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Growth and Survival of Intergeneric Hybrids of *Clarias anguillaris* and *Heterobranchus bidorsalis* in Semi Arid Zone of Nigeria

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ABSTRACT

Growth and survival of *C. anguillaris*, *H. bidorsalis* and their hybrids fingerlings were investigated under semi arid condition. Thirty five days old fingerlings (32.03±0.69-44.57±1.47 g and 4.70±0.04-5.74±0.12 cm) stocked at 5 fish m^{-2} were reared for 9 months in polyethylene-lined fish pond (2.5×2.×1.2 m deep) in triplicates (♀Ca×♂Ca, ♀Ca×♂Hb, ♀Hb×♂Hb and ♀Hb×♂Ca as treatments I, II, III and IV, respectively). The results showed that final mean weights were higher (pooled 8322.00±29.82 g = 509 g $fish^{-1}$) in the reciprocal hybrids (♀Hb×♂Ca), followed by pure breeds, ♀Hb×♂Hb (7632.70±321.88 g = 508 g $fish^{-1}$) and ♀Ca×♂Hb (5980.30 g = 352 g $fish^{-1}$). Lowest (4191 g = 232.83 g $fish^{-1}$) mean final weight was recorded in the pure breeds of ♀Ca×♂Ca. Mean Weight Gain (MWG) and Mean Daily Weight Gain (MDWG) were also higher in ♀Hb×♂Ca. No significant ($p>0.05$) variation was observed in the final mean weight and mean daily weight values of the reciprocal hybrids compared to those of their paternal pure breeds ♀Hb×Hb♂. Survival was higher (70.67±1.33%) in pure line ♀Ca×♂Ca followed by ♀Ca×♂Hb, ♀Hb×♂Ca (69.33±10.91, 65.33±2.67 and 61.33±7.06%, respectively). Positive percentage heterosis was observed in both hybrids progenies. Based on the result of this study, the hybrids of ♀ *H. bidorsalis*×♂ *C. anguillaris* performed better than hybrid ♀*C. anguillaris*×♂*H. bidorsalis* and the two parental progenies. This indicates that, there are great potentials for exploiting hybrids of African catfishes in the semi arid zone of Nigeria. The performances of the hybrid fingerlings to adult stage in the study area needs to be re-examined to confirm the performance of hybrid species in the harsh weather conditions of the zone.

Key words: Growth and survival, intergeneric hybrids, *C. anguillaris*×*H. bidorsalis*, semi arid condition

INTRODUCTION

The African catfish, *Clarias* and *Heterobranchus* species are considered as a highly priced fish in Nigeria and Africa at large. *Heterobranchus* grows faster and attains bigger size than *Clarias* which matures earlier (Oladosu *et al*., 1993). The hybrids of *Clarias* and *Heterobranchus* exhibit fast growing quality of *Heterobranchus* reaching up to 1.0 kg under eight months in ponds. (Hogendoorn, 1981; Hecht and Lublinkhof, 1985).

Hybridization has been used in numerous species of fish to increase growth rate, manipulation of sex ratios, production of sterile fish, improve flesh quality, increase disease resistance, improve environmental tolerance and to improve a variety of other traits to make fish more profitable

(Bartley *et al.*, 2001). They lamented the desired goal of hybridization is to produce offspring that performs better than both parental species (hybrid vigour or positive heterosis). The crossbreeding improves the heterozygosis of non- additive genes causing the heterosis which is important in the adverse environmental conditions (Keambou *et al.*, 2010). In fact, crossings constitute one of the tools for the exploitation of the genetic variation and the hybrid vigour by combination of the different important characteristics of each breed and for the exploitation of maternal genetic effects or sex-linked effects, associated to particular combinations between breeds or lines (Hanafi and Iraqi, 2001).

Several authors conducted studies on intergeneric hybridization between African clariids: Aluko and Ali (2001) produced eight fast growing intergeneric hybrid fingerlings from four clariid species at National Institute for Freshwater Fisheries Research, Nigeria, Akinwande *et al.* (2009) reported growth and survival of interspecific and intergeneric hybrids *C. gariepinus*, *H. longifilis* and *H. bidorsalis* reared for 4 weeks. Diyaware *et al.* (2010) reported the performance of larvae to fingerlings of *C. anguillaris*, *H. bidorsalis* and their hybrids in North East Nigeria (semi arid zone). While Owodeinde and Ndimele (2011) investigated growth performance of intergeneric hybrids of *C. gariepinus* and *H. bidorsalis* reared to fingerling stage in Southern Nigeria. Ataguba *et al.* (2010) states that *Clarias gariepinus* and *Heterobranchus longifilis* and their hybrids have been cultured for 15 days. Rahman *et al.* (1995) investigated the growth performance of interspecific hybridization between *C. batrachus*×*C. gariepinus* cultured for 56 days. Madu *et al.* (1991) documented growth and survival of intergeneric hybridization between *C. gariepinus* and *H. bidorsalis* and they observed heterosis during the first month of indoor management though not prominent in the hybrid hatchlings. Nwadukwe (1995) conducted hybridization between *Heterobranchus longifilis* (Val.)×*Clarias gariepinus*.

Growth and survival African catfish and their hybrids reared to table size have been reported by Owodeinde *et al.* (2013), Aluko (1995) and Madu *et al.* (1993). Legendre *et al.* (1992) reported high final weights of 908 g for *Heterobranchus longifilis*×*C. gariepinus* and 749 g for *C. gariepinus*×*Heterobranchus longifilis* reared for 256 day. Heterosis among hybrids of *Clarias* and *Heterobranchus* fish species have been documented by Madu *et al.* (1992), Salami *et al.* (1993), Nwadukwe (1995) and Aluko (1998).

Information on growth performance of intergeneric hybridization between *Clarias* and *Heterobranchus* to table size in the semi arid condition has not been reported. The objective of this study therefore is to investigate the potentials of F_1 hybrid of *Clarias anguillaris* and *Heterobranchus bidorsalis* with respect to their growth, survival and heterosis in semi arid condition with the view to developing fast growing hybrid within the region.

MATERIALS AND METHODS

The study was conducted in the Department of Fisheries, University of Maiduguri, Nigeria from September 2011 to May, 2012. Alau (Lake Alau) is situated between latitude 13°86' N and 14°N and longitude 12°E and 13°E. Raining season begins in July and lasts till October.

Experimental fish: *Clarias anguillaris* (male and female) broodfish were obtained from Kwantan Bunduram, 2 km away from Baga located at longitude 13°04' N and latitude 13°48' E in Kukawa local government area of Borno state while *Heterobranchus bidorsalis* (male and female) were obtained from Lake Geriyo, located at longitude 12°25' E and latitude 9°17' N in Yola North local government of Adamawa State. Both fish were transported to the hatchery unit of the Department of Fisheries, University of Maiduguri in 50 L Jeri can cut one quarter (¼) horizontally. The fish were packed in perforated nylon bags before inserting them into the Jeri can half filled with fresh

water. The fish were conditioned for 2 days before the hybridization exercise. The follow mating combinations were performed:

- Female *Clarias anguillaris*×male *Clarias anguillaris* (♀Ca×♂Ca)
- Female *Clarias anguillaris*× male *Heterobranchus bidorsalis* (♀Ca×♂Hb)
- Female *Heterobranchus bidorsalis*×male *Heterobranchus bidorsalis* (♀Hb×♂Hb) and
- Female *Heterobranchus bidorsalis*×male *Clarias anguillaris* (♀Hb×♂Ca)

Each mating combination was repeated three times. The hatchlings were fed with shell-free *Artemia* for twelve days and thereafter with Coppens assorted starter diets (0.20-0.30, 0.50-0.8 and 1.00 mm) and reared for 35 days.

Twenty-five 35-day old fingerlings of each combination of *Clarias anguillaris*, *Heterobranchus bidorsalis* and the two hybrids were stocked in polyethylene lined fish pond (2.5×2.0×1.2 m deep) in triplicateds. The fingerlings were conditioned for 5 days. They were fed with locally formulated diet of 40% crude protein (Table 1) at 3% of their body weight two times daily (8.00 am and 3.00 pm).

The fish were weighed monthly to adjust the feeding rate per their body weight. At the end of the culture period, final weight (g), final length (cm), survival rate, for each treatment were recorded. Final mean weight, mean weight gain (g), final mean length, mean daily weight gain (g), specific growth rate (percent/day), survival rate (%) for each treatment were estimated as follows (Adewolu *et al*., 2008):

- **Weight gain (g):** W_1-W_o, Where, W_1= Final weight and W_o= Initial weight
- **Mean daily weight gain (g day^{-1}):** W_1-W_o/t, where, W_1 = Mean final body weight (g), W_o = Initial mean body weight (g) and t = Culture period (days)

Table 1: Proximate composition of experimental diet used for rearing the experimental fish

Parameters	Percentage inclusion
Feed ingredients	
Fish meal	18.30
Groundnuts cake	12.10
Soy bean meal	18.10
Millet	37.60
Wheat offal	6.40
Vitamin premix	1.00
Salt	0.50
Bone meal	0.50
Lysine	1.00
Methionine	1.00
Vitamin C	1.00
Groundnut oil	0.50
Binder	2.00
Total	100.00
Proximate composition (%)	
Calculated analysed	
Crude protein 40.0	38.08
Crude fibre 2.00	4.00
Fats 1.00	2.00
Ash 1.00	1.60

- **Specific growth rate (percent day^{-1}):**

$$\text{Specific growth rate} = \frac{\text{Log}_e\ W_1 - \text{Log}_e\ W_o}{t} \times 100$$

where, W_o = Mean initial body weight of fish (g), W_1 = Mean final body weight of fish (g), Log_e = Natural logarithm and t = Culture period (days)

- **Survival (%):**

$$\text{Survival (\%)} = \frac{\text{No. of fingerlings at the end of culture}}{\text{No. of fingerlings stocked}} \times 100$$

Heterosis: Percentage heterosis was determined for the two hybrids at the end of the culture period after Nguenga *et al.* (2000):

$$\text{Heterosis (\%)} = [(C_1+C_2)/2-(P_1+P_2/2)]/P_1+P_2)\times 100$$

where, C_1 and C_2 are the mean final weight and survival of crossbreeds, respectively while P_1 and P_2 are the mean final weight and survival of the purebreds, respectively.

Water quality parameters: Dissolved Oxygen (DO) was recorded using Digital DO/temperature meter (820 Sanxin China) while pH and Temperature (°C) was taken with means of digital portable pen pH meter (AC-pH/Temp meter) weekly morning and evening (08.00 am and 16.00 pm) for each treatment.

Statistical analysis: Data obtained from the experiment were subjected to one way analysis of variance while differences between the means were determined using Least Significant Difference (LSD) at 95% confidence level (p = 0.05) with the aid of Statistix 8.0.

RESULTS

Table 2 shows mean growth and survival of intergeneric hybrids of *C. anguillaris*×*H. bidorsalis* and their hybrids reared for 9 months under semi arid condition. Final Mean Weights (FMW) were higher (8322.00±29.82 g = 509 g fish^{-1}) in the reciprocal hybrids (♀Hb×♂Ca) followed by pure breeds of ♀Hb×♂Hb (7632.70±321.88 g). Lowest mean weight was recorded in the purebred of ♀Ca×♂Ca. Mean Weight Gain (MWG) and Mean Daily Weight Gain (MDWG) were also higher in ♀Hb×Ca. No significant (p>0.05) variation was observed in the FMW, MWG and MDWG values

Table 2: Mean±SD growth and survival intergeneric hybrids of *C. anguillaris*×*H. bidorsalis* and their hybrids under semi arid condition

	Combinations			
Growth parameters	♀Ca×♂Ca	♀Ca×♂Hb	♀Hb×♂Hb	♀Hb×♂Ca
Final weight (g)	4191.00±326.06^{c}	5980.30±139.67^{b}	7632.70±321.88^{a}	8322.00±29.82^{a}
Final length (cm)	24.36±0.47^{c}	24.63±0.40^{c}	29.92±0.39^{a}	27.90±0.59^{b}
Mean weight gain (g)	3652.30±527.26^{c}	5935.80±139.59^{b}	7600.60±621.35^{a}	8280.40±29.18^{a}
Mean daily weight gain (g day^{-1})	14.68±1.24^{c}	21.18±0.53^{b}	27.31±2.37^{a}	29.72±0.11^{a}
Specific growth rate (percent day^{-1})	0.47±0.12^{b}	0.76±0.13^{a}	0.66±0.11^{ab}	0.54±0.00^{ab}
Survival (%)	70.67±1.33^{a}	69.33±10.91^{a}	61.33±7.06^{a}	65.33±2.67^{a}

Means in the same column having different superscript are significantly different (p<0.05)

of the reciprocal hybrids compared to that of their paternal parents (♀Hb×♂Hb). However, there was significant ($p<0.05$) variation between FMW, MWG and MDWG values of ♀Ca×♂Ca compared to that of their maternal hybrids (♀Ca×♂Hb).

Specific Growth Rate (SGR) was observed to be higher (0.76±0.13 percent day^{-1}) in hybrids of ♀Hb×♂Ca. There was no significant difference ($p>0.05$) between the SGR values of ♀Hb×♂Ca compared to those of ♀Hb×♂Ca and ♀Hb×♂Hb. However, SGR was significantly ($p<0.05$) lower in pure line ♀Ca×♂Ca.

The highest survival was recorded in ♀Ca×♂Ca, followed by their maternal hybrid. The lowest survival rate was observed in pure line ♀Hb×♂Hb. There was no significant variation between percentage survival rates of the entire treatments.

Figure 1 shows mean monthly growth patterns of *C. anguillaris*, *H. bidorsalis* and their hybrids under semi arid zone of condition. At the early growth stage (months 1-2), the entire mating combinations showed slight variation in their parallel growth pattern. However, as from the second month, clear growth pattern was observed. By the third month, growth of offspring of ♀Hb×♂Ca was low due to mortality. High mortality was also observed at the 8th month of culture.

Table 3 shows percentage heterosis for growth and survival for *C. anguillaris*, *H. bidorsalis* and their hybrids after 9 months of culture. Positive heterosis for growth and survival were observed in both ♀Ca×♂Hb and ♀Hb×♂Ca hybrids. Higher heterosis for both growth and survival were observed in ♀Ca×♂Hb while lower heterosis values for growth and survival were recorded in the reciprocal hybrids (♀Hb×♂Ca).

Table 3: Heterosis percent for growth and survival of *C. anguillaris*, *H. bidorsalis* and thier hybrids under semi arid condition

	Combinations	
Heterosis	♀Ca×♂Hb	♀Hb×♂Ca
Growth	29.55	8.27
Survival	41.95	9.00

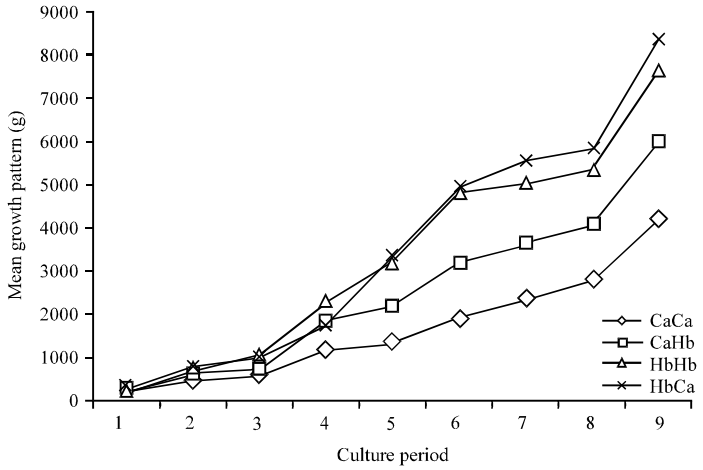

Fig. 1: Mean monthly growth pattern of *Clarias anguillaris*, *Heterobranchus bidorsalis* and their hybrids under semi arid zone condition

Table 4: Mean water quality parameters during rearing of fingerling of *Clarias anguillaris*, *Heterobranchus bidorsalis* and their hybrids under semi-arid zone for 9 months

Combinations	Temperature (°C)	pH	DO (mg L^{-1})
♀Ca×♂Ca	30.40±0.12	8.03±0.37	4.50±0.38
♀Ca×♂Hb	30.10±0.00	7.94±0.35	5.02±0.64
♀Hb×♂Hb	29.43±0.90	7.55±0.01	4.36±0.42
♀Hb×♂Ca	30.13±0.29	7.81±0.11	5.14±0.82

Water quality parameters: Table 4 shows water quality parameters during growth trials of *C. anguillaris*, *H. bidorsalis* there hybrid under semi arid condition. Temperature ranged from 29-30.40°, pH was 7-8.03 while dissolved oxygen was between 4 and 5.14 mg L^{-1}.

DISCUSSION

The higher growth rate (8322.00 g pool weight = 509 g mean individual weight) obtained after 9 months of culture in this study is lower than 1.5 kg reared for 1 year by Aluko and Ali (2001), 846 g $fish^{-1}$ for *C. gariepinus* reared for 8 months and 880 g $fish^{-1}$ for hybrid (*C. gariepinus*×*H. bidorsalis*) reared for 8 months in earthen ponds and 908 g for *Heterobranchus longifilis*×*C. gariepinus* (Legendre *et al*., 1992) and 749 for *C. gariepinus*×*H. longifilis* reared for the period of 256 days. The variation in final weight values may be due to differences in the species used for the hybridization.

Mean daily weight gain observed in this study is higher than those reported by previous studies. This variation may be due to the difference in both species used for the hybridization for the fact that *H. bidorsalis* and *C. gariepinus* grow faster than *H. longifilis* and *C. anguillaris*, respectively.

The higher specific growth rate of ♀Ca×♂Hb recorded in this study is higher than those reported by Owodeinde *et al*. (2012). According to Kerby *et al*. (1987) specific daily growth rate decreases with increase in biomass and consequent increase in metabolic activities.

The survival rates (69.33 and 65.33%) recorded in this study for both hybrids after 9 months culture were lower than 72% reported by Muthukumaran and Sukumaran (2005) for hybrid between *Heteropneustes fossilis*×*Clarias gariepinus*. The crosses between female *C. anguillaris* and male *H. bidorsalis* inherited the fast growth of *H. bidorsalis* coupled with the high survival trait of *C. anguillaris* but did not inherit the poor survival of *H. bidorsalis*. Madu and Aluko (1999) reported similar trend in which the hybrid between male *C. gariepinus* (Netherlands)×*H. bidorsalis* imbibed fast growth of *H. bidorsalis* coupled with the growth trait of *C. gariepinus* but did not also inherit poor survival of *H. bidorsalis* but was not better in growth rate as the *C. gariepinus* (Dada and Olarewaju, 1996).

The higher heterosis for both growth and survival for the two hybrids observed in this study was better than 8.4 and 10.9%, respectively for juvenile and adult Bay scallop, *Argopecten irradians* reported by Zheng *et al*. (2006). Nguenga *et al*. (2000) reported a net positive heterosis of 89.5% for crosses between two strains of *Heterobranchus longifilis*. Heterosis among hybrids of *Clarias* and *Heterobranchus* fish species have also been reported by Madu *et al*. (1992), Salami *et al*. (1993), Nwadukwe (1995) and Aluko (1998).

Based on the result of this study, the hybrids of female *H. bidorsalis*×male *C. anguillaris* performed better than hybrid of female *C. anguillaris*×male *H. bidorsalis* and the two parental progenies. This indicates that, there are great potentials in exploiting hybrid African catfishes in

the semi- arid zone of Nigeria. The performance of the hybrid fingerlings to adult stage in the study needs to be re-examined to confirm the performance of hybrid species in the harsh weather conditions of the zone.

The water quality parameters recorded during these studies were within the acceptable ranges for fish culture and as suggested by Boyd (1981) and Viveen *et al.* (1986).

REFERENCES

Adewolu, M.A., A.O. Ogunsanmi and A. Yunusa, 2008. Studies on growth performance and feed utilization of two Clariid catfish and their hybrid reared under different culture systems. Eur. J. Sci. Res., 23: 252-260.

Akinwande, A.A., F.O. Moody and S.O. Umar, 2009. Growth performance of and survival of *Heterobranchus longifilis*, *Heterobranchus bidorsalis* and their reciprocal hybrids. Afr. Sci., 10: 15-18.

Aluko, P.O., 1995. Growth characteristics of first, 2nd and backcross generations of the hybrids between *Heterobranchus longifilis* and *Clarias anguillaris*. National Institute for Freshwater Fisheries Research Annual Report, New Bussa, Nigeria, pp: 74-78.

Aluko, P.O., 1998. Growth characteristics of the parental, F_1, F_2 and backcross generation of the hybrids between *Heterobranchus longifilis* and *Clarias anguillaris*. West Afr. J. Biol. Sci., 8: 16-21.

Aluko, P.O. and M.H. Ali, 2001. Production of eight types of fast growing intergeneric hybrids from four *Clariid* species. J. Aquacult. Trop., 16: 139-147.

Ataguba, G.A., P.A. Annune and F.G. Ogbe, 2010. Growth performance of two African catfishes *Clarias gariepinus* and *Heterobranchus longifilis* and their hybrids in plastic aquaria. Livest. Res. Rural Dev., Vol. 22.

Bartley, D.M., K. Rena and A.J. Immink, 2001. The use of inter-specific hybrids in aquaculture and fisheries. Rev. Fish Biol. Fish., 10: 325-337.

Boyd, C.E., 1981. Water Quality in Warm Water Fish Ponds. Agricultural Experimental Station, Auburn University, Alabama, AL., USA., Pages: 359.

Dada, A.A. and O. Olarewaju, 1996. Comparative growth and survival of the catfishes: *Clarias* sp., *Heterobranchus* spp. and their hybrid fry under out door nursery management system. National Institute for Freshwater Fisheries Research Annual Report, New Bussa, Nigeria, pp: 115-122.

Diyaware, M.Y., A.B. Haruna and K.A. Abubakar, 2010. Growth and survival of hybrid fingerlings of *Clarias anguillaris* and *Heterobranchus bidorsalis* in North East Nigeria. J. Arid Agric., 19: 24-30.

Hanafi, M.S. and M.M. Iraqi, 2001. Evaluation of purebreds, heterosis, combining abilities, maternal and sex-linked effects for some productive and reproductive traits in chickens. Proceedings of the 2nd International Conference on Animal Production Health in Semi-Arid Areas, September 4-6, 2001, Suez Canal University, El Arish-North Sinai, Egypt, pp: 545-555.

Hecht, T. and W. Lublinkhof, 1985. *Clarias gariepinus* x *Heterobranchus longifilis* (Clariidae) Pisces): A new hybrid for aquaculture. South Afr. J. Sci., 81: 620-621.

Hogendoorn, H., 1981. Controlled propagation of the African catfish, *Clarias lazera* (C and V.): IV. Effect of feeding regime in fingerling culture. Aquaculture, 24: 123-131.

Keambou, T.C., Y. Manjeli, B. Boukila, S. Mboumba, T. Mezui Mezui and B.A. Hako Touko, 2010. Heterosis and reciprocal effects of growth performances in F_1 crosses generations of Local x Hubbard chicken in the Western Highlands of Cameroon. Livestock Res. Rural Dev., Vol. 22.

Kerby, J.H., J.M. Hinshaw and M.T. Huish, 1987. Increased growth and production of striped bass × white bass hybrids in earthen ponds. J. World Aquacult. Soc., 18: 35-43.

Legendre, M., G.G. Teugels, C. Cauty and B. Jalabert, 1992. A comparative study on morphology, growth rate and reproduction of *Clarias gariepinus* (Burchell, 1822), *Heterobranchus longifilis* Valenciennes, 1840 and their reciprocal hybrids (Pisces, Clariidae). J. Fish Biol., 40: 59-79.

Madu, C.T., E.O. Ita and S. Mohammed, 1991. Preliminary Study on the intergeneric hybridization of *Clarias anguillaris* and *Heterobranchus bidorsalis*. National Institute for Freshwater Fisheries Research Annual Report, New Bussa, Nigeria, pp: 68-73.

Madu, C.T, S. Mohammed, A. Mezie, J. Issa and E.O. Ita, 1992. Comparative growth, survival and morphometric characteristics of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrid fingerlings. Annual Report NIFFR, New Bussa, pp: 7.

Madu, C.T., S. Mohammed, J. Issa and E.O. Ita, 1993. Further studies on the growth, morphormetric and meristic characteristics of *Clarias anguillaris*: *Heterobranchus bidorsalis* and their hybrids. National Institute for Freshwater Fisheries Research Annual Report, New Bussa, pp: 23-29.

Madu, C.T. and P.O. Aluko, 1999. Hybrid mudfish production comparative growth and survival of hybrids and putative parents. Proceeding of the 12th Annual Conference of the Biotechnology Society of Nigeria, April 13-17, 1999, New Bussa, Nigeria, pp: 89-94.

Muthukumaran, A. and N. Sukumaran, 2005. Performance of intergeneric hybrid between the Catfishes *Heteropneustes fossilis* and *Clarias gariepinus* world aquaculture 2005. Meeting Abstract 452, World Aquaculture Society.

Nguenga, D., G.G. Teugels and F. Ollevier, 2000. Fertilization, hatching, survival and growth rates in reciprocal crosses of two strains of an African catfish *Heterobranchus longifilis* valenciennes 1840 under controlled hatchery conditions. Aquacult. Res., 31: 565-573.

Nwadukwe, F.O., 1995. Hatchery production of five hybrid groups by artificial hybridization of *Clarias gariepinus* (B) and *Heterobranchus longifilis* (Val.) (Clariidae) using dry powdered carp pituitary hormone. J. Aquacult. Trop., 10: 1-11.

Oladosu, G.A., O.A. Ayinla, A.A. Adeyemo, A.F. Yakubu and A.A. Ajani, 1993. A comparative study of the reproductive capacity of the African catfish species *Heterobranchus bidorsalis* (Geoffroy), *Clarias gariepinus*, (Burchell) and their hybrid Heteroclarias. African Regional Aquaculture Centre Technical Paper No. 92, pp: 1-5.

Owodeinde, F.G. and P.E. Ndimele, 2011. Survival, growth and feed utilization of two clariid catfish (*Clarias gariepinus*, Burchell 1822 and *Heterobranchus bidorsalis*, Geoffroy, 1809) and their reciprocal hybrids. J. Applied Ichthyol., 27: 1249-1253.

Owodeinde, F.G., K.A. Fakoya and M.A. Anetekhai, 2012. Growth performance of hybrid Catfish (*Clarias gariepinus*x *Heterobranchus bidorsalis*) in earthen ponds. Asian J. Biol. Sci., 5: 192-200.

Owodeinde, F.G., P.E. Ndimele, A. Jenyo-Oni and O.B. Onyenania, 2013. Survival, growth and feed utilization of the reciprocal hybrids of *Clarias gariepinus* (Burchell, 1822) and *Heterobranchus bidorsalis* (Geoffroy, 1809) in Concrete Tanks. J. Fish. Aquatic Sci., 8: 122-128.

Rahman, M.A., A. Bhadra, N. Begum, M.S. Islam and M.G. Hussain, 1995. Production of hybrid vigor through cross breeding between *Clarias batrachus* Lin. and *Clarias gariepinus*. Bur. Aquaculture, 138: 125-130.

Salami, A.A., O.A. Fagbenro and D.H.J. Sydenham, 1993. The production and growth of clariid catfish hybrids in concrete tanks. Israeli J. Aquacult. Bamidgeh, 45: 18-25.

Viveen, W.J.A.R., C.J.J. Richter, P.G.W.J. Van Oordt, J.A.L. Janssen and E.A. Huisman, 1986. Practical manual for the culture of the African catfish (*Clarias gariepinus*). Dept. Fish Cult. and Fish., Agric. Univ. Wageningen, Netherlands, pp: 121.

Zheng, H., G. Zhang, X. Guo and X. Liu, 2006. Heterosis between two stocks of the bay scallop, *Argopecten irradians* irradians Lamarck (1819). J. Shellfish Res., 25: 807-812.