



Growth Performances of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their Hybrid (*Heteroclarias*) in Earthen Ponds in Badagry, Southwest, Nigeria

Owodeinde F.G., *Ndimele, P.E., Fakoya, K.A., Adewolu, M.A. and Anetekhai, M.A.
Department of Fisheries, Faculty of Science, Lagos State University, Ojo, P.M.B. 001, Lagos. Nigeria.

Received: April 16, 2016

Accepted: February 17, 2017

ABSTRACT

The mass propagation of good quality fish, seeds remains a major constraint to aquaculture in Nigeria. This study compared growth performances of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrid, *Heteroclarias* ♀ *Clarias gariepinus* x ♂ *Heterobranchus bidorsalis* for commercial culture in earthen ponds in South West Nigeria. Three (3) earthen ponds (each 0.02 ha) were stocked with 330 hatchery-produced fingerlings of *C. gariepinus*, *H. bidorsalis* and their hybrid (*Heteroclarias*). Mean weights at stocking of *C. gariepinus* was 7.5±1.5g, *H. bidorsalis* was 8.5±1.5g and *Heteroclarias* was 7.5±1.5g. The fish were reared on 45% crude protein for 6 months. The result shows that the survival rates for *Heteroclarias* was 97.3±8.10% and final mean weight was 880±78.72 g, *H. bidorsalis* was 75.5±6.40% and final mean weight was 850±73.06 g, while survival rate was 81.1±7.80% and final mean weight was 460±35.53 g for *C. gariepinus*. The final standard length of *H. bidorsalis*, *C. gariepinus* and *Heteroclarias* were: 465.56±67.89 mm, 365.36±43.22 mm and 435.12±56.70 mm, respectively. Standing crop at harvest was 70.55±7.80 kg/0.02ha for *H. bidorsalis*, 94.16±8.60 kg/0.02ha for *Heteroclarias* while it was 45.08±5.40 kg/0.02ha for *C. gariepinus*. Condition factor (K) was 1.40 in *H. bidorsalis*, 1.53 in *Heteroclarias* and 1.23 in *C. gariepinus*. Only *H. bidorsalis* had positive allometry, but all 3 species had a high correlation coefficient ($r > 0.94$). The result demonstrated that all the Clariid species had great potential for use in aquaculture. Therefore, there is a need for selective harvesting as a practice for consolidation of smaller fish into fewer ponds for additional growth.

Key words: Growth performance, *C. gariepinus*, *H. bidorsalis*, *Heteroclarias*, earthen ponds

INTRODUCTION

Clariid industry is the largest aquaculture industry in Nigeria and the fastest-growing segment of Nigeria agriculture with farm production of over 60 million tonnes per annum (FDF, 2015). This growth is as a result of changes in strategies, technological advances, market pressures, pond husbandry, and the ability to withstand harsh environment (Owodeinde and Ndimele, 2011). Recent technologies have increased clariid catfish productivity in Nigeria and in fact, in the sub-Saharan Africa, but these productivity gains are declining as a result of inflation resulting in significant changes in the cost of raising farmed catfish. Several studies have been conducted in Nigeria on intergeneric hybridization between African Clariids. For instance, Aluko and Ali (2001) produced eight fast growing intergeneric hybrid fingerlings from four Clariid species at the National Institute for freshwater Fisheries research, Nigeria. Akinwande *et al.* (2009) reported growth and survival of interspecific and intergeneric hybrids of *Clarias gariepinus*, *Heterobranchus longifilis* and *H. bidorsalis* reared for four weeks. Madu *et al.* (1991) documented growth and survival of intergeneric hybridization between *C. gariepinus* and *H. bidorsalis* and their hybrid raised in indoor tank, while Diyaware and Onyila (2014) reported the growth and survival of intergeneric hybrids of *C. anguilaris* and *H. bidorsalis* in semi-arid zone of Nigeria. Several investigators have demonstrated that hybrid of ♀ *C. gariepinus* x ♂ *H. bidorsalis* and their putative parental species can be grown in commercial size in various types of culture systems (Madu *et al.*, 1991, Madu and Aluko, 1999, and Aluko and Ali, 2001). However, information on growth performance of *C. gariepinus*, *H. bidorsalis* and their hybrid in earthen pond in Lagos State, Nigeria has not been reported. This study, therefore, aims

*Corresponding Author email: emeka.ndimele@lasu.edu.ng; drpendimele@yahoo.com; 08094277377

to investigate the growth performances of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrid with the view to evaluating the potentials of each species for culturing to commercial size in earthen ponds.

MATERIALS AND METHODS

Study area

The study was carried out in the earthen ponds within the Omague Fish Farm, Ijotun in the Badagry Local Government Area of Lagos State, Nigeria.

Experimental procedure

Three rectangular earthen ponds of 20m in length x 10m in width (0.02 hectare) each, were stocked randomly with 330 fingerlings of *Clarias gariepinus* (mean weight 7.5±1.5 g), *Heterobranchus bidorsalis* (mean weight 8.5±1.5 g) and their hybrid ♀*Clarias gariepinus* x ♂*Heterobranchus bidorsalis* (mean weight 7.5±1.5g) for 6 months. Two weeks before stocking, the ponds were filled with water from the farm bore-hole, fertilized with complete inorganic fertilizer (NPK - 15-15-15) at the rate of 112 Kg ha⁻¹, and poultry manure at the rate of 200 Kg ha⁻¹, then seeded with plankton collected from a culture farm pond by pumping pond water through plankton net. The fish were fed at 3% of their body weight twice daily as recommended by Stickney (1979) with compounded artificial feed containing 45% crude protein, prepared by using the following ingredients: fish meal (15.8%), soybean meal (59.4%), yellow maize (18.2%), blood meal (5.1%) vegetable oil (1.0%), and vitamin premix (0.5%).

At two weeks interval, the fish were sampled with a 2.0 cm mesh size bag seine net of 25 m long to monitor growth. The fish were not fed 24 h before the samples were collected to allow the intestinal contents to be digested. To avoid sampling error, at least 30% of the stocked fish species were randomly selected for biweekly weight and length measurements. To avoid stress due to handling, the randomly selected fish were subjected to mild anaesthetisation in a 20 mg/l solution of MS-222 (Tricaine methane sulfonate, Sigma Chemical, St. Louis, Missouri, USA). They were measured for the standard length (SL), total length (TL) (to the nearest 0.1 mm); and wet weight (to the nearest 0.1 g) using graduated long ruler and top loading sensitive scale (Model 1500). After all measurements, the fish species were revived in fresh water and then returned to the ponds. After 6 months, the ponds were drained; all the fish were removed, counted and weighed to determine the survival rate and standing crops. They were held in three 6m³ concrete tanks.

Determination of water quality parameters

Water quality parameters measured during the study are temperature, dissolved oxygen, dissolved carbon dioxide, pH and total ammonia-nitrogen, which were determined by the standard method described by Boyd (1981).

Analysis of growth

The linear regression relationship between body weights and the number of weeks of growth of *C. gariepinus*, *H. bidorsalis* and their hybrids were calculated using this formula: $Y = B_0 + B_1 X_1$ or $Y = a + b X_1$ (Uzoagulu, 1998), Where Y is the mean weight of the fish [g]; B₀ and B₁ are constants; B₀ is the intercept on Y - axis; B₁ is the slope of the line or gradient and X₁ is the number of weeks of growth. With this equation, one can determine the size / weight of the study fish at any point in time. Mean specific (instantaneous) growth rates (SGR) estimated as the percentage increase in weight per growth period of *C. gariepinus*, *H. bidorsalis* and their hybrids were calculated at the end of each growth period using the formula:

$$SGR = \frac{\log_e (W_t) - \log_e (W_0)}{t} \times 100$$

Where SGR is specific growth rate, W_t is the weight (g) at the end of the interval (end of the period), W₀ is the weight (g) at the beginning of the period, and t is time (i.e. the duration between initial and final

sampling) in days. The calculation of SGR, which accounts for both initial and final sizes, is useful in comparing the growth of the fish species at different sizes (Brown, 1957). This formula estimated the percentage increase in weight per growth period. Absolute growth rate (AG), expressed as weight gained per growth period was calculated using Woods *et al.* (1983) formula:

$$AG = \frac{W_t - W_o}{t}$$

where W_t is the mean final weight (g), W_o is the mean initial weight (g) and t is the interval between measurement

Length-weight relationship

The relationships between the body weights and body lengths of the study fish in each experimental pond were computed from the equation of Lagler (1956) and Bagenal (1978): $W = a L^b$ -----1, where W = weight of the fish (g), L = length (mm), a is y-intercept or the initial growth coefficient, and b , is the sloped or growth coefficient. Equation 1 was linearized by logarithmic transformation to enable the estimation of the values of the constants a and b using least square regression (Zar, 1996). After linearization, the equation became: $\log W = \log a + b \log L$ -----2.

The growth coefficient (b) was tested for significant difference from the isometric value (3) by t-test using the equation describe by Sokal and Rohlf (1995), $t_s = (b-3) / SE$, where t_s is the t-test value, b the slope or growth coefficient and SE the standard error of the slope (b).

Condition factors (K) to determine the relative robustness (i.e. The state of wellbeing of the fish) was estimated for each growth period, according to the equation by Lagler (1956):

$$K = \frac{W \times 10^5}{(L)^3}$$

where W is the fresh weight in (g) and L the standard length (mm).

The experimental fish species were fed 3% of their body weight throughout the study period. The amount of feed dispensed (kg) to the fish stocked in the three experimental ponds were adjusted bi-weekly by sub-sampling the population of the fish species in order to reflect the fortnight change in biomass using the equation by Stickney (1979): $W_1 = W_o + (W_o \times F / C)$, Where W_1 is the final weight of the fish, W_o is the weight of the fish at day zero, F is the percentage feeding rate and C is the food conversion ratio (FCR).

Percentage weight gain = $(W_t - W_o) / t \times 100\%$

Survival (%) = $\frac{\text{Number of fish that survived}}{\text{Number of fish stocked}} \times 100\%$

Standing crop at harvest = Weight of the fish harvested/area of pond (ha)

Statistical analysis

The obtained data were subjected to one-way Analysis of Variance (ANOVA) and the differences between means were determined at 5% probability level ($p < 0.05$) using Fisher's least significant difference (LSD).

RESULTS AND DISCUSSION

Water quality parameters during the indoor and outdoor (experimental ponds) are presented in Table 1. Mean values for total ammonia-nitrogen indoors and outdoors were 0.025 ± 0.004 and 0.038 ± 0.003 , respectively. The pH was 7.3 to 8.7. Temperature $25^\circ\text{C} - 27^\circ\text{C}$, dissolved carbon dioxide 6.0 – 9.3 mg/L and dissolved oxygen concentrations, 5.5 – 9.3 mg/L. All the water quality parameters fall within the range reported by Huet (1979) and Boyd and Lichtkoppler (1979) as good for fish pond culture.

Table 1: Water quality parameters in the hatchery complex and experimental Ponds

Parameters	Indoor (Hatchery complex)		Outdoor (Experimental Ponds)	
	Range	Mean	Range	Mean
Temperature [°C]	25 – 27	26.0±0.28	25 – 27	25.76±0.35
pH	6.8 – 7.9	7.3±0.17	7.3 – 8.7	7.78±0.15
DO [Mg/l]	6.5 – 7.6	7.0±0.17	5.5 – 9.3	7.51±0.55
DCO ₂ [Mg/l]	6.0 – 9.0	7.16±0.48	6.0 – 9.3	7.61±1.54
NH ₃ -N [Mg/l]	0.01- 0.04	0.025±0.004	0.02-0.06	0.038±0.003

The growth performance of *C. gariepinus*, *H. bidorsalis* and their hybrids in earthen ponds in Lagos is shown in table 2. Higher (880±78.72g) final weigh was recorded in the hybrids (♂Hb x ♀Cg), followed by the pure line (850 ± 73.06g) ♀Hb x ♂Hb, while ♀Cg x ♂Cg gave the lowest (460±35.53g) final weight. There was no significant variation ($p>0.05$) between the final weight values of ♀Hb x ♂Cg compare to those of ♀Hb x ♂Hb. However, the final weigh values of the pure line ♀Cg x ♂Cg differs significantly ($p<0.05$) from that of ♀Hb x ♂Cg and ♀Hb x ♂Hb. The final weight observed in this study is similar to 880g⁻¹ reported by Legendre *et al.* (1992) for ♀Cg x ♂Hb reared for 8 months and 908 g⁻¹ for *H. longifilis* x *C. gariepinus* by Legendre *et al.* (1992). Diyaware and Onyia (2014) reported lower (508g⁻¹) for reciprocal hybrid of ♀*H. bidorsalis* x ♂*C. anguillaris* reared in polyethylene lined fish pond under arid conditions, in the Northeast Nigeria. Aluko and Ali (2001) also reported higher final weight for *Heteroclarias* reared for 12 months. The variation in the final weights could be due to differences in the environment and the species used for hybridization. Environmental conditions have great influence on both feed intake which is related to growth performance.

Weight gain and percentage weight gain were significantly ($p<0.05$) higher (4.26±0.91 g/day and 1856±18g, respectively) in the hybrids compared to their putative parents who has 4.08±0.74 g/day and 1600±15 in the *H. bidorsalis* and 2.16±0.48 g/day and 1050±12g in *C. gariepinus*, respectively. As a consequence, growth rates of mature *C. gariepinus* were much slower than *H. bidorsalis* and the hybrid. This result agrees with previous findings by Hoar and Randal (1969) and Legendre *et al* (1992) on the growth of gonadal tissues at the expense of the somatic tissues. Absolute growth rate (expressed as weight gained per growth period) followed the same pattern shown in the specific growth rates. It was higher in hybrid, *Heteroclarias* (4.26±0.91 g/day) than in the putative parental species (4.08±0.74 g/day in the *H. bidorsalis* and 2.16±0.48 g/day in *C. gariepinus*). Similar growth pattern was reported by Diyaware and Onyila (2014).

Table 2: Mean (±SEM) Growth performance of *C. gariepinus*, *H. bidorsalis* and their hybrids in Earthen Ponds

Growth parameters	♀Cg x ♂Cg	♀Hb x ♂Hb	♂Hb x ♀Cg
Initial weight (g)	7.5±1.5 ^a	8.5±1.5 ^a	7.5±1.5 ^a
Final weight (g)	460±35.53 ^a	850 ± 73.06 ^b	880±78.72 ^b
Initial SL (mm)	132.45±12.21 ^a	150.24±14.67 ^a	137.67±23.12 ^a
Final Standard length (mm)	365.36±43.22 ^a	465.56±67.89 ^b	435.12±56.70 ^b
Weight gain (g/day)	2.16±0.48 ^a	4.08±0.74 ^b	4.26±0.91 ^b
Percentage weight gain (%)	1050±12 ^a	1600±15 ^b	1856±18 ^b
Specific growth rate (%/day)	1.25±0.09 ^a	1.39±0.08 ^a	1.52±0.07 ^b
FCR	4.28	3.22	3.0
K	1.23	1.40	1.53
Survival (%)	81.1±7.80 ^a	75.5±6.40 ^a	97.3±8.10 ^b
Relative Robustness	1.15±0.23 ^a	1.24±0.21 ^a	1.85±0.24 ^b
Standing crop at harvest Kg/0.02ha pond	45.08±5.4 ^a	70.55±7.8 ^b	94.16±8.6 ^c

Means in the same having similar superscripts are not significantly different ($p>0.05$).

The findings showed that their absolute growth rates in the hybrid (*Heteroclarias*) and *H. bidorsalis* were significantly ($p<0.05$) higher than the value obtained in *C. gariepinus*. However, there was no significant difference ($p>0.05$) in absolute growth rates between the hybrid and *H. bidorsalis*. The lower absolute growth rate observed in the *C. gariepinus* might be due to the early development of gonads at age 6 months. Large amounts of energy were diverted from growth of somatic tissues to growth in gonadal tissues.

The best (1.52 ± 0.07 %/day) specific growth rate was achieved in the hybrid (σ Hb x ϕ Cg), followed closely by *H. bidorsalis*, (1.39 ± 0.08 %/day), while the least was observed in pure line *C. gariepinus*, with 1.25 ± 0.09 %/day. There were significant differences ($p<0.05$) between the SGR values compared to those of the putative parent. However, no significant difference ($p>0.05$) was observed between the SGR of pure breeds of *C. gariepinus* (ϕ Cg x σ Cg) and pure breed of *H. bidorsalis* (ϕ Hb x σ Hb).

Feed utilization of the studied fish was expressed as food conversion ratio (FCR), which gave the weight of food required to produce a unit weight gain. The overall food conversion ratio was 3.0 for the Hybrid (*Heteroclarias*), 3.22 for *H. bidorsalis* and 4.28 for *C. gariepinus*. The FCR in the present study is slightly on the high side. The reason for this high FCR is not clear. Since sinking pelleted feed was used, a significant amount of feed might be wasted, accounting for high FCR observed in this study, though Jensen, (1989) opined that FCR in most fishes e.g. catfishes vary from less than 1.5 to 5.0. The feeding practices can be refined to provide more efficient conversion ratios without reducing growth rates. All the fish species in the present study had condition factor greater than 1.10, which represents desirable levels as most fish were healthy and robust. Fish that were sacrificed after the harvest contained appreciable quantities of abdominal fat. The highest condition (1.53) occurred in the hybrid, followed by the pure line of *H. bidorsalis* (1.40), while 1.23 was the least and was recorded in parental *C. gariepinus*.

At harvest, survival rate was significantly ($p<0.05$) higher ($97.3\pm 8.1\%$) in the hybrid, followed by ϕ Cg x σ Cg with $81.1\pm 7.8\%$, while the lowest ($75.5\pm 6.40\%$) was recorded for ϕ Hb x σ Hb. No significant variation ($p>0.05$) was observed between the survival rate value of the putative parents. The survival rates of all the fish stocked in this study were higher those reported by Akinwande *et al.* (2009) for *C. gariepinus* x *H. bidorsalis* and Diyaware and Onyila (2014) for intergeneric hybrid between *C. anguillaris* x *H. bidorsalis*. Since no physical mortality was recorded during the study period, it could be inferred that the fishes were raised in a conducive environment (ponds) as shown by the condition factors. Over 95% of *H. bidorsalis* and 99% of the hybrid, *Heteroclarias* (ϕ CG X σ HB) were considered marketable (≥ 500 g) and the weight distributions of the samples in 3rd, 4th, 5th and 6th month indicated that about 50, 65, 80 and 95% respectively were considered to be commercially marketable in the restaurant trade, while over 55% of *Clarias gariepinus* were considered marketable (≥ 500 g) and the weight distributions of the samples in 3rd, 4th, 5th and 6th month indicated that about 35%, 45%, 60% and 75% respectively were marketable at those ages.

Relative robustness were best (1.85 ± 0.24) in σ Hb x ϕ Cg, followed by that of σ Hb x ϕ Hb and σ Cg x ϕ Cg with 1.24 ± 0.21 and 1.15 ± 0.23 , respectively. There was a significant difference ($p<0.05$) between the robustness of the hybrids compared to their putative parents. However, no significant ($p>0.05$) variation in terms of robustness was observed among the putative parents. The standing crop at harvest was highest (94.16 ± 8.6 kg/0.02ha) in σ Hb x ϕ Cg, followed by that of ϕ Hb x σ Hb (70.55 ± 7.8 kg/0.02ha), while the least (45.08 ± 5.4 kg/0.02ha) standing crop was observed in ϕ Cg x σ Cg. The standing crop value of the hybrids was significantly ($p<0.05$) higher than those of the putative parent.

It was clearly observed from the data collected that growth performances in terms of increase in body weight, increase in standard length, absolute growth rates and specific (instantaneous) growth rate were generally better in the hybrid than the putative parental species. The high performance of the hybrid over the putative parental species could be attributed to heterotic growth due to hybrid vigor. This is in line with Jensen *et al.* (1983), Bakos (1987), Madu *et al.* (1993) and Madu and Aluko (1999). They observed that hybrids in most cases were superior to the parental line in food conversion, meat quality, resistance to diseases and adaptive environmental conditions. The better growth performance exhibited by the hybrid over their putative parents appeared to be due to the inheritance of traits from fast growing parents and partial transmission of these traits to the hybrid (Chevassus, 1983).

The relationship between the body weight and the number of weeks of growth is shown in Figures 1-3. The graphical representations and the statistical computations of the body weight against the number of weeks of growth of the study fish showed that they were highly correlated:

<i>Clarias gariepinus</i>	----	$Y = +4.731 + 14.90 X_1$; $r^2 = 0.96$	N = 295
<i>Heterobranchus bidorsalis</i>	----	$Y = -46.43 + 33.67X_1$; $r^2 = 0.98$	N = 250
<i>Heteroclarias</i>	-----	$Y = -58.22 + 31.34X_1$; $r^2 = 0.99$	N = 322

The linear growth curve was observed in *C. gariepinus* while geometric growth curves were observed in *H. bidorsalis*, and their hybrid *Heteroclarias* when the relationships between the two variables (body weight against the number of weeks of growth) were plotted in all the experimental fish species. The observed growth curves show the best time to harvest *Clarias gariepinus*, *H. bidorsalis*, and their hybrid *Heteroclarias* for maximum gain in terms of good growth and when the maximum profit on feed utilization can be achieved. The study showed that the best time to harvest *H. bidorsalis* is in 26th week, 24th week for hybrid *Heteroclarias* and 30th week for *Clarias gariepinus*. Beyond these times, there were decreased efficiency of feed utilization and a decline in growth rate sets in (Figures 1, 2 and 3).

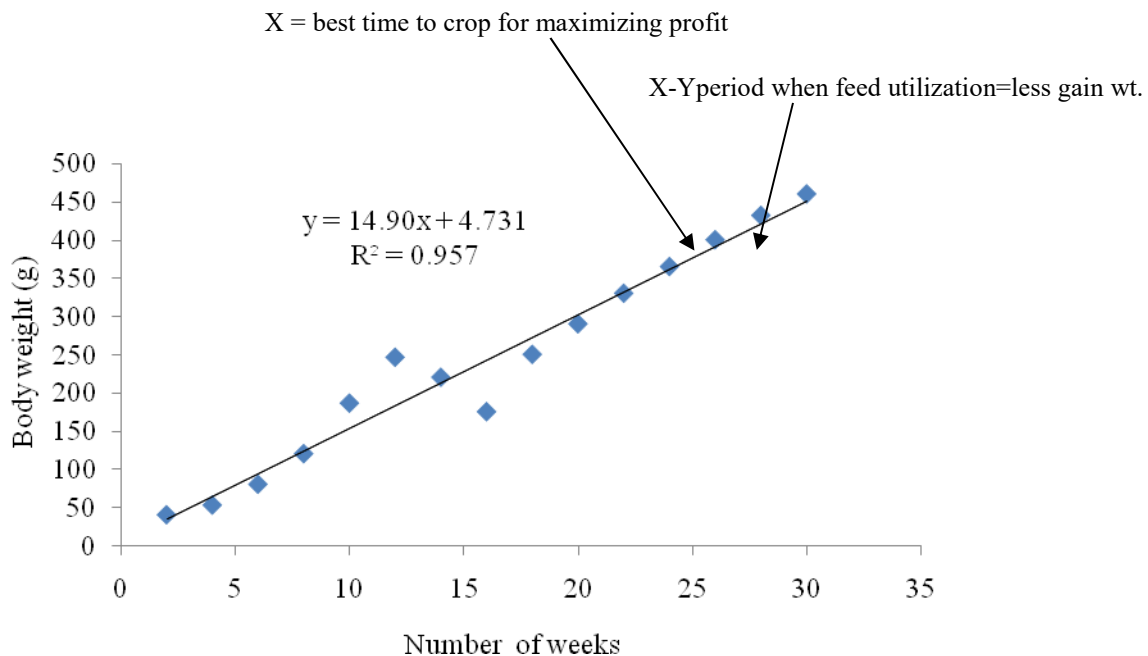


Fig.1: Mean growth of *C. gariepinus*

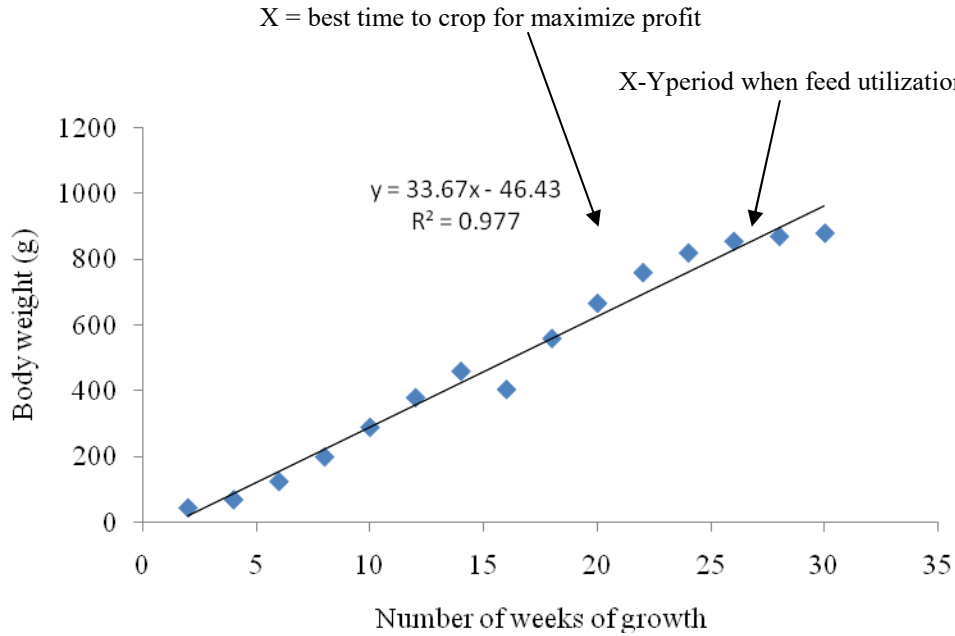


Fig. 2: Mean growth of *H. bidorsalis*.

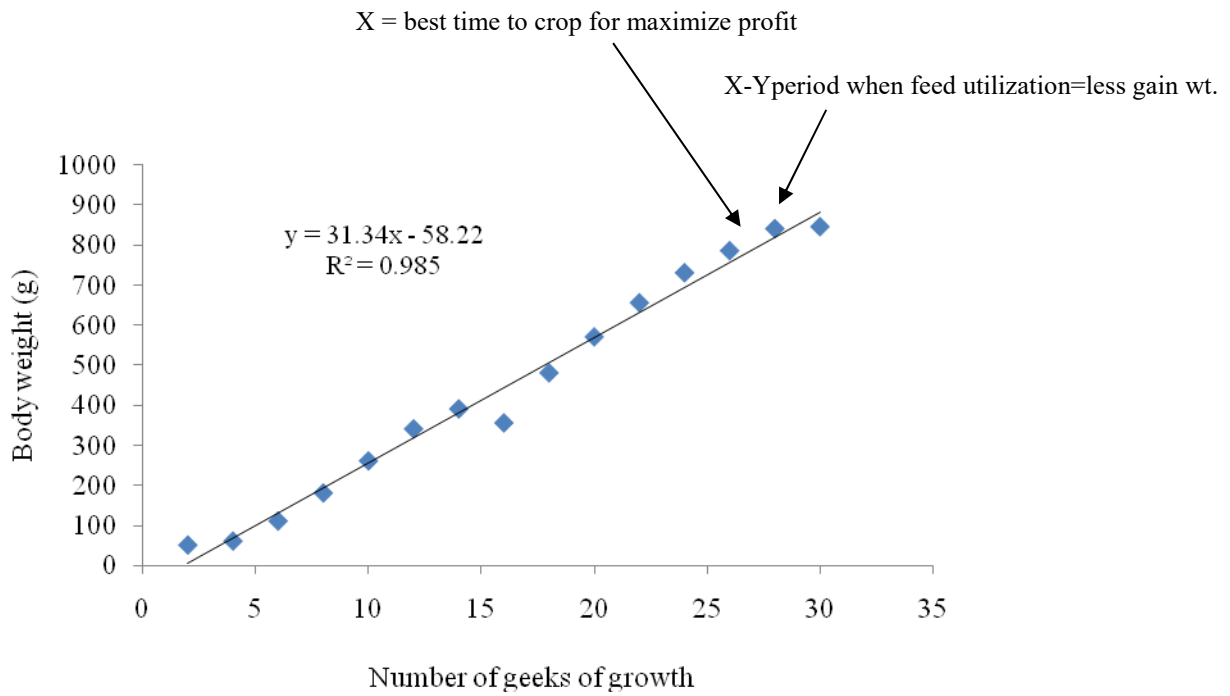


Fig. 3: Mean growth of hybrid of ♀*C. gariepinus* x ♂*H. bidorsalis* (*Heteroclarias*)

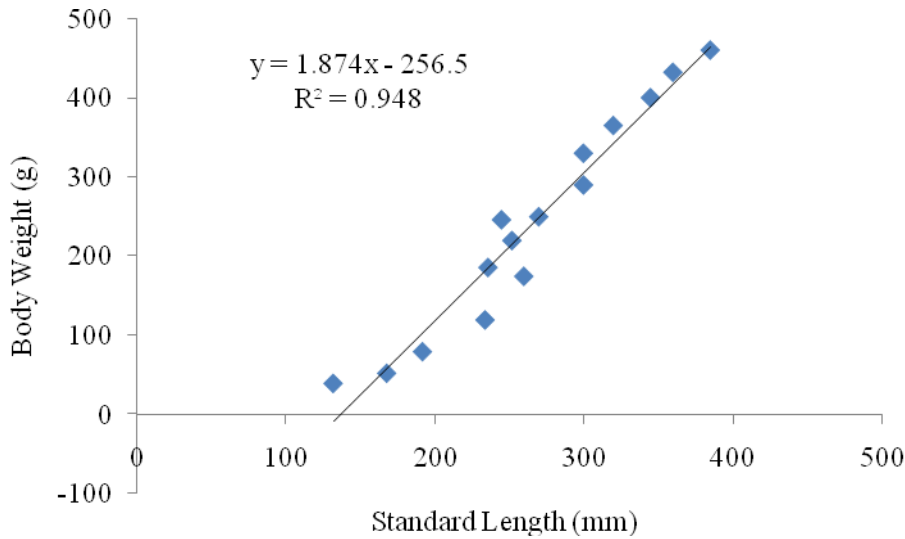


Fig. 4: Relationship between mean body weight and mean standard length in *C. gariepinus* at harvest

Different clusters exhibited by each of these species are shown in Figures 4-6. Two clusters were both observed in *H. bidorsalis* and *C. gariepinus*, while three clusters were observed in the hybrid – *Heteroclarias*. Each cluster belonged to different size range representing different stages of growth, development and relative robustness. These observations further confirmed the wide distributions in weights of the study fish for effective polyculture in earthen ponds; two selective harvesting of *H. bidorsalis* and *C. gariepinus* and three selective harvesting of the hybrid, *Heteroclarias* are recommended to prevent the cannibalistic tendencies that are common in the Clariids. This practice would allow the consolidation of smaller fish into fewer ponds for additional growth.

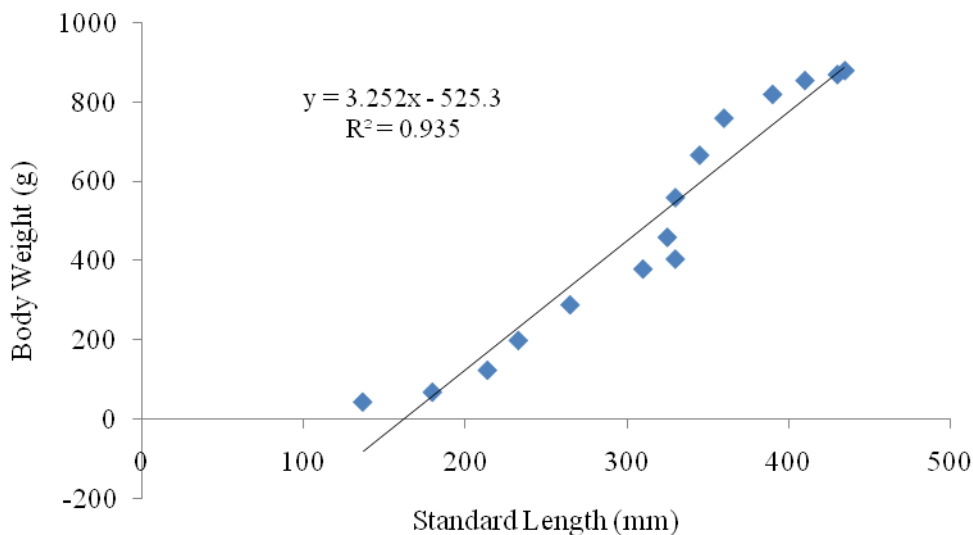


Fig. 5: Relationship between mean body weight and mean standard length in *H. bidorsalis* at harvest

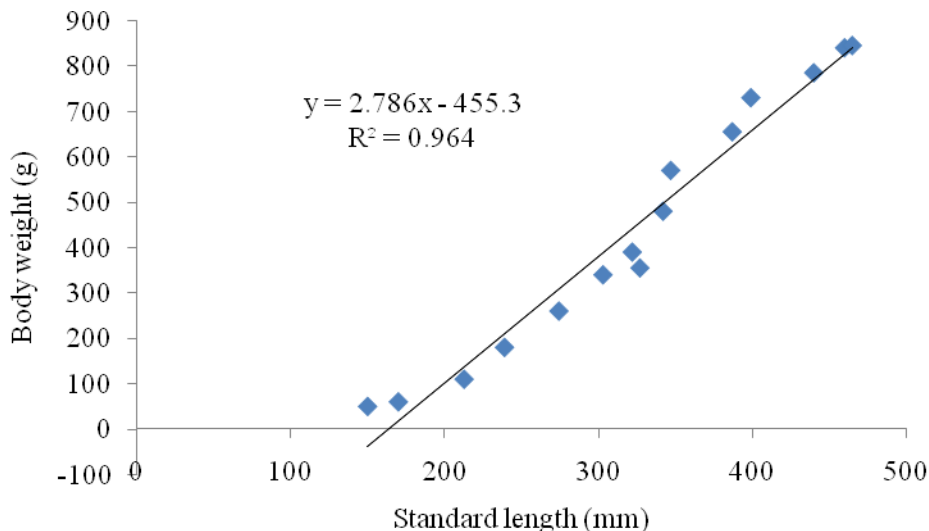


Fig. 6: Relationship between mean body weight and mean standard length of ♀ *C. gariepinus* x ♂ *H. bidorsalis* (*Heteroclarias*) at harvest.

This study has shown clearly widest distributions in weights of the study fish and selective harvesting as a tool in preventing the cannibalistic tendencies that are common in the Clariids catfishes. It also showed the best time to crop the fish for maximum gain in terms of good growth and maximum profit on feed utilization, which serves as a further indication of the potentials of the Clariid catfish for commercial culture.

Acknowledgments

We thank Mr. Austin Anetekhai and Mr. Pascal Opuehi for their assistance in the collection of data and for taking care of the fish. We also give thanks to Omague Fish Farm, Ijotun in the Badagry Local Government Area of Lagos State for allowing us to use their facilities for this study. We express our gratitude to the Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos State, Nigeria for providing the fingerlings for the experiment.

REFERENCES

- Akinwande, A.A., Moody, F.O. and Umar, S.O. (2009). Growth performance of and survival of *Heterobranchus longifilis*, *Heterobranchus bidorsalis* and their reciprocal hybrids. *Africa Science*,10:15-18.
- Akinwande, A. A., Fagbenro, O. A. and Adebayo, O.T. (2017). Growth performance and sex ratio in Interspecific and intergeneric hybrids of three clariid catfish species. *Nigerian Journal of Agriculture, Food and Environment*,13(1):5-11.
- Aluko, P.O. and Ali, M. H. (2001). Production of eight types of fast growing Intergeneric hybrids from four clariids species. *Journal of Aquaculture in Tropic*,16:139-147
- Bagenal, T. B. (1978). *Age and Growth*. In: Methods and Assessment of Fish Production in Freshwater (Ed.Timothy Bagenal),101-136. Blackwell Scientific Publications, Oxford. 365pp.
- Boyd, C E (1981). *Water quality in Warm Water Fish Ponds*. Auburn University. Agricultural Experiment Station Alabama. 359Pp.
- Boyd, C E, and Lichtkoppler, F. (1979). Water quality management in fish pond Culture *Research Development Series 22*. International Center for Agricultural Experiment Station. Auburn University, Auburn, Alabama, USA 30Pp.
- Brown, M.E. (1957). *Experimental studies on growth*. In M.E. Brown editor.361- 400The physiology of

- Fishes, Volume 1 Academic Press, New York, U.S.A. 345pp.
- Diyaware, M. Y. and Onyila, L. U. (2014). Growth and survival of intergeneric hybrids of *Clarias Anguillaris* and *Heterobranchus bidorsalis* in Semi-arid zone of Nigeria. *Journal of Fisheries and Aquatic Sciences*, 9(5):1-9.
- FDF (2015). *Fisheries Statistics of Nigeria*, Federal Department of Fisheries, Abuja, Nigeria, 6th Edition (2010-2015), 18Pp.
- Huet, M. (1979). *Text-book of fish culture. Breeding and cultivation of fish*. Fishing News Books, Furnham. Surrey England, 436Pp.
- Hoar, W. S. and Randal, D. S. (1969). *Fish Physiology* Volume 3. Academic Press. 1st edition, London. 418Pp.
- Jensen, G. (1989). Handbook for Common Calculations in Finfish Aquaculture. Louisiana Agricultural Experiment Station. *Louisiana Cooperative Extension Service and Louisiana State University Agricultural Center*. 59Pp.
- Jensen, J., Durham, R. and Flynn, I. (1983): Production of Channel Catfish Fingerlings *Circular ANR 327 Alabama Co-operative Extension Service. Auburn University Alabama, USA*. 19 – 21.
- Lager, K.F. (1956). *Freshwater Fishery Biology*. Wm. C. Brown. Dubuque, Iowa, U.S.A. 450Pp.
- Legendre, M., Teugels, G. G., Caut, C. and Jalabert, B. (1992). A Comparative Study on the morphology, Growth rate and reproduction in *Clarias gariepinus* (Burchell 1822) *Heterobranchus longifilis* Val. 1840, and their reciprocal hybrids (Pisces, Clariidae): *Journal of Fish Biology*, 40: 59-79.
- Madu, C.T., Ita, E.O. and Mohammed, S. (1991). Preliminary Study on the intergeneric hybridization of *Clarias anguillaris* and *Heterobranchus bidorsalis* NIFFR, *Annual Report*, 68-73. Madu, C. T, and Aluko, P. O. (1999). Hybrid mud catfish production: Comparative growth and survival of hybrids and putative parents. *Proceedings of the 12th Annual Conference of the Biotechnology Society of Nigeria* 89-94
- Ndimele, P. E. and Kumolu-Johnson, C. A (2011). Preliminary study on the physio- chemistry and comparative morphometric characterisation of *Cynothris samento* (Regan, 1917) from Ologe, Badagry and Epe Lagoons, Lagos, Nigeria: *International Journal of Agricultural Research* 6: 736-746.
- Ndimele, P. E. (2012). Effect of water hyacinth (*Eichhornia crassipes* Mart Solms) infestation on the physio-chemistry, nutrient and heavy metal content of Badagry creek and Ologe Lagoon, Lagos, Nigeria. *Journal of Environmental Science and Technology*: 5:128-136.
- Ndimele, P. E., Kumolu-Johnson, C. A. and Anetekhai, M. A. (2011). Spatial and temporal variations of some heavy metals in water, sediment and *Chrysichthys nigrodigitatus* (Lacepede, 1803) from Ologe Lagoon, Lagos, Nigeria. *International Journal of Biological Chemistry*, 5: 248-257.
- Owodeinde, F. G; and Ndimele, P. E. (2011). Survival, growth and feed utilization of two Clariid catfishes, *Clarias gariepinus* (Burchell 1822) and *Heterobranchus bidorsalis* (Goëffroy 1809) and their reciprocal hybrids. *Journal of applied Ichthyology*, 27: 1249-1253.
- Sokal, R. R. and Rohlf, F. J. (1995). *Introduction to Biostatistics* 3rdEdn., Freeman Publication, New York. 887Pp.
- Stickney, R.R. (1979). *Principles of Warm-water Aquaculture*. A Wiley-Interscience Publication, New York, N.Y., 375Pp.
- Uzoagulu, A. E. (1998). *Practical Guide to Writing Research, Project Reports in Tertiary Institutions*. John Jacob's Classic Publishers Ltd., 385Pp.
- Woods, L. C., Kerby, J. H. and Huish, M. T. (1983): Estuarine Cage culture of Hybrid Striped Bass. *Journal of World Mariculture Society*. 114:595 – 612.
- Zar, J. H. (1996). *Biostatistical Analysis*, 3rdEdn., Prentice Hall, USA, 662Pp.