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Determination of Survival and Growth Performance of the Progenies of Broodstock of *C. gariepinus* from three eco-regions in Nigeria: River Niger (N), River Benue (B) and River Hadejia (H)

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ABSTRACT

The study was designed and experimented on the determination of survival and growth performance of the progenies from three eco-regions: River Niger (N), River Benue (B) and River hadejia (H). One hundred hatchlings from each broodstock group for each cross were selected randomly and reared in plastic tanks (60L) for eight weeks using four replicates in each case. These were fed to satiation twice a day (morning: 08:00H and afternoon: 16:00H) using commercial feed (Bluecrown). The experiment lasted for fifty-six days and mean fish weight in each tank was determined every week beginning from the day they were stocked. Waste removal was done via siphoning every three days. For sampling, fish in each tank were weighed in bulk on a sensitive balance using the wet sampling method. After the 56 days period, the surviving juveniles were counted and all fish from the tank were weighed in bulk. Progeny produced were subjected to grow-out for eight weeks (two broodstock sizes). Data for growth and survival (8 weeks) were analysed using one way analysis of variance (ANOVA) and t-test with treatments as appropriate. There was a significant effect ($p<0.05$) of cross on the mean final weight (MFW) under eight weeks of culture among offspring from broodstock >1.0kg with the cross ♀B×H♂ having the highest MFW of 7.74g while the cross ♀N×N♂ had the least MFW of 5.27g. Among progeny of broodstock <1.0kg, there was a significant effect ($p<0.05$) of cross on the mean final weight (MFW) with the cross ♀H×B♂ having the highest MFW of 8.42g while the cross ♀N×N♂ had the least MFW of 5.16g.It was concluded that determination of survival and growth performance of the progenies from three eco-regions: River Niger (N), River Benue (B) and River hadejia (H) were enormous.

Keywords: Survival and growth, performance, *C. gariepinus*, eco-region, Nigeria

1.0 Introduction

The more important factors influencing larval survival are, however, hatchery design, water temperature, water flow rate and prophylactic parasitic treatment(Fourie, 2006). Haylor and Mollah (1995)discovered that temperature significantly affected wet weight at first feeding. They reported that temperature between 20 and 35°C affected the time until the onset of first feeding, yolk sac absorption and the point when unfed larvae no longer have the ability to consume feed offered to them (point-of-no-return). The duration between attaining feeding ability, yolksac absorption and the point-of-no-return is inversely related to temperature. So that at temperatures of 20 and 25°C the optimum period in which to initiate exogenous feeding is 28 and 24 h duration respectively, at 30°C and 35°C this window is less than 12 h.Madu and Ita (1990) compared growth and survival of hatchlings of *Clarias* sp.,*Clarias* hybrid and *Heterobranchus*sp. in an indoor hatchery. They reported that *C. anguillaris* had the highest percentage survival (78.8%) whereas; hybrid *Clarias* (♀ × ♂) had the lowest rate of 56.6%.

Survival rates depend on stocking density and carrying capacity of the rearing facility. If stocking density exceeds the carrying capacity of the tank, mortality is bound to be high. Madu et al. (1989) stocked fry of the common carp *C. carpio* in nursery tanks (6 × 6 × 1.5m) at rates of 80, 107, 133, 160 and 180 fry per m^3. They reported a generally good survival rate for all stocking densities ranging from 82.6% at the stocking rate of 107 fry m^{-3} to 96.0% obtained at a stocking rate of 133 fry m^{-3}. Nwadukwe (1995) successfully hybridized *C. gariepinus* and *H. longifilis* to produce reciprocal F_1 progeny. After rearing eight-day old fry of each group in fertilized nursery ponds, he discovered that F_1 hybrids from *H. longifilis* maternal parent had the best survival rates at the end of 18 days.Sarkar et al. (2004)reported a survival rate of 90% as at day four for fry of vulnerable Indian carp *Cirrhinusreba* propagated artificially with Ovaprim. This rate however dropped to 55% after 15 days of larval rearing.

The performance of fish can be evaluated according to their growth rate or specific growth rate. Although both these growth parameters can be used, the specific growth rate of fish tends to give a clearer indication of fish growth (Fourie, 2006). Madu et al. (1989)reported higher growth rates (0.03 mg g^{-1} day^{-1}) for fry of the common carp *C. carpio* stocked at 80 fry m^{-3}. However, they recommended a stocking density of 133 fry m^{-3} for maximum fry survival when transferred outdoors.With regards to catfish, Aluko et al. (1999)studied the growth performance of intraspecific hybrids of three strains (Kainji, Jos and Onitsha) of *H. longifilis*. Over a period of five months, they reported the best weight gain of 0.35g/day for the Kainji strain among the parental groups and the least value of 0.32 g/day was obtained in the Onitsha strain. They further reported that among the intraspecific hybrids, the Jos – Kainji cross gave the best weight gain (0.45 – 0.48g/day) and the least length gain of 0.063cm/day. The least weight gain of 0.33g/day was recorded for the Jos – Onitsha groups though these were longer (0.085cm/day).Nwadukwe (1995) reported that F_1 hybrid crosses between maternal *H. longifilis* and paternal *C. gariepinus* had the best growth rate compared to the reverse of parental order. He further reported that the reciprocal cross showed intermediate growth rate between both parents. At harvest, differential growth was less pronounced among both hybrids than among the parents.Physico-chemical parameters of water have significant effect on the growth of fingerlings. Brazil and Wolters (2002) reported better weight gain for fingerlings of channel catfish *I. punctatus* reared for 85 days in ozonated water than fish reared in un-ozonated waters. Feed conversion rates of 1.06 and 1.15 under ozonated and un-ozonated conditions, respectively, were significantly different. They reported that dissolved oxygen levels in ozonated water remained above 85% saturation during and immediately following feeding, while oxygen concentrations in un-ozonated waters routinely fell below 3.5 mg/L (40% of saturation). Water clarity improved and chemical oxygen demand was reduced after ozonation.

Aims and Objectives

Determined survival and growth performance of the progenies of *C. gariepinus* broodstock from the three eco-regions

2.0 Materials and Methods

The study Area

This study was carried out in Makurdi, Benue State. Makurdi is located on latitude 7° 43' 55.92" N and 8° 32' 20.76" E. Makurdi town has two main seasons: the wet season usually between April and October and the dry season usually between November and March. Wild broodstock of *Clarias gariepinus* were obtained from artisanal fishermen along the River Hadejia and Jama'are (H) basin and flood plains, River Niger at Lokoja (N) and River Benue (B) at Makurdi.

Determination of Water Quality Parameters

Water obtained from a borehole was used for the hatchery and rearing experiments. The physicochemical parameters of water in the incubation tanks as well as the ponds used for rearing were analyzed as per standard methods by APHA (2005).

Temperature: The temperature of water in each tank was taken using mercury in glass thermometer (0-100^{0}C) every sampling morning.

Hydrogen ion concentration (pH): The pH of the water in the tanks was taken using an electronic pH meter - B. Bran Scientific pH-meter (Model pHS – 25).
Dissolved Oxygen (DO): This was measured using Hanna Multiparameter Water Quality Probe Model HI-98129.

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Experimental Design
Completely randomized design was adopted for the experiments. The Crosses served as treatment alongside tanks and hapas allotment (replication).

Determination of Growth Parameters and Survival Rate
One hundred hatchlings from each broodstock group for each cross were selected randomly and reared in plastic tanks (60L) for eight weeks using four replicates in each case. These were fed to satiation twice a day (morning: 08:00H and afternoon: 16:00H) using commercial feed (Bluecrown). The experiment lasted for fifty-six days and mean fish weight in each tank was determined every week beginning from the day they were stocked. Waste removal was done via siphoning every three days. For sampling, fish in each tank were weighed in bulk on a sensitive balance using the wet sampling method. After the 56 days period, the surviving juveniles were counted and all fish from the tank were weighed in bulk.

Parameters to be determined include:
- Standard length and total length: Metre ruler
- Initial mean weight (g): Electronic weighing scale
- Final mean weight (g);
- Weight gain,: $W_1 - W_0$(g);
- DailyWeight Gain (DWG):$DWG = \frac{W_1 - W_0}{t}$and
- Specific growth Rate (SGR):$SGR = \frac{lnW_1 - lnW_0}{t} \times 100$

Where: W_0 = initial mean body weight,

W_1 = final mean body weight

t = time (days)

- Survival Rate (SR): $SR = \frac{No.Stocked - No.of\ Survivors}{No.Stocked} \times 100$

Data Analysis
Data for growth and survival (8 weeks) were analysed using one way analysis of variance (ANOVA) and t-test with treatments as appropriate.

3.0 Results

Survival and growth performance of the progenies

Early growth performance
The pattern of growth in terms of weight increase according to weeks of sampling for progenies from large broodstock (>1.0kg) (Figure4.7)shows that there was a fairly consistent pattern of weight incerease with progenies from the cross ♀N×N♂ lagging behind followed by progenies from the cross ♀H×B♂. There was no significant difference ($p>0.05$) in the mean initial weight (MIW) of progenies from the crosses (Table 4.8). This ranged from 0.04 to 0.05g. There was a significant effect ($p<0.05$) of cross on the mean final weight (MFW) with the cross ♀B×H♂ having the highest MFW of 7.74g while the cross ♀N×N♂ had the least MFW of 5.27g. Daily weight gain (DWG) was also significantly affected ($p<0.05$) by cross such that the least value of 0.09g.day^{-1} was recorded for progeny from the cross ♀N×N♂ while the highest value of 0.14g.day^{-1} was recorded among three crosses: ♀B×B♂, ♀B×N♂, ♀B×H♂. Specific growth rate (SGR) was independent of cross ($p>0.05$) as was the survival rate.

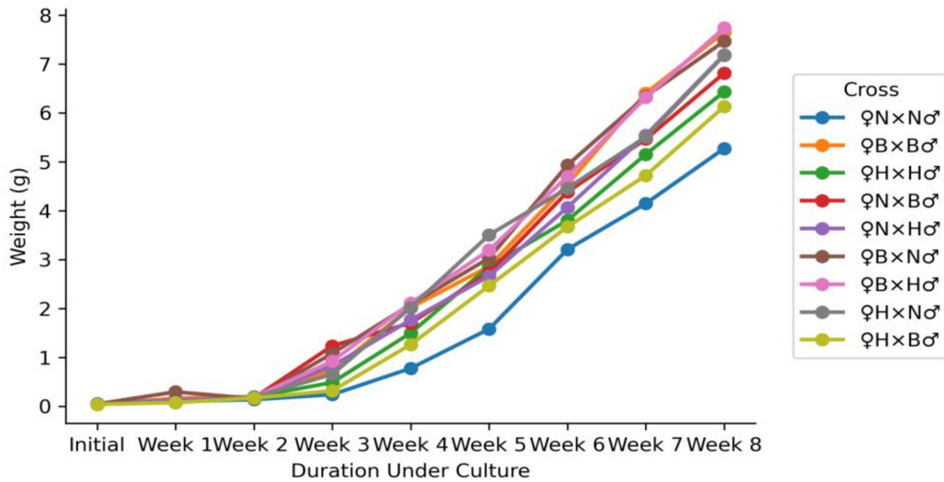

Figure 4.7. Weekly body weight progression of progeny from crosses of broodstock (>1.0kg) from three eco-regions

Table 4.8. Growth performance of progeny from crosses of broodstock (>1.0kg) from three eco-regions

Cross	MIW (g)	MFW (g)	DWG (g/day)	SGR (%/day)	Survival (%)
♀N×N♂	0.04 ± 0.01	5.27 ± 0.42[d]	0.09 ± 0.01[c]	8.68 ± 0.32	76.25 ± 2.14
♀B×B♂	0.04 ± 0.01	7.65 ± 0.26[a]	0.14 ± 0.00[a]	9.72 ± 0.31	69.50 ± 2.10
♀H×H♂	0.04 ± 0.00	6.43 ± 0.40[bc]	0.11 ± 0.01[b]	9.09 ± 0.28	80.50 ± 4.56
♀N×B♂	0.05 ± 0.00	6.82 ± 0.15[abc]	0.12 ± 0.00[ab]	8.79 ± 0.11	76.50 ± 2.40
♀N×H♂	0.05 ± 0.00	7.19 ± 0.59[ab]	0.13 ± 0.01[ab]	8.87 ± 0.24	80.00 ± 5.76
♀B×N♂	0.04 ± 0.00	7.47 ± 0.25[ab]	0.14 ± 0.00[a]	9.14 ± 0.10	75.00 ± 3.44
♀B×H♂	0.04 ± 0.00	7.74 ± 0.22[a]	0.14 ± 0.00[a]	9.20 ± 0.17	71.50 ± 3.80
♀H×N♂	0.05 ± 0.00	7.18 ± 0.31[abc]	0.13 ± 0.00[ab]	8.88 ± 0.20	70.25 ± 2.90
♀H×B♂	0.04 ± 0.00	6.13 ± 0.46[cd]	0.11 ± 0.01[bc]	9.10 ± 0.20	68.00 ± 3.63
p-value	0.201	0.001	0.000	0.118	0.168

Means in the same column followed by different superscripts differ significantly ($p<0.05$)

The pattern of growth in terms of weight increase according to weeks of sampling for progenies from small broodstock (<1.0kg) (Figure4.8)shows that there was a fairly consistent pattern of weight incerease with progenies from the cross ♀H×B♂ being ahead beginning from week 3 to week 8 while the cross♀N×N♂ lagged behind followed by progenies from the cross ♀N×B♂ and ♀N×H♂.

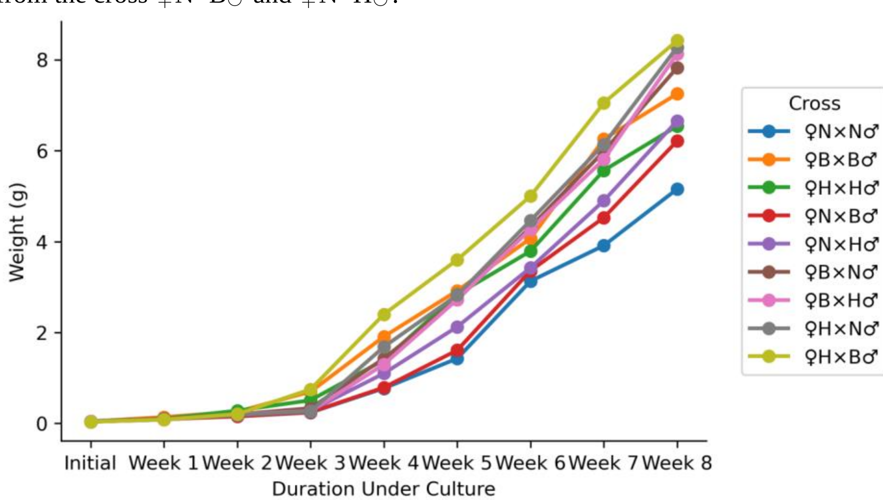

Figure 4.8. Weekly body weight progression of progeny from crosses of broodstock (<1.0kg) from three eco-regions

Among progenies from crosses of broodstock <1.0kg (Table 4.9), there was no significant difference (p>0.05) in the mean initial weight (MIW) of progenies from the crosses. This ranged from 0.04 to 0.05g. There was a significant effect (p<0.05) of cross on the mean final weight (MFW) with the cross ♀H×B♂ having the highest MFW of 8.42g while the cross ♀N×N♂ had the least MFW of 5.16g. Daily weight gain (DWG) was also significantly affected (p<0.05) by cross such that the least value of 0.09g.day^{-1} was recorded for progeny from the cross ♀N×N♂ while the highest value of 0.15g.day^{-1} was recorded among two crosses: ♀H×N♂, ♀H×B♂. Specific growth rate (SGR) was significantly affected by cross (p<0.05) with the cross ♀N×N♂ having the least SGR of 8.39%.day^{-1} while the cross ♀H×B♂ had the highest SGR value of 9.71%.day^{-1}. There is no significant difference (p>0.05) in the survival rates of progenies from broodstock <1.0kg.

The effect of broodstock size on the performance of progenies (Table 4.10) was not significant (p>0.05). All parameters were not affected by the variation in broodstock size.

Water quality (Table 4.11) in the tanks used to rear the progenies indicates that dissolved oxygen was optimal and ranged from 6.66mg.l^{-1} to 7.22mg.l^{-1} while temperature ranged from 27.40°C to 28.27°C. The pH ranged from 6.54 to 7.37. A detailed breakdown of the water quality parameters is presented in the appendix (Appendix 2).

Table 4.9. Growth performance of progeny from crosses of broodstock (<1.0kg) from three eco-regions

Cross	MIW (g)	MFW (g)	DWG (g/day)	SGR (%/day)	Survival (%)
♀N×N♂	0.05 ± 0.00	5.16 ± 0.18^{e}	0.09 ± 0.00^{e}	8.39 ± 0.21^{c}	74.75 ± 2.56
♀B×B♂	0.04 ± 0.01	7.25 ± 0.12^{bc}	0.13 ± 0.00^{bc}	9.23 ± 0.23^{ab}	71.25 ± 1.49
♀H×H♂	0.05 ± 0.01	6.54 ± 0.37^{d}	0.12 ± 0.01^{d}	8.79 ± 0.28^{bc}	79.50 ± 4.92
♀N×B♂	0.04 ± 0.00	6.21 ± 0.23^{d}	0.11 ± 0.00^{d}	9.16 ± 0.18^{ab}	80.50 ± 4.11
♀N×H♂	0.04 ± 0.00	6.66 ± 0.29^{cd}	0.12 ± 0.01^{cd}	9.38 ± 0.15^{ab}	80.00 ± 7.36
♀B×N♂	0.04 ± 0.00	7.82 ± 0.14^{ab}	0.14 ± 0.00^{ab}	9.22 ± 0.14^{ab}	75.75 ± 6.24
♀B×H♂	0.04 ± 0.00	8.13 ± 0.31^{a}	0.14 ± 0.01^{a}	9.52 ± 0.20^{a}	71.50 ± 6.06
♀H×N♂	0.04 ± 0.00	8.28 ± 0.22^{a}	0.15 ± 0.00^{a}	9.68 ± 0.26^{a}	73.75 ± 4.27
♀H×B♂	0.04 ± 0.00	8.42 ± 0.23^{a}	0.15 ± 0.00^{a}	9.71 ± 0.20^{a}	70.50 ± 3.28
p-value	0.479	0.000	0.000	0.003	0.716

Table 4.10. Effect of broodstock weight groups on growth performance of progeny from crosses of broodstock of three eco-regions

Group	MIW (g)	MFW (g)	DWG (g/day)	SGR (%/day)	Survival (%)
>1.0kg	0.04 ± 0.00	6.88 ± 0.17	0.12 ± 0.00	9.05 ± 0.08	74.17 ± 7.68
<1.0kg	0.04 ± 0.00	8.42 ± 0.19	0.13 ± 0.00	9.23 ± 0.09	75.28 ± 9.26
p-value	0.295	0.261	0.250	0.149	0.581

Table 4.11. Water Quality in plastic tanks for each treatment used to rear progeny for 56 days

Cross	pH	Temp	DO
♀N×N♂	6.54 ± 0.09	27.40 ± 0.19	6.66 ± 0.18
♀B×B♂	6.68 ± 0.07	27.70 ± 0.26	7.14 ± 0.14
♀H×H♂	6.64 ± 0.06	27.71 ± 0.14	7.09 ± 0.16
♀N×B♂	6.68 ± 0.04	27.66 ± 0.22	7.22 ± 0.15
♀N×H♂	7.37 ± 0.19	27.84 ± 0.22	6.95 ± 0.19
♀B×N♂	6.66 ± 0.06	27.60 ± 0.19	7.03 ± 0.16
♀B×H♂	6.55 ± 0.10	28.06 ± 0.19	6.99 ± 0.19
♀H×N♂	6.54 ± 0.08	27.80 ± 0.30	6.89 ± 0.14
♀H×B♂	6.55 ± 0.10	28.27 ± 0.35	6.99 ± 0.19

4.0 Discussion

Survival and growth performance of the progenies

Early growth performance

The mean final weights (MFW) obtained in the current study are higher than the final weights of 0.3 g reported by (Campbell et al., 1995) after raising offspring in a protected pond. They are also higher than the value of 0.47 g obtained from fish raised in artificial containers with closed water circuit (Tabaro, 2004; Tabaro et al., 2005). The higher weights are due to the fact that in the present study, hapas in earthen ponds were immersed in greater depth (0.7m) of water as nursery infrastructure with adequate provision for free movement of fish and water for good oxygenation. Moreover, by comparing the genetic types with each other, the best final weights among crosses with broodstock weight >1.0kg was observed in the pure line River Benue cross while crosses with maternal broodstock from River Benue (♀B) produced the best MFW among hybrids and reciprocals. In broodstock combinations with weight <1.0kg, hybrids with maternal contribution from River Hadejia (♀H) gave the best MFW. This indicates that with smaller broodstock, offspring superiority occurs as a result of the acquisition of a heterozygous status as opposed to the homozygous parents with environmental contribution to the phenotypic expression as well (Thompson et al., 2022).Cross breeding is used to achieve improved traits (heterosis), minimize inbreeding and obtain better hybrids (Jothilakshmanan & Marx, 2013). The results of growth in both groups of offspring (from broodstock >1.0kg and from broodstock <1.0kg) in terms of MFW, DWG and SGR indicate that the broodstock size did not affect the growth but the crossing did affect growth. Earlier reports have shown an intermediate growth performance of the parents for F1 hybrids and its reciprocal crosses. Jothilakshmanan and Marx (2013) reported intermediate growth for hybrids of *Hetropneustes longifilis* and *Clarias batrachus*. Rahman et al. (1995) also reported hybrid vigor of fast growth in catfish offspring from crosses between *C. batrachus* (♀) and *C. gariepinus* (♂). According to Nwadukwe (1995), offspring from crosses between *Clarias gariepinus* and *Hetrobranchus longifilis* produced an intermidiate growth performance between the parents for F1 hybrids and its reciprocal hybrid. In the Nile tilapia, the growth rates of different strains and their crosses showed that the crosses were superior to pure Senegal strains (Eknath et al., 1993). In another report, Sahoo et al. (2003) reported a greater performance by hybrids of *C. batrachus* and *C. gariepinus* over the parental strains with the response being attributed to maternal heterosis effects. Between the fry and fingerling stage, the survival rates obtained were low (68.00 to 80.50%) compared to the results of 80 to 96% reported under controlled conditions in *C. gariepinus* and in *H. longifilis* fed on the living food Artemia from the first day of nursery (Nguenga et al., 2000). These results should be due to the low availability of plankton at the beginning of the test. Indeed, during loading, the water was not yet green so it was poor in phytoplankton and consequently poor in zooplankton, essential food for the larvae at the beginning of rearing. These results could also be explained by the effects of stress on animals during sampling. However, these rates were better than the value of 42.68% reported by Tabaro (2004) for larvae raised in basins in a closed circuit of water and fed with an artificial feed. Similarly, the results are better than the range of 30–50% reported by Campbell et al. (1995) in a pond protected from a nylon paper fence and fertilized with chicken droppings. The results also display better survival performance resulting from out breeding compared to values of 37.8–56.4% obtained from pure lines and cross breeds of *Clarias gariepinus* and *Heterobranchus longifilis* raised in plastic aquaria by Ataguba et al. (2010). The crossing of broodstock with weight <1.0kg from River Niger and River Benue, produced the highest survival rate compared to parental lines. This cross would be more suitable for improving the survival rate at this stage of development.

Conclusion

The study was designed and experimented on the determination of survival and growth performance of the progenies from three eco-regions: River Niger (N), River Benue (B) and River hadejia (H). One hundred hatchlings from each broodstock group for each cross were selected randomly and reared in plastic tanks (60L) for eight weeks using four replicates in each case. These were fed to satiation twice a day (morning: 08:00H and afternoon: 16:00H) using commercial feed (Bluecrown). The experiment lasted for fifty-six days and mean fish weight in each tank was determined every week beginning from the day they were stocked. Waste removal was done via siphoning every three days. For sampling, fish in each tank were weighed in bulk on a sensitive balance using the wet sampling method. After the 56 days period, the surviving juveniles were counted and all fish from the tank were weighed in bulk. Progeny produced were subjected to grow-out for eight weeks (two broodstock sizes. Data for growth and survival (8 weeks) were analysed using one way analysis of variance (ANOVA) and t-test with treatments as appropriate. There was a significant effect ($p<0.05$) of cross on the mean final weight (MFW) under eight weeks of culture among offspring from broodstock >1.0kg with the cross ♀B×H♂ having the highest MFW of 7.74g while the cross ♀N×N♂ had the least MFW of 5.27g. Among progeny of broodstock <1.0kg, there was a significant effect ($p<0.05$) of cross on the mean final weight (MFW) with the cross ♀H×B♂ having the highest MFW of 8.42g while the cross ♀N×N♂ had the least MFW of 5.16g.It was concluded that determination of survival and growth performance of the progenies from three eco-regions: River Niger (N), River Benue (B) and River hadejia (H) were enormous.

Reference

Aluko, P. O., Aremu, A., & Issa, S. (1999). *Growth performance of intraspecific hybrids of three strains of H. longifilis* [Annual Report]. National Institute for Freshwater Fisheries Research.

APHA. (2005). *Standard Methods for the Examination of Water and Wastewater* (21 ed.). American Public Health Association.

Ataguba, G. A., Annune, P. A., & Ogbe, F. G. (2010). Growth performance of two African catfishes *Clarias gariepinus* and *Heterobranchus longifilis* and their reciprocal hybrids in plastic aquaria. *Livestock Research for rural development*, *22*, Article #30. http://www.lrrd.org/lrrd22/2/atag22030.htm

Brazil, B. L., & Wolters, W. R. (2002). Hatching success and fingerling growth of channel catfish cultured in ozonated hatchery water. *North American Journal of Aquaculture*, *64*(2), 144-149.

Campbell, D., Obuya, S., & Spoo, M. (1995). A simple method for small scale propagation of Clarias gariepinus in Western Kenya.

Eknath, A. E., Tayamen, M. M., Palada-de Vera, M. S., Danting, J. C., Reyes, R. A., Dionisio, E. E., Capili, J. B., Bolivar, H. L., Abella, T. A., & Circa, A. V. (1993). Genetic improvement of farmed tilapias: the growth performance of eight strains of Oreochromis niloticus tested in different farm environments. In *Genetics in aquaculture* (pp. 171-188). Elsevier.

Fourie, J. J. (2006). A practical investigation into catfish (Clarias gariepinus) farming in the Vaalharts irrigation scheme. Bloemfontein: UFS.

Haylor, G. S., & Mollah, M. F. A. (1995). Controlled hatchery production of African catfish, Clarias gariepinus: the influence of temperature on early development. *Aquatic Living Resources*, *8*(4), 431-438.

Jothilakshmanan, N., & Marx, K. K. (2013). Hybridization between Indian catfish,♀ *Heteropneustes fossilis* (Bloch) and Asian catfish, *Clarias batrachus*♂(Linn.). *African Journal of Biotechnology*, *12*(9), 976-981.

Madu, C. T., & Ita, E. O. (1990). *Comparative Growth and Survival of Hatchlings of Clarias sp., Clarias hybrid and Heterobranchus sp. in the Indoor Hatchery* [Annual Report]. National Institute for Freshwater Fisheries Research.

Madu, C. T., Ita, E. O., Amaatimin, C. Y., Nwaiku, R. C., & Igwe, P. N. (1989). *Induced breeding of the Common Carp, Cyprinus carpio* [Annual Report]. National Institute for Freshwater Fisheries Research.

Nguenga, D., Teugels, G. G., & Ollevier, F. (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. *Aquaculture Research*, *31*(7), 565-573. https://doi.org/10.1046/j.1365-2109.2000.00468.x

Nwadukwe, F. O. (1995). Analysis of production, early growth and survival of Clarias gariepinus (Burchell), Heterobranchus longifilis (Val.)(Pisces: Clariidae) and their F 1 hybrids in ponds. *Netherland Journal of Aquatic Ecology*, *29*(2), 177-182.

Rahman, M. A., Arshad, A., Marimuthu, K., Ara, R., & Amin, S. M. N. (2013). Inter-specific hybridization and its potential for aquaculture of fin fishes. *Asian journal of Animal and veterinary Advances*, *8*(2), 139-153.

Sahoo, S. K., Giri, S. S., Sahu, A. K., & Ayyappan, S. (2003). Experimental hybridization between catfish Clarias batrachus (Linn.) x Clarias gariepinus (Bur.) and performance of the offspring in rearing operations. *Asian Fisheries Science*, *16*(1/2), 157-166.

Sarkar, U. K., Negi, R. S., Deepak, P. K., Singh, S. P., Srivastava, S. M., & Roy, D. (2004). Captive breeding of vulnerable Indian carp Cirrhinus reba with Ovaprim for conservation of wild populations. *Aquaculture Asia*, *9*, 5-7.

Tabaro, S. R. (2004). Juvenile production of Clarias gariepinus (burchull, 1822) at various stocking densities. *University faculties Notre-Dame de la Paix-Namur, Namur, Belgium*.

Tabaro, S. R., Micha, J.-C., & Ducarme, C. (2005). Essais d'adaptation de production massive de juvéniles de Clarias gariepinus en conditions rurales. *Tropicultura*, *23*(4), 231-244.

Thompson, K. A., Peichel, C. L., Rennison, D. J., McGee, M. D., Albert, A. Y. K., Vines, T. H., Greenwood, A. K., Wark, A. R., Brandvain, Y., & Schumer, M. (2022). Analysis of ancestry heterozygosity suggests that hybrid incompatibilities in threespine stickleback are environment dependent. *PLOS Biology*, *20*(1), e3001469.