SIAR-Global Journal of Engineering & Agricultural Review(GJEAR)
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Vol. 1 Issue 1 Sept.-Oct. 2025

# Genetic Improvement of Three Strains of *Heterobranchus longifilis* (Valenciennes, 1840) for Enhanced Food Security and Poverty Alleviation in Nigeria.

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## Abstract

This study was designed for genetic improvement of African Catfish, Heterobranchus longifilis, for enhanced food security and poverty alleviation in Nigeria, through intraspecific hybridization of germplasm from three eco-regions of Nigeria. Sexually mature species of the fish were collected from the wild; Guinea Savanna (Benue River, Makurdi, MK), Rainforest (Niger River, Onitsha, ON) and Sahel Savanna (Rima River, Sokoto,SK). Sex ratio of female to male was 2:1. They were transported to the Coordinating Institution, College of Education, Oju, and acclimatized in earthen ponds for 14 days. Nine mating combinations were attempted in a bid to improve the performance of the progenies. Growth and survival were then monitored for two and a half months (75 days). The progenies of the various mating combinations were further reared in earthen ponds to sexual maturity for a period of nine months (270 days). During this period, their weights and gonads were examined monthly, and in order to determine the true commercial application of the intraspecific crosses, growth performance was evaluated based on mean weight gain, mean final weight and specific growth rate. The hatchlings of the various mating combinations were initially reared indoors for two weeks and later transferred outdoors for 56 days during which length and weight data were collected. Of the nine mating combinations in this study, the highest percentage hatchability was recorded in the pure line crosses; Sokoto, Makurdi and Onitsha strains (85%) while the least was recorded for the intraspecific cross between female Onitsha and male Makurdi (♀ON x ♂ MK:63%). However, the intraspecific hybrids had higher survival rates than pure line hybrids. Growth performance of fry of the various mating combinations reared indoors for two weeks showed that the growth rates of the cross breeds were significantly higher than the pure breeds. The cross breed ♀MK x ♂ON had the highest weight gain (0.88 ± 0.00g) while ♂SK x ♂SK had the least weight gain (0.56 ± 0.00g). The growth parameters of the progenies reared outdoors in hapas for 56 days showed that the cross breed ♀MK x ♂SK had the highest mean final weight (1.560± 0.06g), mean weight gain of 1.450 ± 0.06g and specific growth rate of 0.047 ± 0.00g. At sexual maturity, all the cross breeds had higher mean final weights than their corresponding pure breeds; ♀MK x ♂SK(700g), ♀MK x ♂ON(653g) and ♀MK x ♂MK(615g), ♀ON x ♂ SK(655g), ♀ON x ♂ MK(605g) and ♀ON x ♂ ON(571g), ♀SK x ♂MK(605g), ♀SK x ♂ ON(553g) and ♀SK x ♂SK(501g). Based on the findings of this research, it can be concluded that improving performance of fish population through intraspecific crosses of fish strains from

different eco-regions is possible. It is therefore recommended, amongst others, that there is a need to produce the F2 and F3 generations, and even go further to add selection yield in genetic gains. Also, there is a need to do a comparative study of growth performance of fish raised out in hapas, concrete tanks and earthen ponds.

**Keywords: Pure breed, Cross breed, Hybridization, Germplasm, Progenies.**

**Introduction**

Fish production through aquaculture is an age-long practice especially in Asia and Africa. For instance, production of the African catfishes Clarias gariepinus and Heterobranchus longifilis has been practiced for a long time in Africa (Adah et al., 2014). To ensure fish food security in Africa, increased production of fry and fingerlings with attributes of faster growth rates, high food conversion ratio and better environmental tolerance is greatly inevitable. Therefore, genetic techniques are needed to ensure the production of fish breeds with the aforementioned attributes.

Heterobranchus longifilis is one of the most important species for aquaculture practices all over the world. Outside Africa, it is farmed in Europe, China, Brazil and India (Huisman and Richer, 1987, In: Olufeagba and Okomoda, 2015). There have been several attempts to improve its genetic performance through hybridization, chromosome manipulation, improved feeding and water quality management (Aluko, 1998, In: Olufeagba and Okomoda, 2015). One major strategy in preventing regression in growth is genetic improvement through selective breeding. Cross-breeding different strains of H. longifilis to select for better spawning performance, survival and long-term growth has a great potential in improving this species which is currently limited by poor growth and high cost of production (Olufeagba and Okomoda, 2015). Heterobranchus longifilis is generally considered to be one of the most important tropical catfish species for aquaculture. It has an almost Pan-African distribution, ranging from the Nile to West Africa and from Senegal to Tanganyika (Azeroual et al., 2010).

In Nigeria, aquaculture is dominated by the Clariid fishes which are widely accepted and attracts high market value. The bane of the rapid development of aquaculture industry and stock management in Nigeria is the scarcity of genetically improved fish seed. There is therefore need to assess the genetic value of germplasm from different eco-regions and genetic gains that is possible from various mating combinations of this highly valued fish (Heterobranchus longifilis). Improving H. longifilis genetically in aquaculture is of great importance for so many reasons not only to improve production but also fast growth rate, marketability, culturability and the conservation of natural resources all year round. Mating combinations between strains from different eco-regions results in the production of improved offspring.

The Agriculture Promotion Policy, 2016 - 2020, document," The Green Alternative" enunciated by the Buhari Administration seeks to build an agribusiness economy capable of delivering **sustained prosperity** by meeting domestic food security goals, generating exports, and supporting sustainable income and job growth. In order to key into the objective of the "Green

 

Alternative", this research is designed to produce a strong genetic base for *Heterobranchus longifilis* as fish seed. Nigeria faces significant food security challenges, with growing population and limited domestic food production. Fish is an essential source of protein in Nigerian diet, but the country relies heavily on imports to meet demand. The result, if adopted, proposes a sustainable fish production initiative to enhance food security and poverty alleviation in Nigeria.

**Materials and Methods**

Sexually mature strains of *H. longifilis ,* were obtained from three eco-regions in Nigeria, namely; (1) Sahel Savanna at the Rima River in Sokoto (SK),(Lat.13.0059$^0$N, Long.5.2476$^0$ E), (2) Rainforest at the Niger River, Onitsha (ON) ( Lat., 6.1329$^0$N, Long.6.7924$^0$E) and (3) Guinea Savanna at the Benue River, Makurdi (MK), ( Lat,7.7322$^0$ N, Long.8.5391$^0$ E), respectively. The fish samples were transported live in 50 litres open black plastic jerry-cans with good aeration from the eco-regions to the Teaching and Research Farm of the Federal University of Agriculture, Makurdi and kept in earthen ponds.

Six (6) earthen ponds of small size (5x5x1.5m$^3$) were used for this purpose; each separately containing the male and the female fish samples from each of the eco-region. The fish samples were allowed two weeks to acclimatize. During this period, the fish were fed with 40% crude protein of fish feed for fattening. All the experiments were conducted at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi.

Three pairs each per sex per eco-region of similar size (2kg) were used for the breeding trials following the techniques adopted and reported by Ataguba *et al.*(2009) and Olufeagba *et al*.(2016). In brief, both sexes of the fish were injected with Ovaprim (Syndel, Canada) at the rate of 0.5ml/kg and maintained for latency period of 15h in separate tanks according to their sex and ecoregion. The eggs of the females from the same ecoregion were stripped into a bowl by applying light pressure on the abdominal part of the fish. The collected eggs from the females of the same ecoregion were then gently mixed using a chicken feather to make the eggs uniform. The male fish, conversely, were tranquilized using triacane methane sulphate (Wagner, *et al*,1997), before being euthanized to collect their testes. The milt from the testes of males of the same ecoregion was then used to fertilize the eggs from the same ecoregion, as well as eggs from the different ecoregions for both Parental and Intraspecific breeding experiments as shown below;

**Parental mating groups**

1. Sokoto ♀*H.longifilis*(SK) X ♂*H.longifilis* (SK )

2. Makurdi ♀*H.longifilis*(MK) X ♂*H.longifilis*(MK)

3. Onitsha ♀*H.longifilis*(ON) X ♂*H.longifilis*(ON)

**Intraspecific crosses**

1.♀*H.longifilis* (SK) X ♂*H.longifilis*(MK)

2.♀*H.longifilis*(SK) X ♂*H.longifilis*(ON)

3.♀*H.longifilis*(MK) X ♂*H.longifilis*(SK)

 

4.♀*H.longifilis*(MK) X ♂*H.longifilis*(ON)

5.♀*H.longifilis*(ON) X ♂*H.longifilis*(SK)

6.♀*H.longifilis* (ON) X ♂*H.longifilis* (MK)

♀ = female ♂ = male

After mixing the milt with the eggs, the sperm cells were activated by addition of freshwater. Fertilized eggs were quickly spread across the already prepared triplicate hatching troughs (1 × 1 × 0.5m3) for each eco-region crosses for the incubation process of the egg.

The eggs were maintained in this static system with continuous aeration until they were hatched.

After hatching, direct counting of un-hatched eggs and those on the floor of the bowl was done. Hatched eggs were determined on the basis of the percentage of unhatched eggs.

On the other hand, the percentage hatchability can be calculated using the equation below;

$$\%\, Hatchability = \frac{No. of\ Hatchlings}{Total\ No.\ of\ Eggs}\, X\, 100$$

Feeding of the fry commenced after the third day of hatching, firstly, with artemia for seven days and terminated, while indoor rearing continued in three replicates of 100 fry each in 50 litres plastic bowls, with feeding with 0.2mm Coppens. After two weeks of indoor rearing, the average percentage survival of each cross was determined. 50 fry from each parental and intraspecific crosses were transferred into hapas and reared outdoor in three replicates, and being fed continuously with various sizes of Coppens for 56 days. At this stage, the average weight of each cross was determined using a sensitive weighing balance and the average percentage survival of each cross was also determined.

Also, in order to determine the true commercial application of the intra-generic crosses, following a recommendation by Ataguba *et al* (2010), samples of the fish of each cross were further reared in earthen ponds for nine months. The juveniles of each of the nine mating combinations were stocked in separate earthen ponds and reared until the development of their gonads; being sampled on monthly basis. During this period, their weights were taken monthly, using Mettler weighing balance and growth performance was evaluated based on Mean weight gain, Mean final weight and Specific Growth Rate.

**Results and Discussion**

Table 1, shows the percentage hatchability of fertilized eggs of pure and intraspecific crosses of *H. longifilis*. Our study shows that all the three pure line crosses of *H. longifilis* had high percentage hatchability (85%) which were not significantly different from each other. The least percentage hatchability is 63% in the intraspecific cross between ♀ON x ♂MK. Apochi(2016), also reported highest percentage hatchability (94.40%) in pure line Calabar cross of *Clarias gariepinus*. Since the least percentage hatchability is 63%, it agrees with the report of Viveen, *et al,* 1986, that in general, the mean percentage hatching of eggs should be between 50-80% for successful breeding. The results obtained, therefore, provided a suitable platform for a successful breeding activity.

**Table 1: Percentage hatchability of pure and intraspecific crosses of strains *H. longifilis* from three eco-regions of Nigeria**

| Crosses | Hatchability (%) |
|---|---|
| ♀SK x ♂SK | 85.60 ± 6.97 |
| ♀MK x ♂MK | 85.00 ± 0.58 |
| ♀ON x ♂ON | 85.12 ± 3.87 |
| ♀SK x ♂MK | 83.00 ± 0.58 |
| ♀SK x ♂ON | 82.33 ± 0.33 |
| ♀MK x ♂SK | 70.00 ± 1.15 |
| ♀MK x ♂ON | 66.33 ± 0.33 |
| ♀ON x ♂SK | 84.33 ± 0.88 |
| ♀ON x ♂MK | 63.33 ± 1.76 |
| p-value | $2.31 \times 10^{-16}$ |

Fish egg hatchability could be attributed to several factors ranging from the intensity and stage of maturity of the parent stock. This is further buttressed by Blaster (1992), who stated that theoretically, apart from biological factors, physical and chemical parameters are known to affect egg development, for example; temperature is known to be the main environmental factor governing fish egg development.

The result of this study shows higher percentage hatchability compared to the reported work of the De Graaf and Jansesen (1996), who reported percentage hatching of 59.1% in *Clarias geriepinus,* Aluko and Popoola (2002), reported highest percentage hatchability of 96.09% in the cross involving Kainji and Jos *Heterobranchus longifilis*, Jacob (2017) recorded highest percentage hatchability in the cross between female Common carp Ibadan and male Common carp Bauchi (53.65%). Moses *et al*, (2005) reported 58.58% hatchability in Kaniji strain of *Clarias anguillaris*. Hatchability percentage lower than 50% was reported by Nwadukwe (1995), who reported 40-45% hatching success in *H. longifitis*. In addition, high percentage hatchability of 75 – 85% has been reported in *H. longifilis* by Lengendre et al; (1992).



 

The higher hatchability of the Sokoto strain might be as a result of egg quality. Kjorsvick (1991), observed that during mass rearing of marine fish larvae, variability in performance of eggs was attributed to egg quality.

Table 2, shows the probability of survival by mating combinations of indoor rearing of *H. longifilis* at day 14. There was a significant difference between the percentage survival and mortality of all the mating combinations ($p<0.05$). Generally, there was low survival and high mortality rates in the indoor rearing of the hatchlings in plastic bowls. The pure line cross between ♀ON x ♂ON had the highest percentage survival (35%), followed by intraspecific cross between ♀MK x ♂ON (32.7%) and least for intraspecific cross ♀MK x ♂SK (23%). The result showed a significant difference between the survival probability of pure breeds and intraspecific breeds, with pure breeds having higher survival rate.

**Table 2: Survival probabilities of crosses of strains of *H. longifilis* reared indoor**

| Crosses | Initial | Survivors | Mortality | Survival Probability |
|---|---|---|---|---|
| ♀MK x ♂MK | 300 | 80 | 220 | $0.267^{ab}$ |
| ♀MK x ♂ON | 300 | 98 | 202 | $0.327^{ab}$ |
| ♀MK x ♂SK | 300 | 69 | 231 | $0.230^{a}$ |
| ♀ON x ♂ON | 300 | 105 | 195 | $0.350^{b}$ |
| ♀ON x ♂MK | 300 | 71 | 229 | $0.237^{ab}$ |
| ♀ON x ♂SK | 300 | 76 | 224 | $0.253^{ab}$ |
| ♀ SK x♂SK | 300 | 70 | 230 | $0.233^{ab}$ |
| ♀ SK x♂MK | 300 | 83 | 217 | $0.277^{ab}$ |
| ♀ SK x ♂ON | 300 | 82 | 218 | 0.273ab |

Survival probabilities with different superscripts differ significantly($p<0.05$)

Table 3, shows the probability of survival by mating combinations of outdoor rearing of *H. longifilis* at day 56 (8wk). There was no significant difference between the percentage survival of all the mating combinations ($p<0.05$). The percentage survival for both pure line and intraspecific crosses were quite high with comparatively corresponding low mortality. The intraspecific cross between ♀ON x ♂SK had the highest percentage survival (80%), followed by the intraspecific cross between ♀ON x ♂MK (78.3%) and least for the pure line cross ♀MK x ♂MK (73.3%). The result showed that the intraspecific crosses of Onitsha strain of *H.longifilis* had higher survival rates than its pure line cross; ( ♀ON x ♂SK = 80%**,** ♀ON x ♂MK = 78.3%, and ♀ON x ♂ON=75.0%).

**Table 3: Survival probabilities of crosses of strains of *H. longifilis* reared outdoor**

| Crosses | Initial | Survivors | Mortality | Survival Probability |
|---|---|---|---|---|
| ♀MK x ♂MK | 60 | 44 | 16 | 0.733[b] |
| ♀MK x ♂ON | 60 | 45 | 15 | 0.750[b] |
| ♀MK x ♂SK | 60 | 46 | 14 | 0.766[b] |
| ♀ON x ♂ON | 60 | 45 | 15 | 0.738[b] |
| ♀ON x ♂MK | 60 | 47 | 13 | 0.783[b] |
| ♀ON x ♂SK | 60 | 48 | 12 | 0.800[b] |
| ♀ SK x♂SK | 60 | 46 | 14 | 0.767[b] |
| ♀ SK x♂MK | 60 | 45 | 15 | 0.750[b] |
| ♀ SK x ♂ON | 60 | 46 | 14 | 0.767b |

Survival probabilities not significantly different ($p<0.05$)

Growth and survival are among the most important trait determining yield potential. Purdon (1986) reported that species evolve to maximize their chances of survival against a background of turmoil. He stressed further that domestication of any species of animal or plant is likely to find the turmoil replaced by order and constancy. In this study, there was significant difference in the survival of both parental and intraspecific crosses in indoor rearing. For indoor rearing, highest percentage survival (35.0%) was in the pure line cross between ♀ON x ♂ON while for outdoor rearing, the highest percentage survival (80.0%) was in the intraspecific cross between ♀ON x ♂SK . For parental crosses, Makurdi strain had the highest percentage survival (35.0%) for indoor rearing while Sokoto strain had the highest percentage survival (76.7%) for outdoor rearing. This result is at variance with the work of Apochi (2016) who reported that there were no significant differences in the survival of both the indoor and outdoor rearing of parental and intraspecific crosses. This result, also, has proven the hybrid vigor as expected from intraspecific hybridization.

The pure line parental cross of Sokoto had the highest percentage hatchability (85.6%) but low survival rate (23.3%) for indoor rearing. However, its intraspecific cross with Onitsha strain yielded the highest percentage survival (80.0%) for outdoor rearing. The higher survival value recorded in the cross between parental Onitsha strain for indoor rearing and its intraspecific cross with Sokoto strain for outdoor rearing might be due to good survival trait of Onitsha strain. Mustapha and Rahman (1999) also stated that intra-population genetic diversity provides a range of genotype, thereby presenting more opportunities for survival and evolution under changing environmental conditions. Lamai (1999) reported 52.5%; 40% by Madu *et al*; (1991) and 25.4% by Sule (1991) survival for *Clarias gariepinus*. The low survival value in all the mating combinations for indoor rearing might be due to fluctuating temperature, inadequate conversion of feed by fry, medium of rearing and other likely variables. Brenda and Riley (1981) observed that the survival of larvae beyond yolk stage is dependent on the provision of a suitable food source as they have no built in reserve of food.

Table 4 shows the mean initial weight (MIW), mean final weight ( MFW), mean weight gain (MWG), percentage weight gain (%WG) and specific growth rate (SGR) for pure breeds and cross breeds of three strains *H. longifilis* from different eco-regions of Nigeria , reared under hatchery conditions in plastic bowls for 14days. The pure breed, ♀MK x ♂MK, showed lower weight gain (81.2%) than its cross breed ♀MK x ♂ON (86.2%) and ♀MK X ♂SK(82.3%). The growth rates of the two intraspecific hybrids ♀MK x ♂ON and ♀MK X ♂SK were significantly higher than that of the pure breed ♀MK x ♂MK . In terms of mean final weight, the cross breed ♀MK x ♂ON had a significantly higher weight (0.102g), ($P<0.05$) than the other cross breed and the pure line cross.

The cross breed ♀ONx♂MK had a significantly ($P<0.05$) higher weight gain (83.39%) than the other crosses; ♀ONx♂ON (82.76%) and ♀ONx♂SK (82.57%). The growth rate of the cross breed ♀ONx♂MK was significantly ($P<0.05$) higher than the other cross breed ♀ONx♂SK and pure line cross ♀ONx♂SK. Though higher, the growth rate between pure line cross ♀ONx♂ON and cross breed ♀ONx♂SK was not significantly different ($P<0.05$).

Generally, the growth rates of the cross breeds were significantly higher than the pure breeds. In terms of mean final weights, the cross breed ♀MKx♂ON had a significantly ($P<0.05$) higher weight than the other eight crosses. The pure breeds do not have close SGR; 0.119, 0.125 and 0.116 for ♀MKx♂MK, ♀ONx♂ON and ♀SKx♂SK, respectively. The cross breed ♀MKx♂ON had the highest weight gain (86%) which was significantly different from all other crosses. Growth pattern is similar for all the crosses (Figure 1).

**Table 4: Variations of Growth Parameters of indoor rearing of pure line and cross breeds of strains of *H. longifilis* from Day 4 after hatching for 14 days**

| Growth Parameters |
|---|

| Mating Combinations | MIW(g) | MFW(g) | MWG(g) | %WG | SGR(g) | FCR(g) |
|---|---|---|---|---|---|---|
| ♀MK X ♂MK | 0.014±0.00 | 0.075±0.00$^{de}$ | 0.061±0.01$^{de}$ | 81.290±0.64$^{de}$ | 0.119±0.00$^{de}$ | 0.006±0. |
| ♀MK X ♂ON | 0.014±0.00 | 0.102±0.00$^{a}$ | 0.088±0.00$^{a}$ | 86.274±0.07$^{a}$ | 0.141±0.00$^{a}$ | 0.004±0. |
| ♀MK X ♂SK | 0.014±0.00 | 0.079±0.01$^{cd}$ | 0.065±0.00$^{cd}$ | 82.343±0.29$^{bcd}$ | 0.123±0.00$^{bcde}$ | 0.006±0. |
| ♀ON X ♂MK | 0.013±0.00 | 0.084±0.00$^{bc}$ | 0.070±0.00$^{bc}$ | 83.394±0.74$^{bc}$ | 0.128±0.00$^{bc}$ | 0.006±0. |
| ♀ON X ♂ON | 0.014±0.00 | 0.079±0.00$^{cd}$ | 0.065±0.01$^{cd}$ | 82.760±1.18$^{bcd}$ | 0.125±0.00$^{bcd}$ | 0.005±0. |
| ♀ON X ♂SK | 0.014±0.00 | 0.080±0.00$^{cd}$ | 0.066±0.00$^{cd}$ | 82.572±0.07$^{bcd}$ | 0.124±0.00$^{bcd}$ | 0.006±0. |
| ♀SK X ♂MK | 0.014±0.00 | 0.078±0.00$^{d}$ | 0.064±0.00$^{d}$ | 81.784±0.26$^{cde}$ | 0.121±0.00$^{cde}$ | 0.006±0. |
| ♀SK X ♂ON | 0.014±0.00 | 0.089±0.02$^{b}$ | 0.074±0.01$^{b}$ | 83.871±0.63$^{b}$ | 0.130±0.00$^{b}$ | 0.006±0. |
| ♀SK X ♂SK | 0.013±0.00 | 0.070±0.00$^{e}$ | 0.056±0.01$^{e}$ | 80.394±0.73$^{bc}$ | 0.116±0.01$^{e}$ | 0.007±0. |
| P-value | - | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |

Means on the same column with different superscript are statistically significant ($p<0.05$)

 

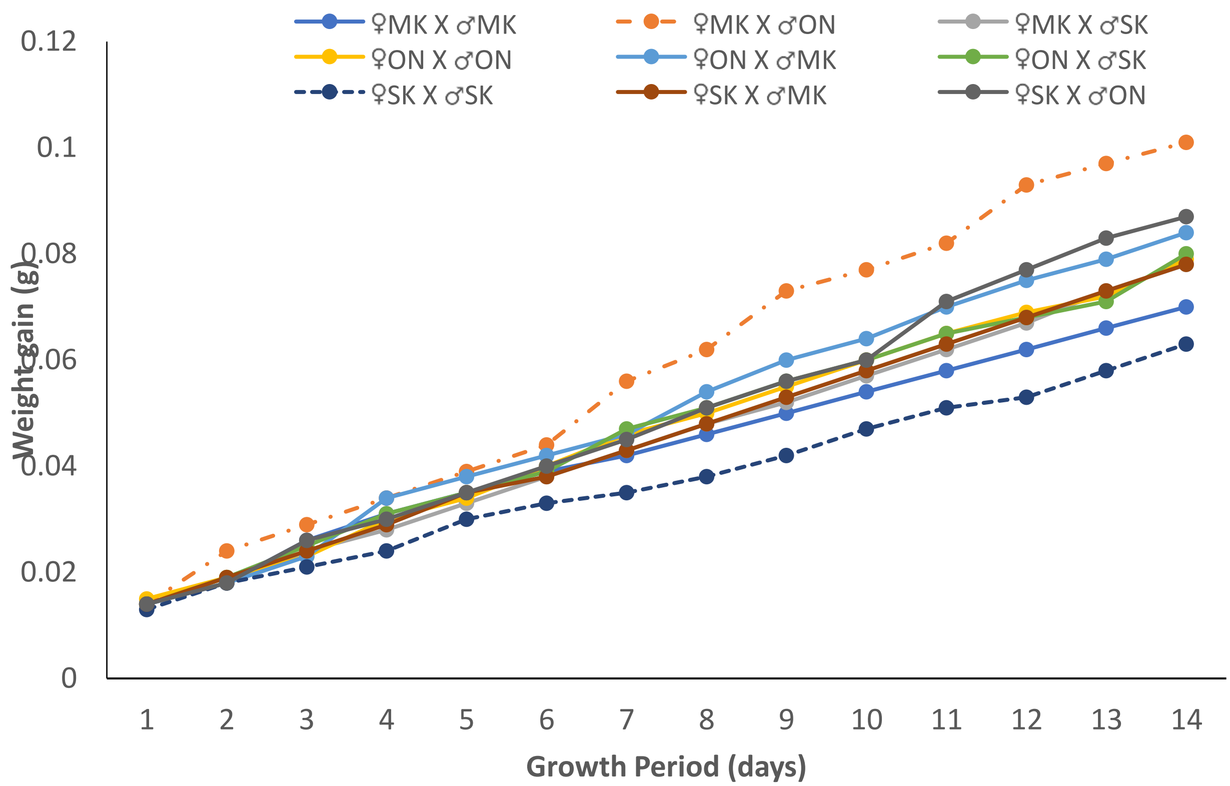


**Figure 1: Growth curve of indoor rearing of pure and reciprocal crosses of *H. longifilis* from three eco-regions of Nigeria**

Table 5 shows the mean initial weight (MIW), mean final weight (MFW), mean weight gain (MWG), percentage weight gain (%WG) and specific growth rate (SGR) for pure breeds and cross breeds of three strains of *H.longifilis* from different eco-regions of Nigeria , reared out door inside hapas for 56days. The pure breed, ♀MK X ♂MK, showed lower weight gain (92.6%) than its cross breed ♀MKx♂ON (92.8%) and ♀MK X ♂SK (92.7%). The growth rates of the two intraspecific hybrids of Makurdi strain were not significantly higher than that of the pure hybrid ($P<0.05$). In terms of mean final weight, the cross breed ♀MK X ♂SK had no significantly ($P<0.05$) higher weight (1.563g) than the other cross breed and the pure line cross.

Generally, the growth rates of the cross breeds were higher than the pure breeds but not significantly different. In terms of mean final weights, the cross breed ♀MK X ♂SK had a higher weight than the other eight crosses. The pure hybrids had similar SGR,0.046,0.046 and 0.046 for ♀MK X ♂MK, ♀ON x ♂ON and ♀SK x ♂SK, respectively. The cross breed, ♀MK X ♂ON, had the highest weight gain (92.88%) which was though not significantly different from all other crosses. Growth pattern was similar for all the crosses (Figure 2).

 

**Table 5: Variations of Growth Parameters of outdoor rearing of pure lines and cross breeds of *H. longifilis* from Day 15 after indoor rearing for 56 days**

| Sex Combinations | Growth Parameters | | | | | |
|---|---|---|---|---|---|---|
| | MIW(g) | MFW(g) | MWG(g) | %WG | SGR(g) | FCR(g) |
| ♀MK X ♂MK | 0.111±0.00 | 1.518±0.00 | 1.407±0.06 | 92.624±0.28 | 0.046±0.00 | 0.0023±0.00 |
| ♀MK X ♂ON | 0.110±0.00 | 1.560±0.06 | 1.450±0.06 | 92.887±0.28 | 0.047±0.00 | 0.0022±0.00 |
| ♀MK X ♂SK | 0.111±0.00 | 1.563±0.06 | 1.450±0.06 | 92.765±0.33 | 0.046±0.00 | 0.0023±0.00 |
| ♀ON X ♂MK | 0.110±0.00 | 1.546±0.05 | 1.435±0.05 | 92.828±0.20 | 0.047±0.00 | 0.0023±0.00 |
| ♀ON X ♂ON | 0.110±0.00 | 1.521±0.06 | 1.411±0.06 | 92.703±0.29 | 0.046±0.00 | 0.0023±0.00 |
| ♀ON X ♂SK | 0.110±0.00 | 1.531±0.05 | 1.420±0.05 | 92.748±0.32 | 0.046±0.00 | 0.0023±0.00 |
| ♀SK X ♂MK | 0.111±0.00 | 1.516±0.05 | 1.406±0.05 | 92.686±0.25 | 0.046±0.00 | 0.0023±0.00 |
| ♀SK X ♂ON | 0.110±0.00 | 1.535±0.06 | 1.423±0.06 | 92.676±0.34 | 0.046±0.00 | 0.0023±0.00 |
| ♀SK X ♂SK | 0.110±0.00 | 1.492±0.05 | 1.380±0.05 | 92.450±0.28 | 0.046±0.00 | 0.0024±0.00 |
| P-value | - | $0.99^{ns}$ | $0.99^{ns}$ | $0.99^{ns}$ | $0.99^{ns}$ | $0.99^{ns}$ |

ns = not significant



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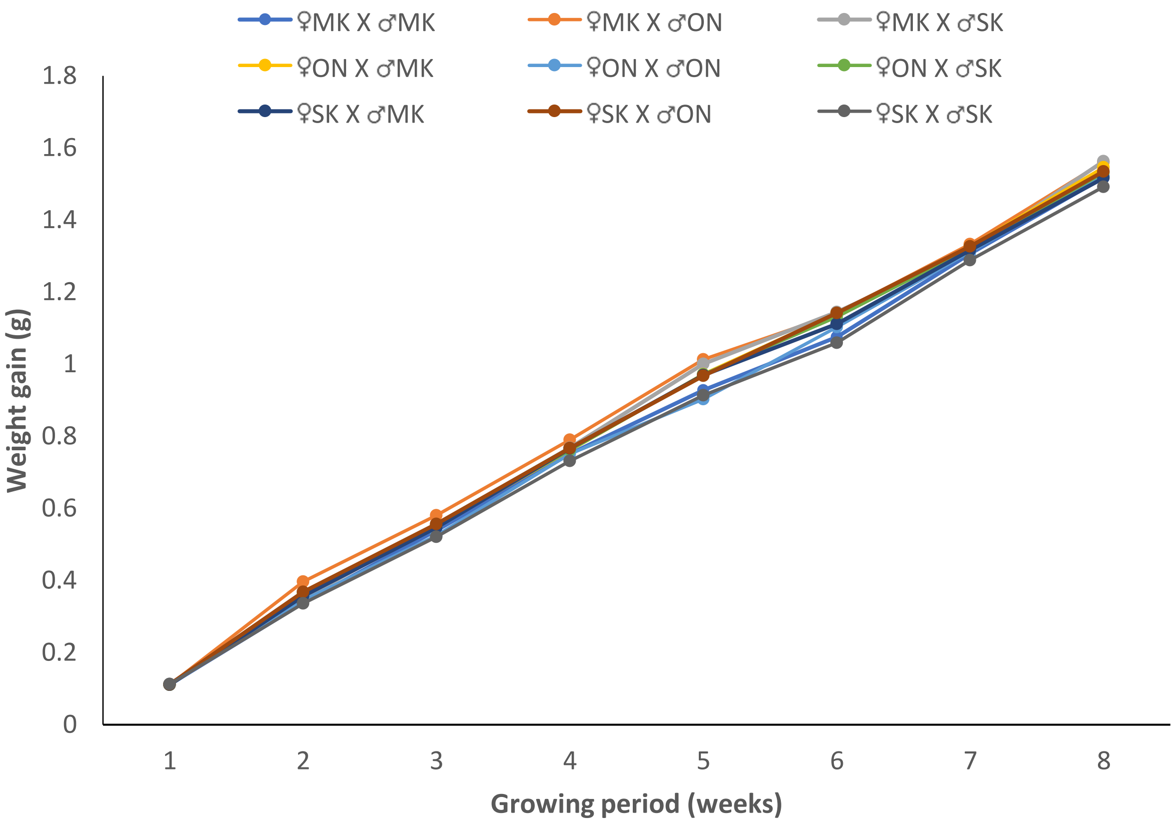


**Figure 2: Growth curve of outdoor rearing of pure and reciprocal crosses of *H. longifilis* from three eco-regions of Nigeria**

Table 6 shows the MIW ( Mean Initial Weight), MFW (Mean Final Weight), MWG (Mean Weight Gain), ADG (Average Daily Weight Gain)and SGR (Specific Growth Rate) of the progenies of the various mating combinations of *H. longifilis* which were further reared in earthen ponds to sexual maturity for a period of nine months (270 days) after outdoor rearing in hapas. There was a significant difference in MIW across the crosses. As a result, Analysis of Covariance was carried out to check the significance of interaction between MIW and the crosses. All ANCOVA results showed that the MIW had no significant effect on all measured parameters across the crosses. To this end, the results of one way ANOVA were used here. At nine months of rearing in earthen ponds the cross breed ♀MK X ♂SK attained the highest weight of 700.00±5.77g while the least weight (501.67±1.67g) was observed in the pure line cross ♀SK x ♂SK. All the cross breeds had higher weights than their corresponding pure line breeds at nine months rearing in earthen ponds: ♀MK x ♂SK, ♀MK x ♂ON and ♀MK x ♂MK had 700.00±5.77g, 653.33±8.82g and 615.00±17.6g, respectively. In like manner, the cross breeds and pure line breed of Onitsha strain had the following weights; ♀ON x ♂SK (655.00±2.89g), ♀ON x ♂MK (605.00±2.89g) and ♀ON x ♂ON (571.67±1.67g). The Sokoto strain followed a similar trend as follows; ♀SK x ♂MK (605.00±2.89g), ♀SK x ♂ON (553.33±3.33g) and ♀SK x ♂SK (501.67±1.67g). Growth pattern was similar for all the crosses (Fig.3).

**Table 6: Variations of mean weights of F1 grow-out of pure lines and cross breeds of *H. longifilis* reared in earthen ponds to sexual maturity (combined sexes)**

| Cross | MIW (g) | MFW (g) | MWG (g) | ADG (g) | SGR |
|---|---|---|---|---|---|
| ♀MKx♂MK | 1.58 ± 0.01[d] | 615.00 ± 17.6[d] | 613.42 ± 17.6[d] | 2.27 ± 0.06[d] | 2.21 ± 0.01[cd] |
| ♀MKx♂ON | 1.56 ± 0.02[cd] | 653.33 ± 8.82[e] | 651.77 ± 8.80[e] | 2.41 ± 0.03[e] | 2.24 ± 0.00[e] |
| ♀MKx♂SK | 1.56 ± 0.00[cd] | 700.00 ± 5.77[f] | 698.44 ± 5.77[f] | 2.59 ± 0.02[f] | 2.26 ± 0.00[f] |
| ♀ONx♂MK | 1.52 ± 0.00[ab] | 605.00 ± 2.89[cd] | 603.48 ± 2.89[cd] | 2.24 ± 0.01[cd] | 2.21 ± 0.00[d] |
| ♀ONx♂ON | 1.55 ± 0.00[bc] | 571.67 ± 1.67[bc] | 570.12 ± 1.67[bc] | 2.11 ± 0.01[bc] | 2.19 ± 0.00[b] |
| ♀ONx♂SK | 1.53 ± 0.00[bc] | 655.00 ± 2.89[e] | 653.47 ± 2.88[e] | 2.42 ± 0.01[e] | 2.24 ± 0.00[ef] |
| ♀SKx♂MK | 1.53 ± 0.00[bc] | 605.00 ± 2.89[cd] | 603.46 ± 2.89[cd] | 2.24 ± 0.01[cd] | 2.21 ± 0.00[d] |
| ♀SKx♂ON | 1.49 ± 0.00[a] | 553.33 ± 3.33[b] | 551.84 ± 3.33[b] | 2.04 ± 0.01[b] | 2.19 ± 0.00[bc] |
| ♀SKx♂SK | 1.52 ± 0.00[ab] | 501.67 ± 1.67[a] | 500.15 ± 1.67[a] | 1.85 ± 0.01[a] | 2.15 ± 0.00[a] |
| p-value | $7.05 \times 10^{-7}$ | $6.09 \times 10^{-12}$ | $6.05 \times 10^{-12}$ | $6.05 \times 10^{-12}$ | $4.95 \times 10^{-13}$ |

MIW = Mean Initial Weight; MFW = Mean Final Weight; MWG = Mean Weight Gain; ADG = Average Daily Weight Gain; SGR = Specific Growth Rate



 

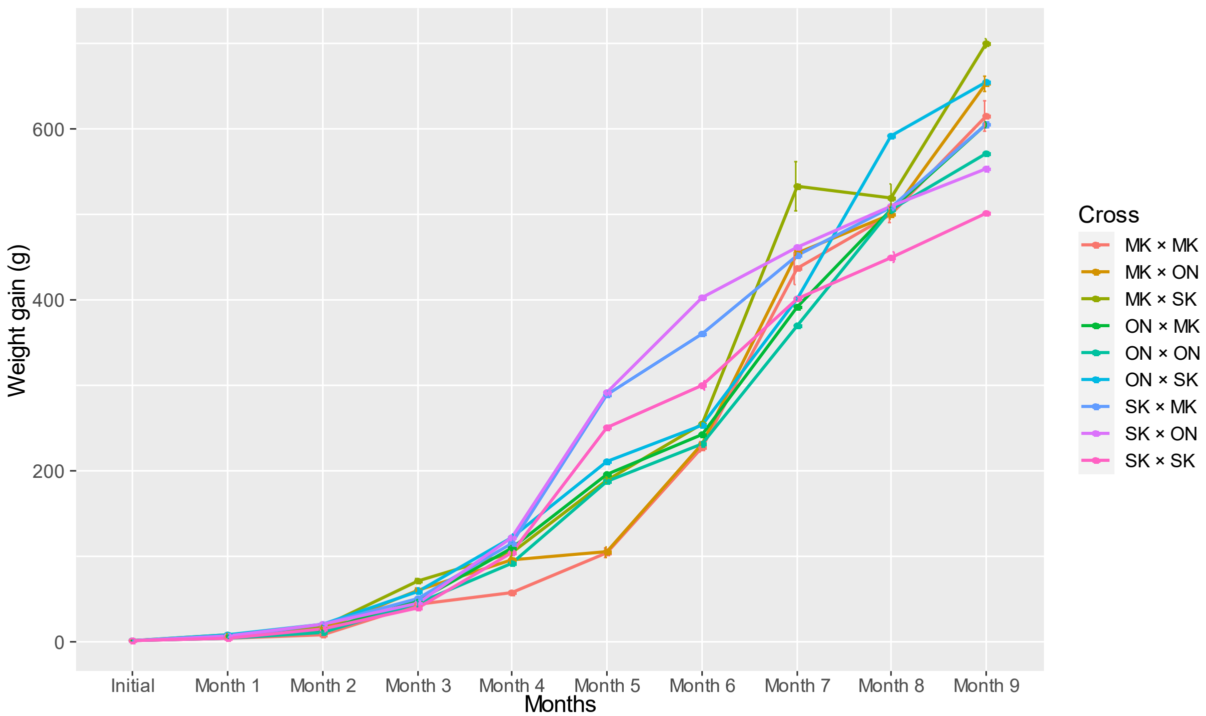


**Figure 3: Growth curve for nine months of rearing in earthen ponds of *H. longifilis* to sexual maturity**

The mean final weights of the nine generic groups under study ranged from 0.070g to 0.102g for indoor rearing and 1.492g to 1.563g for outdoor rearing. For outdoor rearing, the least mean final weight was 1.492g. This value is significantly higher than the value of 1.069g reported for the same pure line cross of *H. longifilis* by Ataguba *et al*; (2010). The maximum growth recorded in the hybrid after eight weeks of outdoor rearing was 1.563g in the intraspecific cross involving female Makurdi and male Sokoto. This is significantly lower than the values obtained by Aluko and Popoola (2002) who working with *H. longifilis*, recorded maximum growth in five weeks of outdoor rearing of 2.460g in the Kainji strain and maximum of 1.984g in the Onitsha strain. Also, among the hybrids, maximum growth was observed in the cross involving female Onitsha and male Kainji (3.000g) and minimum of 1.822g recorded for female Kainji and male Onitsha. This observation may likely be due to the difference in the medium/environment of rearing. The phenotypic variance of a quantitative trait such as growth and survival is governed by the genetic variance, environmental variance and the interaction between the genetic variance and environmental variance (Tave, 1993). A negative interaction between the genetic variance of the hybrid and the environment may have led to poor phenotypic expression of growth. The weight of 1.563g obtained for the cross between female MK x male SK is comparable to the crosses of two strains of *Heterobranchus longifilis* reported by Nguenga *et al*. (2000). There was no significant difference in specific growth rate among the nine genetic groups studied, ($P<0.05$). De-Graaf *et al*; (1995) reported a specific growth rate of 6.9% day$^{-1}$ for *Clarias gariepinus* stocked at a low stocking rate and reared for a long period of (≥51 days). This is higher than the value of 4.7% day$^{-1}$ discovered in the present study. The SGR of 4.6% day$^{-1}$ to 4.7% day$^{-1}$ reported in the present study for the nine genetic groups of *Heterobranchus longifilis* is significantly higher than the range of 2.12% day$^{-1}$ to 3.96% day$^{-1}$ reported for various strains of *Heterobranchus longifilis* by Nguenga *et al*; (2000) and significantly lower than 8.82% as reported by Ataguba *et al*; (2010). Nlewadim *et al*; (2004) reported SGR of 12.0%. day$^{-1}$, 11.6% day$^{-1}$, 11.2%$^{-1}$ and 11.0% day$^{-1}$ for crosses ♀CL x ♂CL, ♀Ht x ♂Ht , ♀Ht x ♂CL and ♀CL x ♂Ht, respectively. (CL = *Clarias gariepinus*, Ht= *Heterobranchus longifilis*). These are, also higher than values of 4.6% day $^{-1}$, 4.7% day $^{-1}$, 4.6% day$^{-1}$, 4.7% day$^{-1}$ 4.6% day$^{-1}$, 4.6% day $^{-1}$, 4.6%day$^{-1}$ , 4,6% day$^{-1}$ and 4.6% day$^{-1}$ reported in our present study.

Hitherto, most growth performance studies of fish have been terminated at week eight (56 days) of rearing. In this study, in order to determine the true commercial application of the intra-generic crosses, following a recommendation by Ataguba *et al* (2010), samples of the fish of each cross (combined sexes) were further reared to sexual maturity in earthen ponds for nine months; the results which have already been shown.

**Conclusion**

From the results obtained, it can be conluded that intraspecific hybridization of germplasm from different strains of *Heterobranchus longifilis* resulted in genetic improvement of the hybrid, thereby improving the performance of the fish. Also, based on the findings of this research, it can be concluded that improving performance of fish population through intraspecific crosses of fish strains from different eco-regions is possible. In addition, all the fish had similar growth pattern.

**Contribution to Knowledge**

1. Results of both survival and growth performance of progenies of intraspecific crosses of the three strains of *Heterobranchus longifilis* comfirmed hybrid vigor or positive heterosis.

**Recommendations**

1. There is need to produce the F2 and F3 generations and even go further to add selection yield in genetic gains.

2. There is need to do a comparative study of growth performance of the fish raised out in Hapas, concrete tank and earthen pond.

3. Governments/ Institutions should show more interest in selective breeding work by providing adequate funds for research; obvious reason being the genetic gain derivable fom such studies.

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