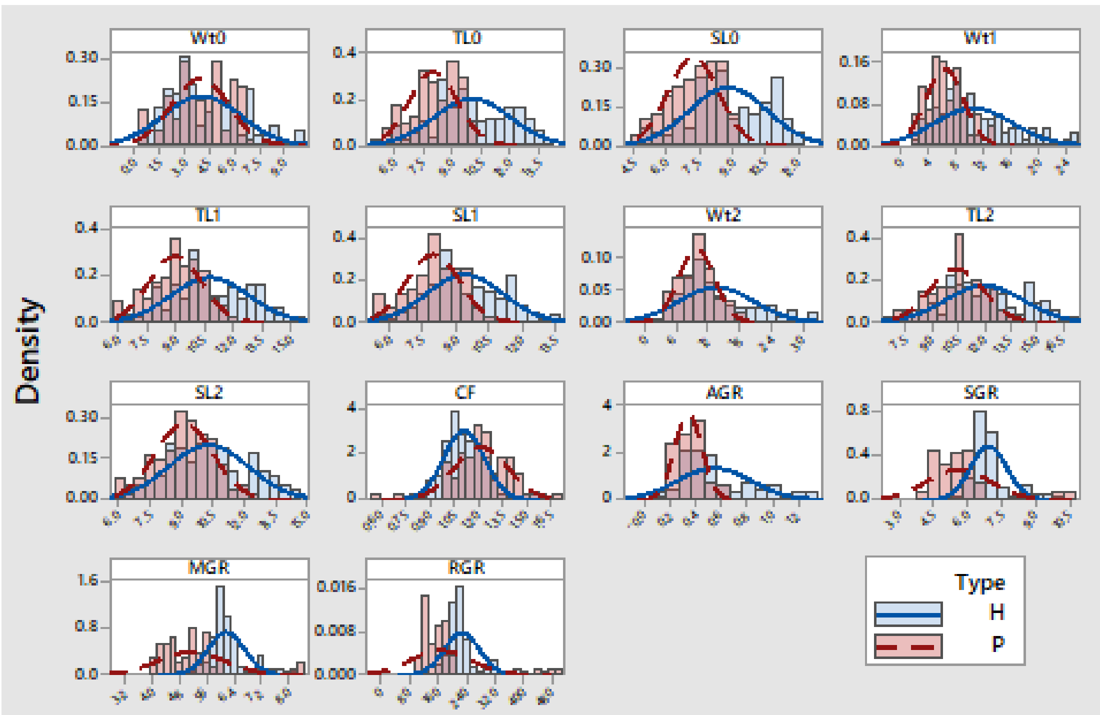

Figure 2: Histogram and normal curves of all variables studied

Data Preparation and Statistical Analyses

Exploratory statistical analysis was conducted to investigate the spread of the measured variables and computed indices, and test for normality of the data (Figure 2). There was an initial total of 281 fingerlings comprising 150 pure *Clarias* and 131 hybrids. However, some mortalities were recorded as the study progresses and only 261 fishes survived when measurements commenced.

Preliminary exploratory analyses were done to check data validity, assess for outlier values and test for normality. After the test of normality, all outliers numbering 21 across both lines were excluded from the data to be analyzed and removed from further analysis (Figure 3). In the final analysis, after studying the fish growth for twenty-one days, a total of 224 fish were studied comprising 108 pure *Clarias* and 116 hybrids.

The General Linear Models of ANOVA was used to test for differences between pure Clarias and hybrid for the three measurements studied (weight, total length and standard length) and the computed indices (length-weight relationship, condition factor, absolute, specific, relative and mean growth rates). The statistical model used in the final analyses is given as;

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk}$$

Where Y_{ijk} is the observed value of parameter on a particular fish;

μ is the overall mean

α_i is the ith effect of specie (i = pure, hybrid)

β_j is the jth effect of tank (j = large, small)

$(\alpha\beta)_{ij}$ is the interaction effect of specie x tank; and

ϵ_{ijk} is residual random error

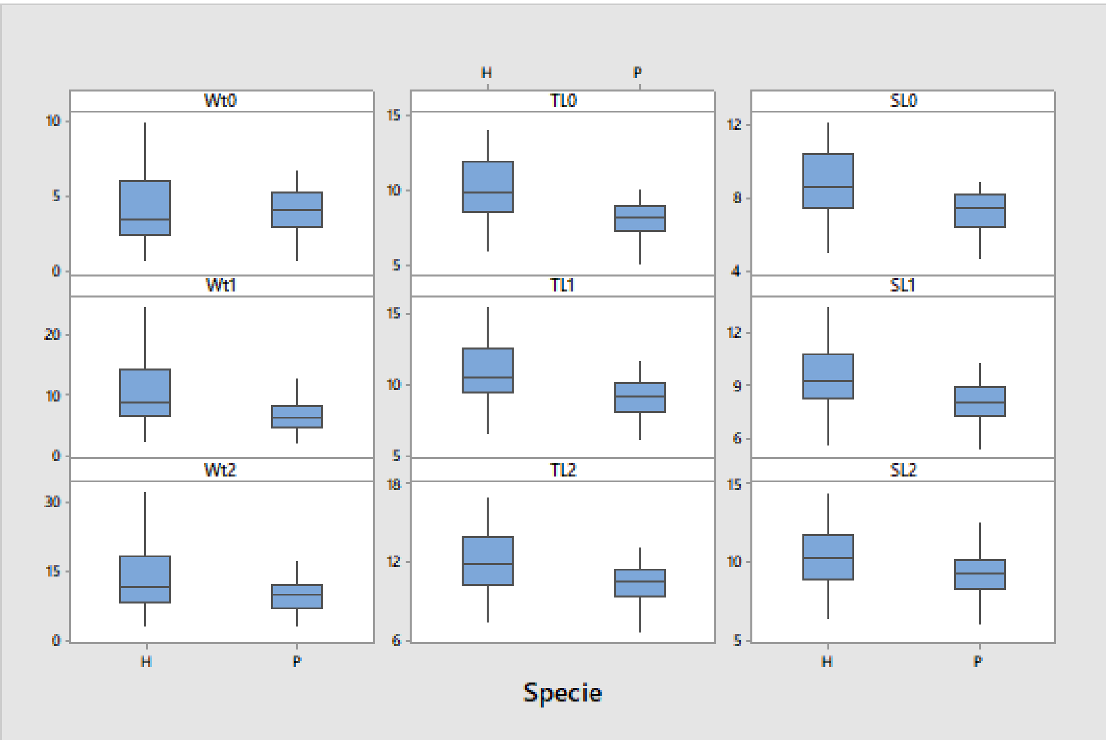

Figure 3: Boxplots of all variables studied

Results and Discussion

Initial Measurements

At the commencement of the experiment, there were 281 fishes comprising 150 Pure Clarias and 131 Hybrids. The exploratory box plot revealed that some of the fishes had outlier weights within each fish species and those outliers were excluded from the data. In all a total of 41 fishes were excluded comprising 27 pure *Clarias* and 14 hybrids, leaving 240 records with 123 pure breed and 117 hybrids for analyses.

Body weight (g): The mean for the pre-experimental body weight across both fish species was 4.09±.13g while body weight was 4.04±.16g for pure breed and 4.15±.21g for the hybrid (Table 2). A one-way analysis of variance for the effect of specie on initial body weight was not significant (P>0.05) at the commencement of the experiment. The hybrid in the study had the higher mean body weight, but it was not large enough to be statistically significant (P>0.05). Tank exerted the largest influence followed by specie (Table 4), and this contrasts earlier findings (12, 29 and 30) who all reported otherwise.

Total Length (cm): Mean for the pre-experimental total length across both fish species was 9.08±.13 while total length was 8.04±.12 for pure breed and 10.08±.18 for hybrid (Table 2). All factors studied exerted significant (P<0.05) influence on total length (Table 4). This result aligns with (12) but contradicted the findings of (29), who reported no significant difference in total length due to differences in species.

Standard Length (cm): Pre-experimental standard length mean across both fish species was 8.04±.11 while standard length of pure breed was 7.22±.11 and 8.82±.16 for hybrid (Table 2). There was significant (P<0.05) effects of all variables studied on standard length (Table 4) which corroborated the earlier report (31), but however contradicted the findings of (29) who reported that specie was not a source of significance on standard length in their work.

Second Measurements

Further measurements were taken on the fish at the 14th day of experimentation where the following parameters were taken:

Body Weight (g): Overall average body weight of both fish species was 8.55±.31 while body weight of pure breed was 6.39±.25 and that of hybrid was 10.61±.50 (Table 2). The hybrid at this stage was about 66 percent heavier (Table 4) than the pure breed and this difference was highly significant (P<0.05) at this stage, which corroborates the findings of (29).

Total Length (cm): The combined average of total length across the two species was 9.99±.13 while total length was 9.05±.13 and 10.88±.18 respectively for the pure breed and hybrid (Table 2). The hybrid had significantly (P<0.05) higher values than the pure breed (Table 4) which was about 20 percent longer. This observation is in line with reports of (29) and can be adduced to the longer caudal fin length of the hybrid.

Standard Length (cm): Although standard length of pure breed was 7.99±.11 and 9.44±.16 for hybrid (Table 2), which translates to the hybrid been 18.15 percent longer than pure breed. This difference is not as pronounced as recorded in total length above, albeit statistically (P<0.05) significant (Table 4). This observation however, contradicted the findings of (29).

Final Measurements

At the end of experimentation at 21st day, measurements were taken on each fish and recorded accordingly, mean values are as given below;

Body weight (g): The overall mean of body weight across both species was 11.68±.40 while hybrid was 38.5 percent heavier than pure Clarias (Table 2). The difference in body weight due to specie was a significant (P<0.05) source of variation, along with tank and interaction of both factors (Table 4) and this agrees with findings of (12 and 29).

Total Length (cm): The significant (P<0.05) difference due to specie and other factors (Table 4) observed in this study contrasts the findings of (12 and 29), who reported otherwise, but confirms the work of (31). It was observed that hybrid were 15.24 percent heavier than pure Clarias (Table 2).

Standard Length (cm): The overall mean standard length at the end of experiment was 9.840±.12, with the hybrid been 12.73 percent longer than pure Clarias (Table 2). Specie, along with tank and their interactions exerted statistically significant ($P<0.05$) influence on standard length (Table 4). This observation is in agreement with (31) but contradicted other findings (12 and 29).

Computed Indices: The effect of factors studied was investigated on the computed indices to assess how the model best explains the differences in observed values.

Condition Factor (K): The overall mean for Fulton's condition factor across both fish species was 1.16±.01, and pure Clarias was almost 10 percent superior in wellness of the fish compared to the hybrids (Table 3). This superiority of Clarias over hybrid in condition factor can be adduced to the shorter length of Clarias compared to the hybrid. Condition factor was significantly influenced by specie and other factors studied (Table 5) and this is in consonance with earlier reports (12, 30 and 32).

Absolute Growth Rate (g/day): The overall mean absolute growth rate across species was 0.44±.02 with the hybrid been 58.8 percent superior to pure Clarias (Table 3). All factors studied exerted significant ($P<0.05$) influence on this parameter (Table 5) and it indicated that the hybrid are better feed converter, and gain faster than the pure Clarias, an observation that corroborated earlier reports (12, 33 and 34) while they worked on growth performance of *Clarias gariepinus* and its hybrids in earthen ponds.

Specific Growth rate (%): Hybrid was 23.5 percent better in this parameter when compared to pure Clarias, while the overall mean across species was 6.31±.09 (Table 3). Specific Growth Rate was significantly ($P< 0.05$) influenced by all factors studied (Table 5) which further confirms earlier works (12 and 13), but contradicted other report (17).

Mean Growth Rate (%): The overall mean growth rate across species was 5.71±.06 and the hybrids had 20.3 percent higher values than pure Clarias (Table 3). Tank, specie and interaction of both factors all exerted significant ($P<0.05$) impact on this parameter (Table 5). This observation supported earlier work on growth performance of *Clarias gariepinus* and its hybrids in earthen ponds (12, 32, 33 and 34).

Relative Growth Rate (%): With the exception of the interaction of tank and specie which was not significant ($P>0.05$) on this parameter, the other two factors exerted significant ($P<0.05$) influence on relative growth rate (Table 5). Overall mean values across species was 199.99±5.02 while the hybrid had 35.3 percent higher values than Clarias (Table 3). This observation aligns with earlier reports (30 and 34).

Length-Weight Relationship: Although this parameter indicated negative allometry in both species (Table 6), it indicated that the model better predicted the hybrid than the pure Clarias and also had better coefficient. The regression coefficient was highly significant ($P<0.01$) in both species but the result revealed that weight of hybrid is better predicted by its length compared to pure clarias. This result is in line with earlier report (35) in their study on the growth patterns of dominant pure breeds and hybrids of the African catfish.

Table 3: Mean ± Standard Error of Computed Indices at end of experiment

Variable	N	Mean ± SE
Condition Factor (K)		
Hybrid	116	[b] 1.12±.01
Pure breed	108	[a] 1.23±.02
Combined	224	1.16±.01
Absolute Growth Rate (g/day)		
Hybrid	116	[a] 0.54±.03
Pure breed	108	[b] 0.34±.01
Combined	224	0.44±.02
Specific Growth Rate (%)		
Hybrid	116	[a] 6.94±.07
Pure breed	108	[b] 5.62±.14
Combined	224	6.31±.09
Mean Growth Rate (%)		
Hybrid	116	[a] 6.22±.05
Pure breed	108	[b] 5.17±.10
Combined	224	5.71±.06
Relative Growth Rate (%)		
Hybrid	116	[a] 228.77±4.61
Pure breed	108	[b] 169.07±8.18
Combined	224	199.99±5.02

Means with different superscript are significantly different (P<0.05)

Table 4: Analysis of Variance for Measured Variables

Source	Df	MS (WT0)	MS (TL0)	MS (SL0)	MS (WT1)	MS (TL1)	MS (SL1)	MS (WT2)	MS (TL2)	MS (SL2)
Tank	1	579.07[3]	393.07[3]	305.95[3]	2235.91[3]	428.07[3]	304.49[3]	2909.07[3]	461.31[3]	361.06[3]
Type	1	9.92[1]	145.65[3]	82.56[3]	547.01[3]	105.99[3]	64.68[3]	199.58[3]	45.13[3]	18.11[3]
Tank x Type	1	5.10[0]	17.37[3]	16.96[3]	210.23[3]	16.47[3]	8.18[2]	308.1[3]	18.17[3]	12.11[2]
Error	236	1.72	1.04	0.90	9.12	1.20	0.93	18.30	1.62	1.21
R^2 (%)		58.99	72.92	69.07	61.97	69.49	66.68	48.63	63.50	62.16

[0]= P>.05 [1] = P<.05 [2] = P<.01 [3] = P<.001

Table 5: Analysis of Variance for Computed Indices

Source	Df	MS (CF)	MS (AGR)	MS (SGR)	MS (MGR)	MS (RGR)
Tank	1	1.02[3]	3.29[3]	103.84[3]	56.34[3]	305228[3]
Type	1	0.39[3]	1.00[3]	128.35[3]	77.89[3]	285942[3]
Tank x Type	1	0.12[2]	0.83[3]	5.67[2]	4.63[3]	5834[0]
Error	236	0.02	0.03	0.78	0.35	3386
R^2 (%)		32.17	48.59	54.73	61.52	40.74

[0]= P>0.05 [1] = P<0.05 [2] = P<0.01 [3] = P<0.001

Table 6: Coefficients for Length – Weight Relationship (LWR)

Type	Intercept (a)	Slope (b)	Eta Squared (r^2)
Clarias	-1.36	^{3}2.42	0.91
Hybrid	-1.77	^{3}2.82	0.96
Combined	-1.56	^{3}2.62	0.94

^{3} = P<0.001

Table 7: Correlations amongst Computed Indices

	CF	AGR	SGR	MGR
AGR	-0.248***			
SGR	0.080^{ns}	-0.017^{ns}		
MGR	0.073^{ns}	0.019^{ns}	0.996***	
RGR	0.095^{ns}	-0.086^{ns}	0.983***	0.962***

^{ns} = P>0.05 *** = P<0.001

Correlations amongst computed indices: The strongest direct relationship was between specific growth rate and mean growth rate on one hand and specific growth rate and relative growth rate on the other hand (Table 7). There was also a strong positive correlation between mean growth rate and relative growth rate, while the least significant correlation was between absolute growth rate and condition factor. The values obtained in this study is at variance with another research earlier reported (13).

Conclusions and Applications

Based on the results of this study the following conclusions can be drawn concerning the effect of species on both the measured and computed variables in this study.

i. With the exception of Standard Length at the final measurement, all factors studied (specie, tank and their interactions) were significant (P<0.05) on all measurements and indices albeit at varying probabilities.
ii. Differences due to species highly significantly (P<0.01) impacted all measured variables and computed indices indicating the superiority of the hybrids over the pure breed in almost all growth parameters except for condition factor where the pure Clarias had higher values.
iii. Length weight relationship in both breeds though negative (b<3) but were close to the cube law, with the hybrid having coefficient higher than the pure Clarias.
iv. Hybrid has potentials as better feed converters, more efficient in feed utilization, and are thus recommended for better yield and higher profit.
v. The study provides a veritable platform for further research on the potentials of interspecific hybridization within the African catfishes.

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