Water Quality Responses of Pureline Parental Crosses of Three African Catfish Species in Controlled Hatchery Systems

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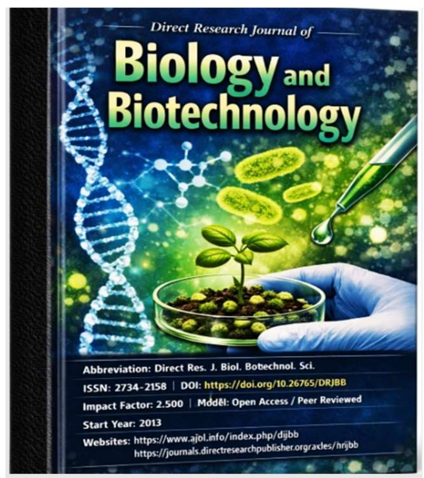
ABSTRACT

The physicochemical water quality responses of pond systems stocked with pureline progenies of three African catfish species: Clarias gariepinus, Heterobranchus bidorsalis, and Heterobranchus longifilis was studied. The study, which used a perfectly randomized design with three replicates per treatment, aimed to investigate environmental tolerances and water-use dynamics among pureline crosses. Pureline progenies were grown in concrete hatchery tanks measuring 10 m × 10 m × 1.5 m for 120 days. Water quality indicators such as temperature, pH, dissolved oxygen (DO), alkalinity, turbidity, ammonia, phosphate, and biological oxygen demand (BOD) were measured using standardized procedures. The findings revealed that water temperature, turbidity, ammonia, phosphate, and BOD did not differ significantly (P>0.05) between treatments, indicating that these parameters are tolerated similarly among species. Significant differences (P<0.05) were seen in pH and DO levels, with H. longifilis crosses showing the greatest pH (8.90 ± 0.02) and DO (9.80 ± 0.02 mg/L), while C. gariepinus crosses showed the lowest values. Despite the differences, all measured metrics were within safe aquaculture limits. These data indicate that, while all three pureline catfish species can be cultivated under identical environmental circumstances, H. longifilis may have better physiological performance in terms of oxygen usage and pH tolerance. This research provides crucial baseline data for optimizing broodstock management and guiding species selection for site-specific aquaculture, particularly in systems where water quality control is a productivity constraint.

Keywords: *African catfish, Progeny, Water parameters, Broodstocks, Pureline*



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INTRODUCTION

The genetic potential of broodstock and the environmental conditions under which progenies are raised have a significant impact on the effectiveness of fish breeding and grow-out systems in aquaculture (Jeney & Bekh, (2020), Torsabo et al., 2024). Genetic factors govern growth capacity, disease resistance, and other desirable features, but environmental factors influence trait expression, as well as overall survival and production (Ingram & Nguyen, (2014). Water quality is one of the most important environmental elements influencing fish health, growth performance, and survival (Omweno et al., 2024). Catfish, specifically Clarias gariepinus, Heterobranchus bidorsalis, and Heterobranchus longifilis, have emerged as top contenders in African aquaculture due to their hardiness, rapid development, and market acceptance (Dagoudo et al., 2025). However, according to Yue (2025), the increasing demand for high-performance fish has sparked interest in improving breeding tactics, such as pureline and hybrid crosses.

While African catfish hybridization has been widely studied for improved growth and feed efficiency (Adah et al., 2014; Duong et al., 2017; Rahman et al., 2018) the performance of pureline parental crosses under standardized water quality circumstances has received less attention. It is critical to understand how these genetically unique pure lines react physiologically and ecologically, particularly to the physicochemical properties of the rearing water. Such data are crucial for developing successful broodstock management methods and guaranteeing long-term seed production in hatcheries.

This study aims to evaluate the water quality dynamics in rearing environments stocked with pureline progenies of C. gariepinus, H. bidorsalis, and H. longifilis, providing insights into their adaptive responses and environmental tolerances. Understanding these interactions will enhance the development of more robust breeding programs and support the selection of species or strains best suited to varying aquaculture conditions.

Materials and Methods

Experimental Design

The study which is designed as a completely randomized experiment (CRD) with 3 replicates involved three independent and simultaneous experiments.

Pure Line Crosses for Parental Progenies

The breeding process involved the production of parental progenies that produced the pure line crosses that served as the control experiment. The parent brood stock includes the following species:

i. Clarias gariepinus
ii. Heterobranchus bidorcalis
iii. Heterobranchus longifilis

Pure lines of these species were bred and reared to raise the same size of parent progenies evaluated (compared) with the reciprocal crosses of the respective fishes in experiment 2. For the purpose of this, there were three pure line crosses as follows:

i. Clarias gariepinus (♀) x Clarias gariepinus (♂)
ii. Heterobranchus bidorcalis (♀) x Heterobranchus bidorcalis (♂)
iii. Heterobranchus longifilis (♀) x Heterobranchus longifilis (♂)

Three concrete hatchery tanks, each measuring 10m x 10m x 1.5m were used for the experiment. Each cross was randomly assigned to one of the spawning tanks and replicated three times. This experiment used brood stocks out of the 21 procured for the entire study.
Consequently a total of 3 x 3 = 9 experimental tank units were used for this phase of the experiment which was carried out at Anufuru farms Ltd, Olakwu in Owerri, Imo State. The layout of the experiment is shown in table 1.

Table 1: The design layout of the first experiment for the production of parent progenies.

Replicates	Treatments (pure line crosses)			
	T_1	T_2	T_3	Total
1	A	B	C	3
2	B	C	A	3
3	C	A	B	3
Total	3	3	3	9

A = *C. gariepinus* (♀) x *C. gariepinus* (♂)
B = *H. bidorsalis* (♀) x *H. bidorsalis* (♂)
C = *H. longifilis* (♀) x *H. longifilis* (♂)
Total = Treatments (crosses) randomly assigned to replicates.
Total broodstock requirement = 9

Water Quality Parameters

Physico-chemical parameters evaluated include water temperature, pH, dissolved oxygen, turbidity, total dissolved solids, hardness, alkalinity ammonia and phosphates. These were measured by the different standard methods:

- Temperature was measured in situ using the mercury in glass thermometer;
- Transparency and turbidity was measured instrumentally in accordance with Boyd (1979).
- Water pH was determined in situ using the pH meter (model 370 portable probe),
- Dissolved oxygen (Winkler method) and ammonia were determined by APHA et al., (2015)
- Alkalinity together with phosphate by methods described by Boyd and Lichtkoppler (1979) and Njoku (2007).

Statistical Analysis

Water quality parameters of the experimental tanks of the three purline breeds crosses were compared using the one-way analysis of variance (ANOVA), the trial having been given a completely randomized design (CRD). For the purpose of this, the computer statistical package for social science (SPSS), window 8 version 15 was employed.

RESULTS

The results of mean water parameters of ponds stocked with pureline (parental) progenies of three formed cat fishes, reared for 120-days are presented in Table 2.

At the end of the experimental period, the temperature across the treatments of parent crosses were within the range of 28.75±0.450C to 29.00±2.000C, this showed no significant difference (P>0.05) between the treatments. Meanwhile, there was significant difference (P<0.05) in the pH with H. longifilis (♀) x H. longifilis (♂) having the highest pH (8.90±0.02) and Clarias gariepinus (♀) x Clarias gariepinus (♂) had the lowest (8.50±0.02) pH value.

Dissolved oxygen also followed the same trend with significant increase (P<0.05) at H. longifilis (♀) x H. longifilis (♂) and the lowest value was recorded at Clarias gariepinus (♀) x Clarias gariepinus (♂) and was significantly low (P<0.05) compared to others in the group. The alkalinity across the treatment, 13.41±0.02 mg/L (Clarias gariepinus (♀) x Clarias gariepinus (♂)), 13.45±0.02 mg/L (H. bidorsalis (♀) x H. bidorsalis (♂)) and 13.49±5.84 mg/L (H. longifilis (♀) x H. longifilis (♂)), showed no significant difference (P>0.05). In the same way, the values were statistically the same (P>0.05) in the turbidity recorded which are 8.91±0.2 mg/L in Clarias gariepinus (♀) x Clarias gariepinus (♂), 8.92±0.02 mg/L in H. bidorsalis (♀) x H. bidorsalis (♂) and 8.90±0.02 mg/L in H. longifilis (♀) x H. longifilis (♂) and ammonia (0.51±0.01 mg/L, 0.52±0.02 mg/L and 0.53±0.23 mg/L in C. gariepinus (♀) x C. gariepinus (♂), H. bidorsalis (♀) x H. bidorsalis (♂) and H. longifilis (♀) x H. longifilis (♂) respectively). Also, there was no significant difference (P>0.05) in the value of phosphate and BOD recorded which are 0.08±0.01 mg/L and 8.30±0.02 mg/L in the pureline cross C. gariepinus (♀) x C. gariepinus (♂), 0.09±0.01 mg/L and 8.40±0.02 mg/L in pureline cross (H. bidorsalis (♀) x H. bidorsalis (♂) and 0.08±0.03 mg/L and 8.80±3.8 mg/L in pureline cross (H. longifilis (♀) x H. longifilis (♂) respectively.

Table 2: Water quality parameters of pond stocked with parental progenies (Pureline breeds) of three farmed catfishes

	Parent Crosses		
Parameter	***Clarias gariepinus* (♀) × *Clarias gariepinus* (♂)**	***H. bidorsalis* (♀) × *H. bidorsalis* (♂)**	***H. longifilis* (♀) × *H. longifilis* (♂)**
Temperature (^{0}C)	28.90±0.02^a	29.00±2.00^a	28.75±0.45^a
pH	8.50±0.02^a	8.70±0.02^b	8.90±0.02^c
Alkalinity (mg/L)	13.41±0.02^a	13.45±0.02^a	13.49±5.84^a
Dissolved Oxygen (mg/L)	9.10±0.02^a	9.30±0.02^b	9.80±0.02^c
Turbidity (mg/L)	8.91±0.02^a	8.92±0.02^a	8.90±0.02^a
Ammonia (mg/L)	0.51±0.02^a	0.52±0.02^a	0.53±0.23^a
Phosphate (mg/L)	0.08±0.01^a	0.09±0.01^a	0.08±0.03^a
BOD (mg/L)	8.30±0.02^a	8.40±0.02^a	8.80±3.80^a

DISCUSSION

It has been reported that specific water parameters of the catfish environment are of relevance in determining the growth and survival of the species in varying degrees (Kasihmuddin et al., 2024). The results of this study showed that the parent crosses of the hybrids performed at the same temperature or under the temperature that is not significantly different to one another. This was also observed by Garba et al., (2024) when the temperature had no significant difference compared within the experiment of Clarias gariepinus progeny from different location. Meanwhile, the temperature from Garba et al., (2024) experiment ranged between 27.40oC and 28.27oC which is a little lower from the observation of this research. According to FAO (2006) the temperature throughout this experiment was within the optimum range (250C to 300C) for aquaculture. Meanwhile, their tolerance to pH differs from the report of this experiment, this variation in the pH can be related to the findings of Ivoke, et al., (2007) who also reported that most organisms normally possess a specific range or pH tolerance. But the findings of Ivoke, et al., (2007) indicate that Heterobranchus bidorsalis (male) x Clarias gariepinus (female) hybrid juveniles would have their tolerance pH range at 6.0 to 8.0 and an optimum pH range of 7.0 to 7.5 as maximum growth performance was recorded within this range since there was 100% survival at this pH range. The difference (pH range of 8.90 to 8.92) observed in comparison with Ivoke, et al., (2007) observation may be the peculiarity of the pureline breed used in this experiment. Meanwhile, pureline breed used in an experiment by Garba et al. (2024) had pH range of 6.54 to 7.37 and is lower from the observation from this experiment. Despite the variation within the pH of pureline breeds, the pH still falls within the optimum range (6.0 to 9.0) of the fish culture system based on the report of Davies (1993). The alkalinity as reported in this present research also was not significantly different from one another but higher than the optimum value for the freshwater aquaculture. This was also against the report of Gaunder (2005) who had observed that the alkaline death points for fish are about 11 with reproduction and growth diminishing with increasing alkalinity.

The dissolve oxygen was significantly high at the H. longifilis (♀) × H. longifilis (♂) progeny with the lowest at Clarias gariepinus (♀) × Clarias gariepinus (♂) this might be as result of the ability of the Clarias gariepinus species to withstand stress more than the rest. This result range of dissolved oxygen (9.10 mg/L to 9.80 mg/L) was higher than the observation reported by Garba et al. (2024) with the range of 6.66 mg/L to 7.22 mg/L when Clarias gariepinus progeny from different location was studied. The insignificant difference noticed in the turbidity, ammonia, phosphate, and BOD in this experiment showed that the pureline breed of Clarias gariepinus (♀) × Clarias gariepinus (♂), H. bidorsalis (♀) × H. bidorsalis (♂) and H. longifilis (♀) × H. longifilis (♂) can thrive under the same environmental condition especially water physico-chemical parameters (Loucif and Chenchouni, 2024).

CONCLUSION

The study looked at the water quality responses of pureline parental crossings between Clarias gariepinus, Heterobranchus bidorsalis, and Heterobranchus longifilis. The examination of critical physicochemical parameters demonstrated that all three pureline crosses were raised in water conditions that were within permissible limits for aquaculture. The results also show that all three catfish species can survive and adapt under similar environmental conditions, with just minor differences in specific parameters. Notably, Clarias gariepinus pureline tolerated somewhat lower dissolved oxygen levels, whilst H. longifilis exhibited greater oxygenation and pH tolerance.

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