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Comparison of Fitness Traits between Reciprocal Hybrids and Parentals of *Clarias gariepinus* (Burchell, 1822) and *Heterobranchus bidorsalis* (Geoffroy Saint-Hilaire, 1809)

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***Abstract**: This study determined the viability performance of the hybrids produced from the crosses between Clarias gariepinus and Heterobranchus bidorsalis. Crosses were carried out on the parents; ♀ C. gariepinus x ♂ C. gariepinus, ♀ H. bidorsalis x ♂ H. bidorsalis, and for the hybrids; ♀ C. gariepinus x ♂ H. bidorsalis and ♀ H. bidorsalis x ♂ C. gariepinus. Fitness characteristics for the parental and reciprocal crosses of the fish species were determined on 30 hatchlings, for the first four weeks. The average percentage survival of the hybrids derived from the crosses between ♀ C. gariepinus and ♂ H. bidorsalis were significantly higher (77.38±5.37%) than that of the parental progenies and the reciprocal hybrid progenies of ♀ H. bidorsalis and ♂ C. gariepinus with 71.25±3.20% at p<0.05. The study showed that hybridization between C. gariepinus and H. bidorsalis produced intermediate results between both parental crosses.*
***Keywords:** African catfish, hybridization, reciprocal crosses, fitness*

I. Introduction

Fishes are one of the most important sources of high quality protein. [1] reported that they are widely used as food because of their nutrient values and even their muscle types. The importance of fish to humans cannot be overemphasised. However, in Nigeria and other developing countries, the production of fish is less than its consumption. Lack of quality fish seeds is one of the leading factors responsible for this. [2] reported that in the aggregate, these factors create “scarcity syndrome” and lead to situation where farmers are forced to wait for a long period before receiving fish seeds, sometimes abandoning ponds in the interim.

Both natural and artificial selection as well as cross-breeding between stocks and replacement of one stock with another are typical methods of breed development worldwide [3]. Some work has been done on genetic improvement and hybridization between different Cichlid [4] and Clariid fishes [5-9]. The present study was undertaken for stock improvement of *C. gariepinus* through inter-generic hybridization with *H. bidorsalis*.

II. Materials And Methods

The broodstocks of *C. gariepinus* and *H. bidorsalis* were obtained from the Teaching and Research Farm: University of Agriculture, Abeokuta, Ogun State and Gureje Aquaculture Centre in Ile-Ife, Osun State, Nigeria, respectively. They were obtained from two different farms to prevent the incidence of in-breeding.

The brood stocks were transported in a 50 litre- tank opened at the top to the Wet laboratory of the Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife. They were kept at constant temperature of 25ºC in 1000-liter tank and were fed with 37% Crude Protein commercial feed (DURANTE®, Nigeria) three times daily. The water quality was maintained through proper monitoring and weekly replacement. They were fed for three months to allow for proper acclimatization and maturity before their utilization.

Gravid females of *C. gariepinus* and *H. bidorsalis* were selected based on their swollen reddish genital papilla and a well-distended, swollen soft abdomen that oozed out eggs when gently pressed. Sexually matured males of *C. gariepinus* and *H. bidorsalis* were equally selected based on reddish pointed and vascularised urogenital papillae.

Hypophysation of the specimens was carried out in the Department of Animal Sciences, Wet laboratory, Obafemi Awolowo University. The selected female broodstock of *C. gariepinus* and *H. bidorsalis* (1.0±0.6 kg) were kept separately in the hatchery for two days without feeding so that the alimentary tract was empty at the time of stripping. Sexually matured males of *C. gariepinus* and *H. bidorsalis* weighing 1.1±0.8 kg were selected and kept in different tanks of 50 litre capacity for two days prior to the time of sperm collection. Oocyte maturation and ovulation in the female fish of both species were induced with a single intramuscular injection of Ovaprim(R) (SYNDEL, Canada) at a dosage of 0.5ml/kg live weight and then left for 10-17 hr latency period depending on the catfish species.

The female broodstock was carefully dried with a clean towel and tightly held at head and tail ends while the eggs were handstripped by pressing their abdomen into clean and dry petridishes. The eggs were fertilized with milt obtained from lacerated testes (and kept in physiological salt solution of 0.9%) by using feather to spread the mixture evenly for 1.0 min. The fertilized eggs from each mating combination were spread out in single layer on the screen nets (mesh size of 1mm) placed in the 500-liter hatching tanks at 27 -28ºC.

The following crosses were carried out in replicates:
1. ♀ *C. gariepinus* x ♂ *C. gariepinus* (parental cross)
2. ♀ *H. bidorsalis* x ♂ *H. bidorsalis* (parental cross)
3. ♀ *C. gariepinus* x ♂ *H. bidorsalis* (hybrid)
4. ♀ *H. bidorsalis* x ♂ *C. gariepinus* (hybrid)

Incubation was carried out using water recirculating system for continuous aeration and filtration. Water quality parameters; temperature, dissolved oxygen, nitrite level and pH were measured in each tank. Temperature varied between 27–28^{o}C for incubation between 20-23 hrs depending on the catfish species.

White eggs (indicating dead eggs) were siphoned to avoid development of fungi. The presence of eggs with transparent greenish brown colour implies that they were healthy. The success of each cross, intra or interspecific, was evaluated by counting the number of dead eggs after hatching and this was used to calculate the percentage hatchability. Latency and incubation periods were recorded. At hatching, batches of normal larvae or hatchlings were sorted. Fitness tests were done on the parentals and hybrids. Percentage fertility, hatchability and survival for four weeks were recorded. The average weekly increase in total length of the fry was used to determine the increase in growth.

Exogenous feeding of the fry with decapsulated Artemia (INVAQUACULTURE®, USA) cysts started on the fourth day after hatching, immediately after complete yolk absorption. Fry were fed every 3 hours with 3 – 5g decapsulated Artemia cysts for one week before the commencement of 0.1– 0.3mm exotic feed (40% crude protein) for four weeks three times daily.

The performance and viability of the parents and hybrids were recorded. At the end of the experiment, the following were determined:

$$\% \text{ Fertility} = \frac{\text{Total number of fertilized eggs - Total number of unfertilized eggs}}{\text{Total number of fertilized eggs}} \times 100\%$$

$$\% \text{ Hatchability} = \frac{\text{Total no of fertilized eggs - Total no of unhatched fertilized eggs}}{\text{Total no of fertilized eggs}} \times 100\%$$

$$\% \text{ Survival rate} = \frac{\text{Total no of hatched larvae - Total no of dead larvae}}{\text{Total number of hatched larvae}} \times 100\%$$

2.1 Data Analysis

Data obtained from the experiment were subjected to analysis of variance. Differences between the means were determined using Duncan's Multiple Range Tests.

III. Results

Fig. 1 shows that the latency period for the females of *H. bidorsalis* was significantly higher (14-17 hrs) than that of *C. gariepinus* females (10-11 hrs) at 25ºC and $p<0.05$. The cross involving the parentals of *C. gariepinus,* showed the highest incubation period which was significantly higher ($p<0.05$) than that of the parentals of *H. bidorsalis*. The incubation periods of the hybrids were not significantly different ($p>0.05$) from each other but significant from the parental cross of *C. gariepinus* at 27-28ºC (Fig. 1). The percentage fertility of the parental species and their hybrids is shown in Table 1. Fertility was high in all the four crosses studied and there was no significant difference ($p>0.05$) among the four crosses. The parental cross of *C. gariepinus*, (♀ C. g x ♂ C. g) had the highest hatchability. While the percentage hatchability was greater in the parental species than in the hybrids, *C. gariepinus* parentals' percentage hatchability was significantly higher ($p<0.05$) than *H. bidorsalis* parentals. Although the difference in percentage hatchability between the hybrids was not significantly different, the differences between the hybrids and the parentals were significant (Table 1).

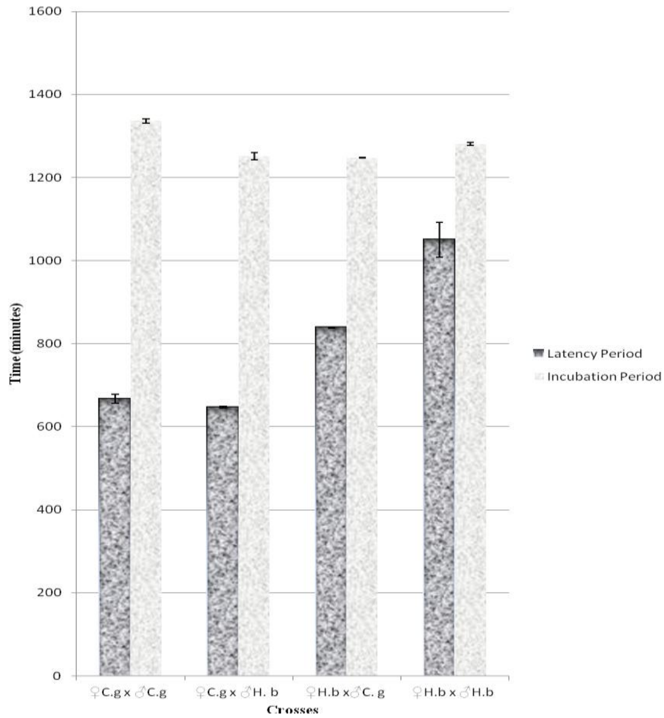

Fig. 1: Latency and incubation periods of the four crosses.

Data are given as means with standard deviations (±s.d.). ♀C.g x ♂C.g (*C. gariepinus* parentals); ♀C.g x ♂H. b (hybrid of female *C. gariepinus* and male *H. bidorsalis*); ♀H.b x♂C. g (hybrid of female *H. bidorsalis* and male *C. gariepinus*); ♀H.b x ♂H.b (*H. bidorsalis* parentals)

Table 1: Fitness (measured as percentage fertility, hatchability, survival and increase in length) of the catfishes from fertilization to the fourth week of development.

	Crosses	Fertility (%)	Hatchability (%)	Average weekly survival (%)	Average weekly total length (cm)
Week 1	♀C.g x ♂ C.g	83.0±1.41^{a}	81.0±1.41^{a}	81.50±0.71^{a}	0.80±0.00^{b}
	♀C.g x ♂H. b	81.5±0.71^{a}	61.0±1.41^{c}	71.50±0.71^{b}	1.10±0.00^{b}
	`♀H.b x ♂C. g	81.0±1.41^{a}	59.0±1.41^{c}	67.50±0.71^{c}	1.10±0.14^{b}
	♀H.b x ♂H. b	80.5±0.71^{a}	72.0±0.00^{b}	51.50±0.71^{d}	1.50±0.14^{a}
Week 2	♀C.g x ♂C. g	–	–	88.00±0.00^{a}	1.40±0.00^{c}
	♀C.g x ♂H. b	–	–	75.00±1.41^{b}	2.00±0.28^{ab}
	♀H.b x ♂C. g	–	–	70.50±0.71^{c}	1.90±0.14^{cb}
	♀H.b x ♂H. b	–	–	54.00±1.41^{d}	2.55±0.07^{a}
Week 3	♀C.g x ♂C. g	–	–	89.50±0.71^{a}	1.95±0.21^{b}
	♀C.g x ♂H.b	–	–	78.00±1.41^{b}	2.20±1.14^{b}
	♀H.b x ♂C.g	–	–	71.50±0.71^{c}	2.20±0.07^{b}
	♀H.b x ♂H.b	–	–	59.50±2.12^{d}	3.05± 0.10^{a}
Week 4	♀C.g x ♂C. g	–	–	90.00 ±0.00^{a}	2.35±0.07^{b}
	♀C. g x ♂H. b	–	–	85.00±0.00^{b}	3.70±0.00^{a}
	♀H. b x ♂C. g	–	–	75.50±2.12^{c}	3.60±0.14^{a}
	♀H. b x ♂H. b	–	–	61.00±0.00^{d}	3.80 ±0.28^{a}

C. g = *C. gariepinus*, H. b= *H. bidorsalis*

Data are given as means with standard deviations (±s.d.). Mean values for groups within each experiment with common superscripts in the column are not significantly different.

Table 2: The average of the percentage survival and total length of the parents and hybrids for four weeks after fertilization.

Crosses	Average survival (%)	Average total length (cm)
♀C. g x ♂ C. g	87.25±3.65[a]	1.63±0.63[c]
♀C. g x ♂H. b	77.38 ±5.37[b]	2.25±1.01[b]
♀H.b x ♂C. g	71.25±3.20[c]	2.20±0.97[b]
♀H. b x ♂H. b	56.50±4.28[d]	2.73±0.90[a]

C. g = *C. gariepinus*, H. b= *H. bidorsalis*

Data are given as means with standard deviations (±s.d.). Mean values for groups within each experiment with common superscripts in the column are not significantly different

Table 1 also shows that the average survival for the first four weeks of development were significantly different ($p<0.05$) among the parents and the hybrids. *C. gariepinus* parentals had the highest survival while the *H. bidorsalis* parentals had the least. The survival of the reciprocal hybrids was significantly different with the ♀ C. g x ♂ H. b cross having a higher value. Table 2 shows that the reciprocal hybrids had intermediate values between the parentals for survival and length. The differences among the crosses were significant except the reciprocal hybrids, which were not significantly different in total length. While *C. gariepinus* had significantly higher survival (87.25±3.65%) than the others, *H. bidorsalis* had the least value (56.50±4.28%). For total length, *H. bidorsalis* had significantly higher length (3.80 ±0.28cm), than the others while *C. gariepinus* had the least length (2.35±0.07cm), (Table 1). The differences among the crosses were significant except the reciprocal hybrids, which were not significantly different ($p>0.05$) in total length at the end of the experiment.

IV. Conclusion

Relatively equal fertility rates indicate that the broodstock were similar in maturity in terms of egg and milt qualities. Successful reciprocal hybridizations between *C. gariepinus* and *H. bidorsalis* were carried out with higher percentages of hatchability among the parental crosses of *C. gariepinus* and *H. bidorsalis* at incubation periods of approximately 22 hour and 21 hour respectively with approximately 21 hour recorded for the hybrids. This was expected because similar intergeneric crosses performed within the Clariid fish species produced viable hybrids [5, 10]. [7] reported similar incubation period for *H. longifilis* parental cross and 20 hr for *C. anguillaris* while a higher incubation period of 23 hr was recorded for the reciprocal hybrids. The percentage hatchability was greater in the parents than in the hybrids. *C. gariepinus* had the highest value (81±1.41%) while ♀ *H. bidorsalis* x ♂ *C. gariepinus* had the least value (59±1.41%). [7] also reported the highest percentage hatchability (99.6%) for *C. anguillaris* and the least (55.6%) for ♀ *C. anguillaris* x ♂ *H. longifilis*.

The hybrid fry produced using the eggs of *C. gariepinus* had significantly higher survival (85.00±0.00%) than the fry of hybrid derived from the eggs of *H. bidorsalis* (75.50±2.12%), thus indicating maternal inheritance of survival while *C. gariepinus* (90.00 ±0.00%) survived better than *H. bidorsalis* (61.00±0.00%). This is in line with the reports of [5] that recorded highest survival in *C. gariepinus* and the lowest in *H. bidorsalis.* [10] posited that crosses between male *H. longifilis* and female *C. anguillaris* were significantly heavier than the reciprocal cross. [7] reported the survival of ♀ *C. anguillaris* x ♂ *H. longifilis* (78%) and ♀ *H. longifilis* x ♂*C. anguillaris* (60%) at 21 days while *C. anguillaris* (78%) survived better than *H. longifilis* (72%) though the hybrid from ♀ *H. longifilis* x ♂*C. anguillaris* had the least value.

The growth performance (total length) of ♀ *C. gariepinus* x ♂ *H. bidorsalis* cross was not significantly different from the reciprocal hybrid cross. This is at variance with the earlier reports of [5] that ♀ *C. gariepinus* x ♂ *H. bidorsalis* cross had highest growth performance (greatest weight and mean growth rate) in outdoor hatchery. [6] also reported the highest growth rates in the hybrids of *C. gariepinus* and *H. bidorsalis* compared with the parental crosses. In the outdoor tanks, the hybrid from ♀ *C. anguillaris* x ♂ *H. bidorsalis* cross recorded the highest growth rate followed by *H. bidorsalis* while *C. anguillaris* recorded the highest percentage survival**.** **[7]** reported that ♀ *H. longifilis* x ♂ *C. anguillaris* had higher performance than the reciprocal cross and that the hybrids performed better than *C. anguillaris* growth-wise, therefore hybridization has potentials for increasing growth performance. [11] performed similar hybridization experiments between *C. gariepinus* and *H. longifilis* and reported that the growth rate of ♀ *H. longifilis* x ♂ *C. gariepinus* hybrids is either equal to or greater than *H. longifilis*, and that the expression of heterosis for growth could depend on the conditions of culture environment.

The growth and survival data suggest that selective intergeneric hybridization can be a useful tool in broodstock improvement and management. This result agrees with earlier reports by [5] and [7]. Both hybrids showed intermediate values in growth between the parents suggesting that the trait is quantitative [12].

Since they were bred and grown under similar conditions and there were differences in growth and survival, it suggests that the differences could be genetic rather than environmental. Intergeneric cross is usually made to evaluate the levels of heterosis among hybrid progenies. [13] posited that 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 and environmental variance. There was a significant difference in growth from fry to fingerling stage. This showed that there was normal growth and development in both the parentals and their reciprocal hybrids.

In conclusion, data collected on fitness may prove useful in fish improvement which may lead to subsequent biotechnological application that can alleviate the problem of production of quality fish and food insecurity. Fish farmers can adopt intergeneric hybridization of ♀ *C. gariepinus* x ♂ *H. bidorsalis* because the hybrid produced from the cross performed intermediately between the parents in terms of survival and growth rates and this could bridge the gap between the demand and supply of fish, consequently, ensuring fish food security for the populace.

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