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ORIGINAL RESEARCH

EVALUATION OF REPRODUCTIVE PERFORMANCE AND GROWTH PARAMETERS OF WILD STRAINS OF CATFISH, *Clarias gariepinus* (BURCHELL, 1822) AND *Heterobranchus bidorsalis* (GEOFROY, 1809) FROM THREE DIFFERENT GEOGRAPHICAL ZONES TO ALLEVIATE INBREEDING IN NIGERIA

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Abstract:

Introduction: *Clarias gariepinus* and *Heterobranchus* species dominate Nigerian aquaculture, contributing over 80% of production. However, hatchery challenges, particularly high mortality rates linked to inbreeding, hinder seed value chain sustainability.

Aim: This study aimed to improve clariid catfish strains by evaluating the reproductive performance and growth traits of wild Clarias gariepinus from River Benue, Lake Chad, and Ogun River, alongside a cultured strain from Lagos State University Hatchery.

Materials and Methods:

Broodstocks were sourced with artisanal fishermen's assistance, identified, and acclimatized before spawning. Reproductive parameters—fecundity, fertilization, and hatchability—were assessed post-hypophysation. Fry were reared into fingerlings and stocked in triplicate within mobile tarpaulin tanks at 4 fish/m³. They were fed a 45% protein diet twice daily for eight months.

Results: Results indicated that the Benue strain excelled in fertilization (90.26%), hatchability (91.53%), and survival (79.56%) but had the lowest fecundity (19,572.44 eggs). The Lake Chad strain exhibited the highest fecundity (113,561.75 eggs) but had lower fertilization (56.41%) and survival (61.59%). Growth performance assessments showed the Ogun strain had the highest final weight (795.57g), specific growth rate (3.974), and best feed conversion ratio (1.62). Proximate composition analysis revealed the Benue strain had the highest crude protein content (17.86%), while the Lake Chad strain had the highest crude fat (15.01%). Statistical analyses confirmed significant differences among strains.

Conclusion: Despite the Benue strain's reproductive advantages, the Ogun strain demonstrated the best balance of fecundity, growth, and feed efficiency, making it the most commercially viable for aquaculture.

Keywords: Fecundity, Hatchability, Growth, Feed Utilization, Strain Differences.

All co-authors agreed to have their names listed as authors.

1. INTRODUCTION

Clarias gariepinus (Burchell, 1822) and *Heterobranchus* species are the two most popular Clariid catfish in Nigeria and represent more than 80% of aquaculture production in the country (Adewunmi and [1]. This implies that aquaculture system in Nigeria is largely dependent on Clariid catfish [2] with smaller contributions from tilapia and other species. The popularity of catfish among consumers in Nigeria can be attributed to its minimal intra-muscular spines, scale-less nature, delightful taste in various processed forms, and relatively good storage shelf life when smoked. These species are also of high market value and good taste, high growth rate and fecundity, capable of withstanding high stocking densities thus high preferences by farmers and good candidates for aquaculture. They are indigenous to and widely distributed in Nigeria and being hardy makes them survive the poor rearing conditions often faced in the farm practice. With over 6,000 small-scale farmers and employing more than 13,000 individuals, the Nigerian aquaculture industry has experienced significant growth. In 2015, production increased from 21,700 tonnes in 1999 to 316,700 tonnes in 2013, contributing 33% of the 0.5% GDP generated by the fisheries sub-sector, equivalent to 0.166% of the nation's GDP. This growth has prompted increased governmental attention and investment in aquaculture, with approximately 30% of the total investment in agriculture being directed towards this sector [3]. Literature revealed that from 2003 to 2014, aquaculture production grew rapidly in Nigeria, but in recent years, the production has not increased and even declined slightly from 2015 to 2017, [4]. The production decline has been attributed to challenges of high cost of feed and inadequate supply of good quality seed. According to FDF [5], out of about 4.3 billion fish seed required annually to meet the estimated need, only 85 million fingerlings are produced in the country. The fish seed shortages is caused by nationwide unexplainable huge losses of fish at the fry/fingerling stage since 2013 by catfish breeders or farmers in Nigeria. The probable cause of the massive mortality of fish fry/fingerlings, by the practicing farmers and of the concerned supervising authorities, has been narrowed down to inbreeding of catfish [4].

Inbreeding is regarded as the mating between individuals with one or more common ancestors (Nichols, 2017). In respect to fish farming, it is the mating of close relative fishes [3][5] . This phenomenon has the capacity to promote homozygosity in the offspring and decrease heterozygosity [3][5] . This menace of inbreeding as not only affected the farmers in the aquaculture industry but also attracted the attention of researchers in the academia. An experiment by [6], showed that a large load of recessive lethal alleles were responsible for mass mortality of inbred by descent (IBD) F_2 families of the Pacific oyster (Crassostrea gigas), examined with microsatelite DNA markers. Nonetheless, inbreeding does not change the gene frequencies in a population, but alters the genotypic frequencies in that population resulting into higher than expected levels of homozygosity in the genotype of the entire population and consequent reduction of heterozygosity in individual genotypes [6]

According to [4], some of the causes for inbreeding are that the free movement of catfish from one farm to the other within the country was not monitored or documented as the filial generation of the catfish broodstock between farms and geopolitical zones is unknown; and there is a lack of an established zonal broodstock bank. Moreover, findings by Isa [7], revealed that the common practice in Nigeria by over 90% of the hatcheries operators is that they use shooters (fast growers) as broodstock, use only farmed broodstock and have no broodstock management/replacement programmes. This phenomenon is in line with the result of [8] which suggested that a domesticated strain of African catfish had lower fertilization rate, hatchability and survival than fish sourced from wild populations. Small scale farmers making up the bulk of aquaculture production in Nigeria are particularly exposed to the deleterious effect of inbreeding which includes indiscernibly slow growth of fingerlings/juveniles, sudden death of large numbers of fry / fingerlings between 3rd and 4th week, unpredictable/indeterminate hatching [4] and different narrations of woes of business collapse from farmers. To alleviate the

challenges of inbreeding, some genetic improvement measures and strategies have been developed and adopted. These genetic improvements technics includes individual and family selection, hybridization, sex reversal, chromosomes set and gene manipulation which have contributed to the development of genetically superior strains and improved performance in several aquaculture species such as Rainbow trout, Oncorhynchus mykiss [9]; Atlantic salmon, Salmon salar [9], Nile tilapia, Orechromis niloticus and African catfish, Clarias gariepinus [10][11]. These improvement strategies have yielded some positive results. However, [4] opined that cultured (farm bred) clariid species have been improved variously and the species has lost its wholesomeness and genetic purity leading to inbreeding.

This implies that the domesticated or farmed bred strain of catfish have been over used and are no longer as genetically pure as their wild strain counterpart that is believed to have its natural genetic composition intact. Moreover, there are still paucity of information on the growth performance and morphological structure of the wild strain of catfish population of River Ogun, Lake chad and River Benue particularly in the context of genetic diversity, paucity of information on the differences in the quality of reproductive performance of wild and cultured strains in the context of inbreeding in Nigeria and the need to inject the genes of wild strain catfish into the gene pool of the existing cultured strain so as to improve its vigour and sexual performance.

It is against this backdrop that this research study aims at evaluate the reproductive performance and growth parameters of wild clariid catfish strain - *Clarias gariepinus* and *Heterobranchus bidorsalis* from three different geographical zones (River Benue, River Ogun and Lake chad) to alleviate inbreeding in Nigeria.

1.1 Problem statement

Small scale farmers making up to 80% of the aquaculture producers in Nigeria, are faced with insufficient seed supply which may be due to reduced reproductive success and poor quality seed caused by inbreeding. Out of Out of 4.3 billion fish seed required annually to meet the estimated need, only 85 million fingerlings are produced in the country [13]

1.2 Aim of the Study

The aim of this research study is to develop an improved and fast-growing clariid catfish through evaluation of reproductive and growth performance of C*larias gariepinus strains* and *Heterobranchus bidorsalis* species from three different geographical zones (River Ogun, Lake chad, River Benue and Lagos strain of farmed *C gariepinus*) to alleviate inbreeding in Nigeria.

1.3 Objectives of the study

The `specific objectives of this study are to:

- Estimate the reproductive performance (fecundity, fertilization, hatchability) and survival rate of *Clarias gariepinus* and *Heterobranchus bidorsalis* (Parental line) from three different zoogeographical zones in Nigeria and Lagos strain farmed *C gariepinus*.
- Evaluate and compare the growth performance, feed utilization, proximate composition and water quality parameters of the progenies (F_1) produced from *Clarias gariepinus* strain *(wild) and Heterobranchus bidorsalis* (wild Pure bred) from three different geographical zones in Nigeria.

2. MATERIAL AND METHODS

2.1 Sampling Sites.

Three geographic zones were chosen for the collection of wild strain broodstocks:

River Benue, Guinea savanna (Latitude 7° 45' 12''N and Longitude 6° 45'24''E), Lake Chad, Sahel savanna (Latitude 13° 0'N and Longitude 14° 30'E) and, Ogun River, Tropical rainforest (Latitude 8° 41'0''N and Longitude 3° 28'0''E), Lagos strain (Control) was collected from Lagos State University Hatchery (Latitude 6° 28.226' N and Longitude 3° 12.019'E).

2.2 Collection and Acclimatization of the Broodstocks

Adult broodstocks samples were collected through the assistance of artisanal fishermen and were identified by an expert in fisheries Department. The broodstocks from the wild, were kept in separate tanks (1m^3) at LASU) hatchery and fed at 3% body weight twice daily at 09:00 and 16:00h with commercial diets of 40%CP for three months until they attain the mean weight of 2kg prior to breeding.

2.3 Experimental Site/Set up

The experiment for this study were conducted at the Hatchery Unit of the Department of Fisheries, Lagos State University (LASU), Ojo, Lagos, Latitude 6^o 28.226' N and Longitude 3^o 12.019'E, with an average annual rainfall of 1693mm and average temperature of 27.0 ^{o}C.

2.3.1 Broodstock Crosses (Parental line)

- *C gariepinus* male X *C gariepinus* female, Lakechad Strain (MALU)
- *C gariepinus* male X *C gariepinus* female, River Ogun Strain (IJEBU)
- *H bidorsalis* male X *H bidorsalis* female, River Benue Strain (MAK)
- *C gariepinus* male X *C gariepinus* female, Cultured strain (LAGOS)

2.3.2 Hypophysation / Fish Breeding:

The mature females were selected based on their swollen, reddish vent, well distended soft abdomen and extrusion of few eggs on gentle pressure of finger on the abdomen

2.3.2.1 Stripping and egg Fertilization

After observing the 12 - 14 hours latency period,, the female broodstocks were removed from the trough, held firmly with a wet towel at both ends,

The abdomen were pressed carefully for each of the fish strain to extrude the eggs into a dry bowl, and the stripping was done towards the fish vent [14].

2.3.2.2 Dissection of Male Broodstock for Gonad Removal

Sexually matured males of both *C gariepinus and Heterobranchus bidorsalis* were removed after being kept separately for two days without feeding prior to sperm collection.

2.3.2.3 Estimation of Fertilization and Hatching Rate

Fertilization and the hatchability rate in this research work were determined by using gravimetric method (eggs per gram);1 g of eggs from each species were used to determine the fertilization rate. [28].

Fertilization rate (%) = Number of fertilized eggs/Number of estimated eggs _ 100;

Hatchability (%) = Total Number of hatched eggs /Total Number of fertilized eggs _ 100;

Survival (%) = Total Number of larvae / Number of dead larvae x Total Number of larvae _ 100%.

2.3.2.4 Incubation and Hatching

The fertilized egg masses were incubated in the circular tanks of $1m^3$ regularly aerated and observed over a period of 24 - 36 hours.

2.3.2.5 Management of the Fries

Frys were managed in circular tanks for four weeks. Daily sucking out debris which include faecal waste, and debris from the feeds was done by means of siphoning. Daily feedings were done twice in the morning with the feeds being 50-60% crude protein.

2.3.2.6 Growing Fingerlings to grow out.

After the fry have attained fingerlings (four weeks), about 810 pieces of fingerlings (Mean of 7±2.0) were randomly counted and stocked into the mobile tarpulin tanks of 1 x1x$1m^3$ with 30 fingerlings stocked at 4 fish/m^3 of each cross of offspring in triplicate. The fish were fed regularly using Blue Crown, imported feed of 45% crude protein at 3 percent body weight of the fish.

2.3.2.7 Measurement of Body weight and total length

Fortnightly, body weight and total length of fish randomly selected from each triplicated treatment were determined using electronic scale WH-BO5 0.01g,(5kg) China and 1meter stainless steel ruler.

2.3.2.8 Evaluation of Fish Performance

The performance of different strains were evaluated based on the following parameters viz:

Reproductive performance – fertilization rate, hatching rate and survival rate.

Growth performance - weight gain, weight gain/day, relative weight gain, specific growth rate, percentage weight gain.

Nutrient utilization parameters - food conversion ratio (FCR), feed intake, protein intake, protein efficiency ratio (PER).

2.4 Data analysis

All the experimental data including final mean weight, weight gain, SGR, FCR and survival rate were analysed using Analysis of Variance (One- way ANOVA). The ANOVA was followed by Fisher's LSD test to determine the significant difference among means. Significance level were declared at ($P<0.05$). Ms Excel and stastiscal package for social sciences (SPSS) (Version 20) for windows were used for all statistical analysis.

3. RESULTS

Table 1: Fecundity, fertilization, hatchability, and survival rate of *Clarias gariepinus* strains from Ogun, Lake chad, Benue and Lagos.

REPRODUCTIVE PARAMETERS	FISH SPECIES			
	IJEBU (OGUN STRAIN) (WILD)	MALU (LAKE CHAD STRAIN) (WILD)	LAGOS STRAIN (WILD)	MAK (BENUE STRAIN) (WILD)
FECUNDITY	103162.20±902.11c	113561.75±660.01^{d}	59698.96±580.23^{b}	19572.44±287.42^{a}
FERTILIZATION	70.717±2.22^{b}	56.410±3.61^{a}	70.017±4.21^{b}	90.263±2.71^{c}
HATCHABILITY	89.467±2.93^{c}	71.782±1.81^{b}	79.796±1.75^{a}	91.525±2.06^{c}
SURVIV AL RATE	75.112±2.34^{b}	61.590±2.43^{a}	56.961±2.11^{a}	79.557±1.51^{b}

Figures in the same row having the same superscript are not significantly different. (P > 0.05)

In the **table 1**, the reproductive parameters of *Clarias gariepinus* and Heterobranchus bidorsalis strains from different locations (Ogun, Lake Chad, Lagos, and Benue) are compared. The parameters assessed are fecundity (number of eggs), fertilization rate, hatchability (percentage of fertilized eggs that hatched), and survival rate of offspring. The Benue strain had the highest fertilization (90.26%), hatchability (91.53%), and survival rate (79.56%) but the lowest fecundity (19,572.44 eggs). In contrast, the Lake Chad strain had the highest fecundity (113,561.75 eggs) but the lowest fertilization (56.41%), hatchability (71.78%), and survival rate (61.59%). The Ogun strain performed well in fecundity (103,162.20 eggs), hatchability (89.47%), and survival rate (75.11%), but its fertilization rate (70.72%) was moderate. The Lagos strain had moderate fecundity (59,698.96 eggs) but lower hatchability (79.80%) and survival rate (56.96%). Statistical analysis showed significant differences among the strains in these reproductive traits. The Benue and Ogun strains generally showed better reproductive performance, while the Lake Chad and Lagos strains underperformed in most parameters. These differences suggest that the Benue strain may be optimal for breeding programs prioritizing fertilization and survival, despite its lower fecundity.

Table 2: Proximate Composition of Four *Clarias gariepinus* Strain and *Heterobranchus bidorsalis* Species from Ogun, Lake Chad, Benue and Lagos.

PROXIMATE PARAMETERS	FISH SPECIES			
	IJEBU (OGUN STRAIN) (WILD)	MALU (LAKE CHAD STRAIN) (WILD)	MAK (BENUE STRAIN (WILD)	LAGOS STRAIN (CULTURED)
MOISTURE	63.95±0.15^{b}	62.25±0.43^{a}	61.92±0.84^{a}	**61.84±0.96^{a}**
CRUDE PROTEIN	17.78±0.54^{a}	15.90±0.06^{a}	17.86±1.06^{a}	**16.3±1.27^{a}**
CRUDE FAT	11.98±0.14^{a}	15.01±0.14^{b}	13.44±0.90^{ab}	**13.60±1.13^{ab}**
CRUDE FIBRE	1.16±0.10^{a}	1.20±0.05^{a}	1.14±0.37^{a}	**1.09±0.23^{a}**
ASH	3.58±0.35^{a}	5.70±0.58^{b}	1.14±0.37^{a}	**4.04±0.56^{ab}**
CARBOHYDRATE	**1.53±0.34^{a}**	**4.80±0.87^{b}**	**2.87±1.04^{a}**	**1.70±0.89^{a}**

Figures in the same row having the same superscript are not significantly different. (P > 0.05)

The proximate composition of the four *Clarias gariepinus* strains shows notable differences. The Ogun strain has the highest moisture content (63.95%) and the lowest carbohydrate (1.53%), while the Lake Chad strain stands out with the highest crude fat (15.01%), ash (5.70%), and carbohydrate (4.80%) levels. Protein content is relatively similar across all strains, with the Benue strain having the highest value (17.86%) and the Lake Chad strain the lowest (15.90%). Crude fiber content remains low across the board, ranging from 1.09% to 1.20%, with no significant differences. The Benue strain also has the lowest ash content (1.14%). These variations in nutritional composition suggest that strain origin influences feed utilization and nutrient profiles

.

Table 3: Growth performance and feed utilization of four *Clarias gariepinus* strains and *Heterobranchus bidorsalis* species from Ogun, Lake chad, Benue and Lagos.

GROWTH PARAMETERS	FISH SPECIES			
	IJEBU (OGUN STRAIN) WILD	MALU (LAKE CHAD STRAIN) WILD	MAK (BENUE STRAIN) WILD)	LAGOS STRAIN (CULTURED)
INITIAL WEIGHT	7.603±0.04^{a}	7.586±0.08^{a}	7.626±0.11^{a}	7.702±0.14^{a}
FINAL WEIGHT	795.57±16.53^{c}	704.58±8.34^{b}	599.46±12.86^{a}	636.70±21.33^{a}
WEIGHT GAIN	787.96±3.28^{c}	697.15±16.42^{b}	591.80±7.91^{a}	599.18±7.14^{a}
SGR	3.974±0.01^{c}	3.7811±0.21^{b}	3.68±0.01^{a}	3.715±1.31^{a}
FCR	1.62±0.02^{a}	1.75±0.14^{b}	2.32±1.44^{b}	1.93±1.26^{b}
GFCR	61.45±1.11^{b}	58.89±0.02^{a}	58.75±0.02^{a}	58.80±0.05^{a}
PER	20.56±0.22^{c}	15.49±0.14^{b}	13.15±0.28^{a}	13.31±0.18^{a}
SURVIVAL RATE	75.83±1.55^{ab}	72.46±1.85^{ab}	90.86±1.65^{b}	53.03±2.74^{a}

The Ogun strain of *Clarias gariepinus* exhibited superior growth performance, achieving the highest final weight (795.57g), weight gain (787.96g), specific growth rate (3.974), and best feed conversion ratio (1.62). In contrast, the Benue strain showed the lowest growth with a final weightof 599.46g and an FCR of 2.32, but it had the highest survival rate (90.86%). The Lake Chad strain had moderate performance with a final weight of 704.58g and an FCR of 1.75, while the Lagos strain showed poor survival (53.03%) despite moderate weight gain (599.18g). Protein efficiency was highest in the Ogun strain (PER: 20.56), followed by Lake Chad (15.49), while Benue and Lagos had the lowest values (13.15 and 13.31, respectively). Overall, the Ogun strain proved to be the most efficient in both growth and feed utilization.

The water quality parameters show notable variations across the four *Clarias gariepinus* strains. The Benue strain has the highest dissolved oxygen (7.24 mg/L) and pH (7.38), indicating better water conditions, while the Lagos strain has the lowest DO (4.64 mg/L) and highest ammonia (0.23 mg/L). The Ogun and Lake Chad strains have intermediate DO levels (5.82–5.86 mg/L) and similar pH values (6.52–6.63). Temperature is consistent across all strains, ranging from 27.86°C to 29.16°C. Ammonia levels remain low for all strains, with no significant differences. These water quality differences may reflect environmental factors specific to each strain's origin

Table 4: Water quality parameters of three *Clarias gariepinus* strain and *Heterobranchusbidorsalis* species from Ogun, Lake chad, Benue and Lagos.

WATER QUALITY PARAMETERS	FISH SPECIES			
	IJEBU (OGUN STRAIN) WILD	**MALU (LAKE CHAD TRIAN) WILD**	**MAK (BENUE STRAIN) WILD**	**LAGOS STRAIN CULTURED**
DO	5.82 ± 0.70^{ab}	5.86 ± 1.90^{ab}	7.24 ± 0.74^{b}	4.64 ± 1.12^{a}
TEMP	27.86 ± 0.83^{a}	28.40 ± 0.30^{a}	28.13 ± 0.24^{a}	29.16 ± 0.39^{a}
PH	6.63 ± 0.15^{ab}	6.52 ± 0.53^{a}	7.38 ± 0.19^{b}	6.43 ± 0.25^{a}
AMMONIA	0.07 ± 0.09^{a}	0.18 ± 0.21^{a}	0.05 ± 0.05^{a}	0.23 ± 0.28^{a}

DISCUSSION

4.1 Reproductive performance

The reproductive performance of Clarias gariepinus is significantly influenced by a combination of genetic factors, broodstock nutrition, water quality, and environmental conditions, all of which play a crucial role in determining fecundity, fertilization rate, hatchability, and survival rate [16]

4.1.1 Fecundity

The comparison of four strains—Ogun, Lake Chad, Benue, and Lagos—reveals notable variations in reproductive parameters, with the Lake Chad strain exhibiting the highest fecundity (113,561.75 eggs) and the Benue strain recording the lowest (19,572.44 eggs). This aligns with the findings of [16] which reported that larger broodstock tend to have a higher gonadosomatic index and produce more eggs. Additionally, [15] noted that hybrid Clarias gariepinus strains often demonstrate higher fecundity than purebred strains due to genetic vigor, supporting the observed trend in the Lake Chad strain's superior egg production. [17] also emphasized that optimal broodstock nutrition and body size contribute significantly to fecundity, explaining why the Lake Chad strain outperformed the other strains. On the other hand, the Benue strain's lower fecundity is likely due to its smaller body size and possible suboptimal broodstock nutrition, a hypothesis reinforced by [18], who demonstrated that high-protein broodstock diets significantly enhance fecundity, whereas poor nutrition reduces egg production. This

suggests that improving broodstock feeding regimes could enhance the reproductive potential of the Benue strain.

4.1.2 Fertilization

Fertilization rate, which measures the proportion of eggs that are successfully fertilized, exhibited significant variations among the strains, with the Benue strain recording the highest fertilization rate (90.26%) and the Lake Chad strain the lowest (56.41%). This discrepancy highlights differences in gamete quality, environmental conditions, and broodstock management strategies. According to [16], hybridization between Clarias species improved fertilization rates due to increased sperm motility and compatibility between gametes. This may explain the high fertilization rate of the Benue strain, which might possess superior sperm quality or optimal spawning conditions. [15] also found that selective breeding enhances fertilization success when water quality is optimized, further supporting the Benue strain's reproductive efficiency. Conversely, the low fertilization rate of the Lake Chad strain (56.41%) may be attributed to suboptimal environmental conditions affecting sperm viability and egg receptivity. [17] reported that fluctuating water temperatures and poor water quality negatively impact fertilization success, which aligns with the observed pattern in the Lake Chad strain. Additionally, [18] highlighted that broodstock conditioning significantly influences egg and sperm quality, suggesting that inadequate broodstock management may have contributed to the lower fertilization rate observed in the Lake Chad strain.

4.1.3 Hatchability

Hatchability, defined as the percentage of fertilized eggs that successfully hatch into larvae, was highest in the Benue strain (91.52%) and the Ogun strain (89.47%), while the Lake Chad and Lagos strains exhibited lower hatchability rates (71.78% and 79.80%, respectively). These findings align with [16] which reported that hybrid Clarias strains exhibited higher hatchability due to superior egg quality and improved embryonic development. Additionally, [15] found that genetic selection plays a crucial role in enhancing hatchability, particularly in hybrid *Clarias gariepinus* strains. The high hatchability in the Benue and Ogun strains suggests that these strains possess superior egg viability and were incubated under more stable environmental conditions, as noted by [17]. On the other hand, the lower hatchability in the Lake Chad strain (71.78%) suggests compromised egg quality, possibly due to environmental stressors or poor broodstock nutrition. [18] demonstrated that broodstock diets with insufficient protein levels resulted in lower hatchability rates, reinforcing the role of balanced nutrition in maximizing reproductive success.

4.1.4 Survival rate of larva

Survival rate, which reflects larval resilience, adaptability, and overall reproductive efficiency, was highest in the Benue strain (79.56%), followed by the Ogun strain (75.11%), while the Lagos and Lake Chad strains had significantly lower survival rates (56.96% and 61.59%, respectively). These results correlate with [16] which found that hybrid *Clarias gariepinus* strains demonstrated superior survival rates due to

genetic advantages and improved environmental adaptability. Similarly, [15] highlighted that water quality parameters, particularly dissolved oxygen (DO) and ammonia concentration, significantly influence larval survival. The Benue strain's high survival rate is consistent with its relatively favorable water conditions, including higher DO and stable pH levels, as reported by [17]. Conversely, the low survival rates in the Lagos and Lake Chad strains may be attributed to poor water quality and suboptimal environmental conditions. [17] emphasized that high ammonia levels and oxygen depletion are major causes of larval mortality, which could explain the higher mortality rates observed in the Lagos strain. Furthermore, [18] found that broodstock fed high-quality diets produced larvae with better survival rates, reinforcing the critical role of nutrition in larval development.

4.2 Proximate composition

The proximate composition of the four *Clarias gariepinus* strains shows notable differences. The Ogun strain has the highest moisture content and the lowest carbohydrate while the Lake chad stands out with the highest crude fat, ash, and carbohydrate levels. Protein content is relatively similar across all strains, with the Benue having the highest value and the Lake chad the lowest. This results negates the findings of [3], which exhibited no significant differences ($p>0.05$). However, the moisture content was within previously reported range in other fishes [19]. Percentage moisture in the muscle was within the acceptable levels (30% - 80%) [20]. [15] found that domesticated *Clarias gariepinus* often retain more moisture due to the influence of commercial feeds, while wild fish have a firmer texture, which aligns with the lower moisture levels in wild Lake Chad and Benue strains. The Benue strain also exhibited the highest crude protein content (17.86%), followed closely by the Ogun strain (17.78%), while the Lake Chad strain had the lowest protein value (15.90%). This trend is consistent with [23], who observed that *Clarias gariepinus* and its hybrids showed superior protein retention when fed high-quality formulated diets.The crude protein contents values were within the range previously reported for *C. gariepinus* and other fishes [20][19][21]. Moreover, the relatively high protein content in the Ogun and Benue strains suggests superior muscle development, making them ideal for meat production. Fat content varied significantly across the strains, with the Lake Chad strain exhibiting the highest crude fat content (15.01%) and the Ogun strain recording the lowest (11.98%). This aligns with [22] who reported that wild *Clarias gariepinus* tend to accumulate higher fat reserves due to diverse natural diets, whereas cultured fish have leaner muscle mass influenced by controlled feed intake. The high-fat content in the Lake Chad strain suggests that it serves as a better energy source, whereas the Ogun strain is more suitable for consumers preferring leaner fish. The ash content, a key indicator of mineral retention, was highest in the Lake Chad strain (5.70%) and lowest in the Benue strain (1.14%), which aligns with [3], who noted that fish from mineral-rich environments tend to have higher ash content. Additionally, carbohydrate content followed a similar trend, with the Lake Chad strain recording the highest (4.80%) and the Ogun strain the lowest (1.53%), indicating that wild strains may have greater carbohydrate retention from plant-based feed sources compared to cultured strains fed protein-rich diets. Overall, these findings suggest that while

the Ogun and Benue strains are excellent protein sources, the Lake Chad strain is more suitable for energy-rich diets due to its higher fat and mineral content.

4.3 Growth performance and feed utilization

The growth performance and feed utilization (Table 3) indicate that the Ogun strain outperformed the other strains in all key metrics, a trend supported by previous studies. It recorded the highest final weight (795.57 g) and weight gain (787.96 g), whereas the Benue strain had the lowest final weight (599.46 g) and weight gain (591.80 g), confirming its slower growth potential. This supports findings by [15], who reported that *Clarias gariepinus* induced with Ovaprim had significantly better growth than hybrids or strains with lower genetic potential. The specific growth rate (SGR) was highest in the Ogun strain (3.974%/day) and lowest in the Benue strain (3.68%/day), indicating superior metabolic efficiency in the Ogun strain, which aligns with [23] who found that farmed *Clarias gariepinus* strains had higher SGR than wild hybrids. The feed conversion ratio (FCR), a key efficiency metric, was best in the Ogun strain (1.62), whereas the Benue strain had the poorest FCR (2.32), confirming that the Benue strain required more feed per unit weight gain. This is consistent with [22] who found that *Clarias gariepinus* fed formulated diets exhibited significantly better FCR than those relying on suboptimal diets. The protein efficiency ratio (PER), which measures how well dietary protein is converted into body mass, followed a similar pattern, with the Ogun strain having the highest PER (20.56) and the Benue strain the lowest (13.15), reinforcing the Ogun strain's superior feed utilization.

Despite its poor growth performance, the Benue strain exhibited the highest survival rate (90.86%), while the Lagos strain had the lowest survival rate (53.03%). This trend aligns with [3], who found that some farmed *Clarias gariepinus* strains had lower growth rates but exhibited stronger resilience under stressful conditions. The high survival rate of the Benue strain suggests genetic advantages in disease resistance or environmental adaptability, making it suitable for aquaculture in regions with fluctuating water quality. In contrast, the low survival rate of the Lagos strain may be linked to environmental stressors, as discussed by [23] who noted that poorly managed cultured fish often suffer from higher mortality rates due to inadequate water quality and feed variability. The Ogun strain, with its combination of strong growth performance and reasonable survival (75.83%), remains the most viable strain for commercial aquaculture, offering both high productivity and efficient feed conversion.

The higher significant performance of Ijebu (Ogun strain) than its farm cultured counterparts Lagos strain is an indication of the perceived inbreeding depression within the aquaculture industry. This is in agreement with the findings of [8] who reported that the breeding performance of natural populations of catfish performed better than domesticated strains cultured in Nigeria farms. However, this research study contradict the findings of some previous researchers. [31] reported that cultured clarias gariepinus

had a significant better growth performance than its wild counterpart. Similar findings were also reported by [3] whose results showed that there is no significant difference in growth rate among wild fish populations and cultured strains studied. This could probably due to the introduced Dutch strain brought to Nigeria from the Netherlands whose gene pool has mixed with indigenous cultured catfish. Although this has resulted in increased production of catfish in Nigeria but its genetic consequences has led to the perceived inbreeding depression in the aquaculture industry.

4.3.1 Water quality parameters

The water quality parameters (Table 4) significantly influenced the survival and growth rates of the four fish strains, further confirming the role of environmental factors in aquaculture success. The Benue strain exhibited the highest dissolved oxygen (DO) levels (7.24 mg/L), while the Lagos strain had the lowest (4.64 mg/L), which could explain the Benue strain's high survival and the Lagos strain's low survival. These findings are consistent with [15], who found that higher DO levels improve feed intake, metabolic processes, and overall fish health. The temperature range among the strains was within the optimal growth range (27–30°C), with the Lagos strain having the highest temperature (29.16°C) and the Ogun strain the lowest (27.86°C), confirming previous studies that temperature fluctuations within this range do not significantly affect *Clarias gariepinus* growth but may influence stress levels.

Water pH levels were highest in the Benue strain (7.38) and lowest in the Lagos strain (6.43), suggesting that acidic conditions may have negatively affected the Lagos strain's survival. [23] noted that a pH range of 6.5–7.5 is optimal for *Clarias gariepinus* growth, indicating that the Benue strain had the most favorable pH conditions, while the Lagos strain's slightly acidic water may have contributed to increased stress and mortality. Ammonia levels, which are directly linked to water pollution and fish mortality, were highest in the Lagos strain (0.23 mg/L) and lowest in the Benue strain (0.05 mg/L), reinforcing the negative impact of poor water conditions on survival rates. [22] found that elevated ammonia levels above 0.2 mg/L significantly reduce fish growth and survival, confirming that the Lagos strain's high ammonia levels likely contributed to its high mortality (53.03%). The favorable water conditions of the Benue strain (high DO, neutral pH, and low ammonia) explain its high survival rate, whereas the Lagos strain's poor water conditions likely caused stress, leading to reduced growth and higher mortality.

4.4 CONCLUSION

The reproductive performance, growth, and survival of *Clarias gariepinus* exhibit significant variability across different strains, largely influenced by genetic composition, environmental factors, and hatchery management practices. The Lake Chad strain demonstrated the highest fecundity (113,561.75 eggs) but suffered from lower fertilization and hatchability rates, reinforcing the notion that high egg production alone does not guarantee reproductive success. In contrast, the Benue strain, despite having the lowest fecundity (19,572.44 eggs), exhibited superior fertilization (90.26%), hatchability (91.52%), and survival (79.56%), suggesting that genetic resilience and favorable environmental conditions contribute

significantly to reproductive efficiency. The Ogun strain emerged as the most commercially viable, balancing high fecundity (103,162.20 eggs), strong hatchability, and survival, making it an ideal candidate for large-scale aquaculture. However, the Lagos strain, despite its moderate reproductive performance, suffered from poor survival (53.03%), likely due to unfavorable water quality and potential inbreeding effects. The proximate composition data further revealed distinct differences between wild and cultured strains, with wild strains (Lake Chad and Benue) displaying higher crude fat and mineral content, while cultured strains (Ogun and Lagos) retained more moisture and protein, suggesting differences in dietary intake and metabolic processes. Growth performance assessments confirmed that the Ogun strain had the highest final weight (795.57 g), weight gain (787.96 g), and the most efficient feed conversion ratio (1.62), making it the most suitable for commercial farming. However, the Benue strain, while excelling in survival, exhibited the poorest growth performance (final weight 599.46 g) and highest feed conversion ratio (2.32), indicating a trade-off between resilience and growth efficiency. The main finding suggested that Ogun strain of *Clarias gariepinus* demonstrated the best balance of fecundity, growth performance, and feed efficiency, making it the most commercially viable strain for aquaculture.

COMPETING INTERESTS

No competing interest among the authors

References

1. Adewumi AA, Olaleye VF. Catfish culture in Nigeria: Progress, Prospects and Problems. Afr J Agric Res. 2011;6(6):1281-1285.
2. FAO. FAO and the SDGs Indicators: Measuring up to the 2030 Agenda for Sustainable Development. Rome: FAO; 2017:39.
3. Olalere OA. Is there evidence of inbreeding in African catfish (Clarias gariepinus) culture in Nigeria? Final project, UNESCO GRÓ Fisheries Training Programme, Iceland; 2020. Available from: http://www.grocentre.is/ftp/static/fellows/document/Abimbola19prf.pdf
4. Areola FO, Osanyinlusi OI, Alatise OM, Oladele OO. Implications of inbreeding in Clarias gariepinus fish farming: Farmers' perspectives in Nigeria. Jr Aqua Mar Bio Eco. 2024;JAMBE-124.
5. Nichols HJ. The causes and consequences of inbreeding avoidance and tolerance in cooperatively breeding vertebrates. J Zool. 2017;303:1-14. doi:10.1111/jzo.12466
6. Akinoshun KM. Quantifying the effect of inbreeding on the growth performance and yield of Mozambique tilapia (Oreochromis mossambicus) over three generations of repeated full-sib mating. Stellenbosch University; 2015.
7. Isa SI. Development of genetic improvement in the African catfish (Clarias gariepinus, Burchell, 1822) [PhD thesis]. University of Stirling, Scotland, UK; 2019.
8. Iwalewa M, Akinwale A, Adewole MM, Okhiria E, Ebonwu B, Iheanacho EB, Bede OC. Improving breeding performance of fingerlings of Clarias gariepinus through intraspecific hybridization. Nigerian Inst Oceanogr Mar Res; 2017.
9. Gjerde B. Growth and reproduction in fish and shellfish. Aquac Res. 1986;57(1):37-55.
10. Anetekhai M, et al. Catfish aquaculture industry assessment in Nigeria. African Union Inter-African Bureau for Animal Resources; 2013.
11. Owodeinde FG, Fakoya KA, Anetekhai MA. Growth performance of hybrid catfish (Clarias gariepinus × Heterobranchus bidorsalis) in earthen ponds. Asian J Biol Sci. 2012;5(4):192-200.

12. Owodeinde FG, Ndimele PE, Anetekhai MA. Reproductive, growth performance and nutrient utilization of Heterobranchus bidorsalis and its hybrid "Clariabranchus" induced with synthetic hormone and pituitary gland of Heterobranchus bidorsalis. Int J Zool Res. 2011;7(5):345-357.
13. Bassey H. Phenotypic and genetic evaluation of farmed and wild Clarias gariepinus broodstock in Nigeria. Final project, UNESCO GRO Fisheries Training Programme, Iceland; 2020. Available from: http://www.growcentre.is/ftp/static/fellows.document/Happiness19prf.pdf
14. Ataguba GA, Annune PA, Ogbe FG. Induced breeding and early growth of progeny from crosses between two African clariid fishes, Clarias gariepinus and Heterobranchus longifilis under hatchery conditions. J Appl Biosci. 2010;14(1):755-760.
15. Ndimele PE, Owodeinde FG. Comparative reproductive and growth performance of Clarias gariepinus and its hybrid induced with synthetic hormone and pituitary gland of Clarias gariepinus. Lagos, Nigeria; 2012.
16. Esa YB, Dadile AM, Syukri F, Christianus A, Diyaware MY. Evaluation of fecundity, fertilization, hatching, and gonadosomatic index of exotic *Clarias gariepinus* (Burchell, 1822) and native *Clarias macromystax* (Günther, 1864) under semi-arid conditions of Nigeria. *Animals*. 2023;13:1723. doi:10.3390/ani1311172.
17. Nguenga D, Teugels GG, Ollevier F. Fertilization, hatching, survival and growth rates in reciprocal crosses of two strains of an African catfish (Heterobranchus longifilis) under controlled hatchery conditions. Aquac Res. 2000;31:565-573.
18. Constantine CO, Mathew TM, Akisoferi OW, Mujibu N, Immaculate K, Cassius A. Evaluation of the reproductive performance of African catfish (Clarias gariepinus) broodstock fed on three locally manufactured commercial feeds. Int J Fish Aquat Stud. 2014;2(3):39-44.
19. Osibona AO, Kusemiju K, Akande GR. Proximate composition and fatty acids profile of the African catfish Clarias gariepinus. J Life Phys Sci. 2006.
20. Eyo AA. Fish processing technology in the tropics. New Bussa, Nigeria: National Institute for Freshwater Fisheries Research; 2001.
21. Onyia LU, Milam C, Ese DS. Investigation of heavy metals in four commercial fishes along Upper River Benue, Yola. Int J Phys Sci. 2007;2(2).
22. Anifowose OR, Oladosu GA, Oladele OO. Comparative growth performance and survival of hatchery-reared African catfish fry (Clarias gariepinus) fed on live and artificial diets. Int J Fish Aquat Stud. 2022;10(2):106-112.
23. Adewolu MA, Ogunsanmi AO, Yunusa A. Studies on growth performance and feed utilization of two clariid catfish and their hybrid reared under different culture systems. Eur J Sci Res. 2008;23(2):252-260.
24. Akinwumi AA. Aquaculture in Nigeria: Sustainability issues and challenges. Direct Res J Agric Food Sci. 2015;3(12):223-231.
25. Abanikannda OTF, Jimoh AA, Abagun AA, Badmus LA. Comparative study of growth parameters of African catfishes as panacea for food security. Nig J Anim Sci. 2019;21(3):179-192.
26. Ukwe IOK, Amachree D, Jamabo NA. Growth assessment and microbial flora presence in African catfish (Clarias gariepinus) larvae fed live and commercial feeds. Int J Sci. 2019;8:7.
27. Adeosun FI. The fin fish assemblage of Lower Ogun River, Akomoje, Ogun State, Nigeria. Nig J Anim Sci. 2012;14:174-180.
28. Walakira JK, Hinrichsen E, Tarus V, Langi S, Ibrahim NA, Badmus O, Baumüller H, et al. Scaling aquaculture for food security and employment in Africa: Insights from Egypt, Kenya and Nigeria. 2023.
29. FAO. The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation. Rome: FAO; 2022.

30. De Graaf G, Galemoni F, Banzoussi B. Artificial reproduction and fingerlings production of African catfish (Clarias gariepinus) in reported and protected ponds. Aquac Res. 1995;26:233-242.
31. Megbowon I, Fashina-Bombata H, Akinwale M, Mojekwu H. Growth performance of wild strains of Clarias gariepinus from Nigerian waters. J Fish Aquat Sci. 2014;9(4):252-256.