

EVALUATION OF HETEROSIS OF CROSSES BETWEEN *CLARIAS GARIEPINUS*,
HETEROBRANCHUS BIDORSALIS AND THEIR HYBRIDS
COLLECTED FROM MINNA METROPOLIS

ABSTRACT

Hybridization of Clarias gariepinus (Cl) and Heterobranchus bidorsalis (Ht) and determining their growth and heterosis parameters were performed. Four crosses (♀ × ♂) were tested: Cl X Cl, Cl X Ht, Ht X Cl, and Ht X Ht. Fifty 14-day-old juveniles from each of the four crosses were stocked separately in tripled plastic bowls. Fifteen fish were randomly selected each week using a fine mesh mosquito net and then weighed on a sensitive scale. The highest percentage of fertilization (58.57%) was recorded in the pure breed (Ht x Ht). The hybrid (Cl x Ht) had the highest hatching rate. Pure breeds recorded the highest condition factor (2.37), and hybrids had the highest feed conversion ratio. The Cl X Cl cross had the highest final mean weight (1980 mg) and the specific growth rate (SGR) of 4.91% / day compared to the other three crosses. Negative heterosis for growth (-14.95%) was observed in hybrids, while hybrid survival showed positive heterosis (26.56%). Poor growth of the hybrids explained the negative heterosis. Therefore, crossbreeds survived better than purebred catfish. There was a significant difference in the specific growth rate between the four genetic groups studied (P > 0.05).

Key words: Hybridization, Heterosis, Growth, Hybrid catfish, Weight gain

INTRODUCTION

One of the agro-industrial sectors with the most substantial growth rates over the past five decades is aquaculture, which is expected to help with population increase. The combined output from aquaculture and capture is anticipated to surpass that of other livestock products during the next ten years [1]. To ensure fish food security in Africa, it is essential to increase fry and fingerling productivity, accelerate growth rates, and improve environmental tolerance. Genetic approaches are consequently required to attain a faster growth rate that will result in a shorter production cycle and a higher tolerance for unfavorable water conditions.

Hybridization is used to produce advantageous results, such as heterosis or hybrid vigor, which is widely described as an

increase in the progeny's performance value above the average of the parental performance value [2].

Due to its resilience, omnivorous diet, rapid growth, and highly regarded flesh, *Clarias gariepinus* was thought to be a fish that would be good for breeding in the future [3]. The genus *Heterobranchus* (Geoffroy St. Hilaire, 1809) is endemic to Africa, and its native distribution is restricted to the Rivers Nile, Senegal, Gambia, Volta, Niger, and Benue, as well as to Lake Chad [4]. *Clarias gariepinus* and *Heterobranchus bidorsalis* are essential in the aquaculture industry of African countries because they can achieve a large size within a short time [5].

Through hybridization and selective breeding, artificial propagation has produced strains superior to the original stock. 'Heteroclarias' and 'Clariabanchus,' which combine or transfer beneficial features from the two species, are inter-specific hybrids of *C. gariepinus* and *H. bidorsalis* [6].

Dependence on natural reproduction will result in an unmanageable gap. This is due to the fact that, with such low levels of production, aquaculturists have not been able to satisfy market demand. Fish seeds must be produced in greater quantities to guarantee the industry's ongoing expansion. This can be accomplished by induced breeding and artificial propagation [7].

Therefore, this study aimed to test the crossbreeds of (*Clarias gariepinus* x *Heterobranchus bidorsalis*) for growth and survival heterosis through embryological studies of the species to improve its breeding aquaculture potentials and biodiversity.

MATERIALS AND METHODS

The broodstocks of *Heterobranchus bidorsalis* and *Clarias gariepinus* with known breeding records were acquired from the Water Resources, Aquaculture and Fisheries Technology Department's Teaching and Research Farm in Minna, Niger State.

Catfish Hybrid: These species were crossed in the Wet Laboratory of Water Resources, Aquaculture, and Fisheries Technology Department. These were labeled as: Ht X Ht (*Heterobranchus bidorsalis* X *Heterobranchus bidorsalis*), Cl X Cl (*Clarias gariepinus* X *Clarias gariepinus*), Cl X Ht (*Clarias gariepinus* X *Heterobranchus bidorsalis*), and Ht X Cl (*Heterobranchus*

bidorsalis X *Clarias gariepinus*). In all the crosses, the female is mentioned first (♀ × ♂).

Oocyte maturation and Ovulation: Ovatide, at a dose of 0.5 ml kg⁻¹, was administered intramuscularly once to stimulate oocyte maturation and ovulation. *Clarias gariepinus* required 12 hours, and *Heterobranchus bidorsalis* required 15 hours between injection and ovulation. Eggs were manually retrieved after ovulation by squeezing the abdomen toward the caudal fin and placing them in a dry, clean plastic basin. The testicles were surgically removed to obtain milt. In a solution of NaCl at 0.9 percent, sperm were expanded. The prolonged milt mixture was added to the oocytes to fertilize them. To ensure full fertilization, the resulting liquid was swirled with a plastic spoon for one minute. A 25L plastic aquarium with a flow-through water system was used to incubate batches of eggs from each cross using mosquito mesh netting as the substrate.

The crosses involved three females and two males. To measure fertilization, an un-inseminated control sample of eggs was utilized. When the control eggs became opaque (i.e., dead eggs), it was recorded, then the brownish/greenish eggs in the incubators were considered fertilized.

Diet: Dried, decapsulated *Artemia* sp. cysts were given ad libitum twice daily to hatchlings. Following two weeks of feeding, the fish were gradually transitioned to an artificial dry diet consisting of Skretting catfish feed (0.2mm-0.3mm) for two weeks and 0.5mm-0.8mm for the following four weeks.

Experimental Design: In duplicate 25L plastic aquariums with water that was

continually aerated and changed every two days, fifty 14-day-old juveniles from each of the four crosses Cl × Cl, Ht × Ht, Ht × Cl, and Cl × Ht were stocked individually. The mean fish weight in each tank was calculated weekly, starting on the day the fish were first placed inside. The experiment ran for 56 days. Every day, waste was removed via siphoning. A fine mesh mosquito-sized net was used to randomly select 10 fish for sampling, which were subsequently bulk-weighed on a sensitive weighing balance. The juvenile fish that survived after 56 days were counted, and the entire fish population of the tank was bulk-weighed.

Production Parameters:

Total length: Using a fish measuring board, the total length of juvenile catfish in various treatments was recorded to the nearest 0.01 cm.

Weight gain: Over a sampling period, weight gain was computed as W2 - W1, where W2 represents final weight and W1 represents initial weight.

% Fertilization =

$$\frac{\text{Total No of Fertilized eggs}}{\text{Total No of Eggs stripped}} \times 100$$

One gram of fertilized eggs is equal to 700 pieces of eggs by the NIFFR standard.

% Survival =

$$\frac{\text{Cummulative No of survival}}{\text{Total No of fishes stocked}} \times 100$$

% Hatchability =

$$\frac{\text{Total No of Hatched eggs}}{\text{Total No of Eggs fertilized}} \times 100$$

Specific growth rate: This formula was used to determine the specific growth rate of catfish under various conditions;

$$\frac{\ln W_2 - \ln W_1}{t} \times 100$$

Where: W₂ = Final mean body weight,

W₁ = Initial mean body weight and t = time in days.

To determine heterosis for growth and survival, respectively, the mean weights and surviving percentages of the crossbreeds and the pure breeds were utilized.

Condition factor (K) =

$$\frac{W}{L^3} \times 100$$

Where W = Weight while L = Length

Feed Conversion Ratio (FCR) =

$$\frac{\text{Total Feed Fed}(g)}{\text{Weight Gain}(g)}$$

Here, heterosis refers to the growth or survival of the crossbred animals in comparison to the purebred species, as represented in percentage by the formula [8].

$$\text{Heterosis} = \frac{(\frac{C1+C2}{2}) \cdot (\frac{P1+P2}{2})}{P1+P2} \times 100$$

Where P1 or P2 represents the mean final weight or survival of purebred animals and C1 or C2 represents the mean final weight or survival of crossbreed animals.

Growth and survival rates were evaluated using one-way analysis of variance (ANOVA) and Fisher's LSD to identify significant differences between means. The initial weight was used as a covariate in an analysis of covariance to compare the fish's specific growth rate (SGR) because mean initial weights varied significantly among the genetic groups under investigation.

RESULTS

Table 1 displays the fertilization, hatchability, mean initial weight, mean final weight, weight gain, specific growth rate (SGR), survival rate (SR), condition factor (K), and feed conversion ratio for pure breeds and crossbreeds of two African catfish, *Clarias*

gariepinus and *Heterobranchus bidorsalis*, raised in plastic aquaria under hatchery conditions for 56 days.

Compared to other crossings, the pure breed (Ht X Ht) had greater rates of fertilization and survival (58.57 % and 38.42 %, respectively). Compared to the other crosses, the hatchability rate for the Ht♀ X Cl♂ cross was significantly higher (85.18%; P<0.05).

The two hybrids' feed conversion ratios (FCR): Ht♀ X Cl♂ and Cl♀ X Ht♂ were significantly higher than those of the pure breeds. In terms of final mean weights, the pure cross (Cl X Cl) had a significantly (P<0.05) higher weight (1980mg) than the other three crosses. The pure breeds recorded higher SGR, 4.91%day-1 and 2.64%day-1 for Cl X Cl and Ht X Ht, respectively. The result of the condition factor (K) indicated that the pure cross (Ht X Ht) gave the highest value (2.37g/cm³). There was significantly different from other crosses (P>0.05), with values of 2.17g/cm³ for Cl♀ X Ht♂, 1.77 g/cm³ for Ht♀ X Cl♂ and 0.87 g/cm³ for Cl X Cl.

Table 1. Fertilization, Hatchability, Mean Growth, condition factor, feed conversion ratio and survival rates of pure lines and cross breeds of *Clarias gariepinus* and *Heterobranchus bidorsalis*.

Variables	Cl X Cl	Ht♀ X Cl♂	Cl♀ X Ht♂	Ht X Ht
Fertilization, % ±S.E.	40.29 ± 0.04 ^d	44.50 ± 0.04 ^c	48.18 ± 0.04 ^b	58.57 ± 0.04 ^a
Hatchability, % ±S.E.	53.76 ± 0.01 ^c	85.18 ± 0.01 ^a	57.57 ± 0.01 ^b	50.42 ± 0.01 ^d
Initial Weight, mg ± S.E.	100 ± 8.16 ^a	90 ± 8.16 ^a	80 ± 8.16 ^a	80 ± 8.16 ^a
Final Mean weight, mg ± S.E.	1980 ± 8.16 ^a	280 ± 8.16 ^c	250 ± 8.16 ^d	360 ± 8.16 ^b
Weight Gain, mg ± S.E.	1880 ± 8.16 ^a	190 ± 8.16 ^c	170 ± 8.16 ^d	280 ± 8.16 ^b
SGR, % day ⁻¹ ± S.E.	4.91 ± 0.01 ^a	2.07 ± 0.01 ^c	1.98 ± 0.01 ^d	2.64 ± 0.01 ^b
Survival Rate, % ± S.E.	12.25 ± 0.01 ^b	12.08 ± 0.01 ^c	10.88 ± 0.01 ^d	38.42 ± 0.01 ^a
Condition factor, g/cm ³ ± S.E.	0.87 ± 0.01 ^d	1.77 ± 0.01 ^c	2.17 ± 0.01 ^b	2.37 ± 0.01 ^a
FCR, ± S.E.	0.14 ± 0.01 ^d	1.11 ± 0.01 ^b	1.25 ± 0.01 ^a	0.76 ± 0.01 ^c

Means (n=3) in each row with same superscript were not significantly different (P>0.05)

Table 2: Heterosis for the various stages of development of progeny of the crosses.

STAGE	GROWTH	SURVIVAL
FINGERLINGS	-14.95	26.56

After 56 days, the hybrids showed a negative heterosis for growth (-14.95 %) as a result of their subpar growth in comparison to the pure breeds. After 56 days of raising, the hybrids shown a positive heterosis (26.56 percent) in terms of survival.

Figure 1: Growth pattern of fry from crosses of *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrids reared for 56 days.

DISCUSSION

The quality and viability of the egg and milt were responsible for the cross Ht X Ht's greatest fertilization percentage. This supports the findings of the study on the karyomorphology of African catfish [9].

The greatest hatchability percentage was produced by the inter-generic cross of Ht♀ X Cl♂. This research was comparable to that of [10], which showed that eggs from smaller brood stocks—200–599 g—had higher fertility and viability and were more likely to hatch than eggs from bigger brood stocks, 600–799 g.

The survival rate findings revealed a significant difference between Ht X Ht and the other crosses ($P < 0.05$).

This finding contrasts with those of studies by [11], and [12], which found lower values (80% and 86%) for *C. gariepinus*, and 70% for hybrid crossings between male *H. longifilis* and female *C. anguillaris*.

Since the fry was so vulnerable at this time, the lower overall survival rate in this study can be attributable to deaths brought on by the stress of the weekly sampling.

The four genetic groups under research had end mean weights ranging from 250 mg to 1980mg. With 250mg, the cross Cl♀ X Ht♂ demonstrated the least final mean weight gain. This is considerably less than the 2250mg readings that [13] reported for the same cross.

The resulting mean weight value for Cl X Cl was 1980 mg, which is higher than the 1950 mg reported by [13]. These genetic groups' weight gain exhibits the same trend as the final mean weights. In comparison to the other three genetic groups, the cross Cl X

Cl's final mean weight was considerably different ($P < 0.05$).

The four genetic groups under investigation have significantly different specific growth rates ($P > 0.05$). The SGR of 4.91%.day-1 for the cross Cl X Cl reported in the current study is marginally greater than the range of 2.12%.day-1 to 3.96%.day-1 reported for various strains of *Heterobranchus longifilis* by [8].

In this experiment, pure strains grew more quickly than hybrids, suggesting that the heterotic impact of hybridization (hybrid vigor) had not yet materialized in the hybrids at this early stage.

This agrees well with [14], who states that it will take the hybrids 12 months of development from fingerlings to adults before their better growth traits become apparent. According to [15], mean weight was inversely associated to the length of the raising period, which also explains why hybrids weigh less than parent crossings on average.

The two hybrids in this study (Ht♀ X Cl♂ and Cl♀ X Ht♂) and the pure breed (Ht X Ht) both had condition factors > 1 . This backs up [16], who claimed that a condition factor of one or higher indicates appropriate nutrition and suitable environmental conditions. Recommended K value range for adult freshwater fish is (2.9-4.8) [17].

According to [18], the FCRs of 1.0-2.0 is considered suitable for most fish species. Therefore, the two hybrids showed the best Feed Conversion Ratio (FCR).

The hybrids displayed negative growth heterosis (-14.95). This is because of their slow growth, yet after 56 days of rearing, they showed positive heterosis for survival (26.56). According to [19], the negative

heterosis value for growth indicates a negative interaction between the parental genes at various loci in the inter-generic hybrid genome. Growth and survival are examples of quantitative traits whose phenotypic variance is influenced by genetic, environmental, and genetic-ecological interaction variance [20]. The inadequate phenotypic manifestation of growth may have been caused by a detrimental interaction between the hybrid's genetic variation and the environment.

CONCLUSION

This study evaluated reciprocal crossings between *Clarias gariepinus* and *Heterobranchus bidorsalis* under controlled conditions to increase their fry's production capacity. Since the crossbreeds showed positive heterosis for survival, a greater proportion of fry and fingerlings reached the adult stage. The results from the hatchery should be conveyed to the field to boost the hybrids' economic output. More investigation into these crosses in earthen ponds is required to identify the optimal economic applicability of the inter-generic crosses examined here. To confirm the performance of hybrid species, the hybrid fingerlings in the adult stage of the study needs to be revisited. Ultimately, unless superior catfish hybrids are more accessible, the catfish aquaculture sector won't undergo a significant change on a global scale.

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