World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Comparative studies on reproductive parameters of parents and hybrids of *Clarias gariepinus* (African mud catfish)

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World Journal of Advanced Research and Reviews, 2025, 25(01), 2328-2334

Publication history: Received on 20 December 2024; revised on 27 January 2025; accepted on 30 January 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.1.0312

Abstract

This study investigates the reproductive parameters of *Clarias gariepinus* (African catfish) with normal and snout mouth deformities under indoor hatchery conditions across three senatorial districts in Ekiti State, Nigeria. Fertilization, hatchability, and survival rates of offspring from 16 crossing combinations of parental strains were assessed. Results indicated that normal mouth *Clarias gariepinus* exhibited superior reproductive and survival outcomes compared to hybrids and deformed counterparts. Hatchability ranged between 4.29% and 8.82%, with the highest recorded in the cross of Ado normal mouth strains. Survival rates were consistently highest in normal mouth progeny across the 13-week study. These findings highlight the importance of selecting normal mouth *Clarias gariepinus* for aquaculture to enhance productivity and profitability.

Keywords: *Clarias gariepinus* (Cat fish); Hybrids; Reproductive parameters; Ekiti State

1. Introduction

The problem of ever-increasing population without a matching increase in the farming of animal protein is a major challenge facing developing countries which includes Nigeria (Olopade *et al*., 2015). According to Olopade *et al*., (2015) the deficit in the recommended protein intake in comparison to the average consumption rate has led to an increase in demand for animal protein by Nigerians. In the search for a feasible and sustainable solution to this problem, fish has been spotted as an affordable source of good quality protein of animal source in many developing countries including Nigeria (Gebeyehu, 2004). The potentials of fish for reducing the protein deficiency in the developing world especially Nigeria cannot be swept under the carpet (Olopade *et al*., 2015), of which they might be sourced from the wild or through fish farming/aquaculture.

The rearing of *Clarias gariepinus*, which was reported to have started in the early 1970s in central and western African countries, has been reported to have received wide acceptance because of its suitability for aquaculture and its high economic value (Awe, 2017). For these reasons, it has gained popularity amongst fish farmers, and it is said to be the most widely cultured fish in Nigeria and even in Africa (Adewumi and Olaleye, 2011; Awe, 2017) because of its hardiness in the face of harsh climatic condition, disease resistance and its maturity (Huisman and Richter, 1987; Awe, 2017).

Studying reproductive parameters and growth potentials of fish species, such as *Clarias gariepinus*, holds significant implications for aquaculture management, genetic improvement, and conservation efforts. Understanding reproductive parameters allows aquaculturists to develop more effective breeding programs. Focusing on the selection of individuals with desirable reproductive traits, such as higher egg production and fertility rates, spawning behaviour, and hatching

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success can enhance the operations and productivity of aquaculturists. The knowledge of reproductive parameters helps in identifying optimal environmental conditions for spawning, such as temperature, photoperiod, and water quality. With the provision of these conditions, aquaculturists can manipulate reproduction, synchronize spawning, and maximize the yield of viable eggs for subsequent production. Understanding the timing of reproductive events, including spawning seasons and durations, allows for better planning and management of production cycles in aquaculture systems (Sue *et al*., 2024). It facilitates the scheduling of breeding, larval rearing, and grow-out phases, resulting in more efficient and profitable operations.

Comparative studies on reproductive parameters provide insights into the heritability of these traits. This information is crucial for implementing selective breeding programs, where individuals with superior reproductive and growth characteristics are chosen as parents to produce the next generation with enhanced performance. This approach leads to the development of improved strains or hybrids with higher reproductive output and faster growth rates. Studying the relationship between genetic variations and reproductive parameters or growth potentials helps in identifying genetic markers associated with these traits. This enables the use of molecular tools, such as genetic markers or genomic selection, to facilitate the identification and selection of superior individuals for breeding, accelerating the genetic improvement of the species.

Comparative studies on reproductive parameters and growth potentials provide insights into the health and vitality of fish populations. By monitoring these parameters, conservationists can assess the reproductive success and population dynamics of the species. This information is crucial for identifying population declines, implementing conservation measures, and developing effective management strategies for sustainable exploitation. Understanding the reproductive parameters and growth potentials of fish species is essential for successful stock enhancement programs. By selecting individuals with optimal reproductive traits and high growth potentials, conservationists can breed and release individuals that are more likely to survive, reproduce, and contribute to the recovery of wild populations.

Abnormalities in the morphology of *Clarias gariepinus* has been reported on a global scale (Alarape *et al*., 2015). These deformities have taken toll on the productivity of most fish farmers as they affect the economics. Also, the presence of these deformities poses a substantial threat to the sustainability of any aquaculture enterprise as they mar the breeding process for the production of healthy offsprings. A major challenge facing fish farmers especially in Ekiti State is the non-availability or inadequate supply of quality *Clarias gariepinus* seeds. It is imperative for fish breeders and growers to select individuals with optimal reproductive traits and high growth rates. This study aims at determining the effects of snout mouth deformity on egg hatchability, hatchlings, fry, fingerlings and their survival rates under indoor conditions.

2. Material and methods

2.1. Study Areas

The study areas consists of ABUAD Fish Farm in Ado-Ekiti representing Ado Local Government Area, Ayenco Farm in Ido-Ekiti representing Ido Osi Local Government Area and Owoeye Farm in Ikere Ekiti representing Ikere Local Government Area.

Ado-Ekiti is a city in Southwest Nigeria and it is the capital of Ekiti State. It is the headquarters of Ado Local Government Area of Ekiti State. Ado-Ekiti is located in Ekiti Central Senatorial District of Ekiti State.

Ido-Ekiti is the headquarters of Ido/Osi Local Government Area of Ekiti State and it is located in Ekiti North Senatorial District of Ekiti State.

Ikere-Ekiti is the headquarters of Ikere Local Government Area of Ekiti State and it is located in Ekiti South Senatorial District of Ekiti State.

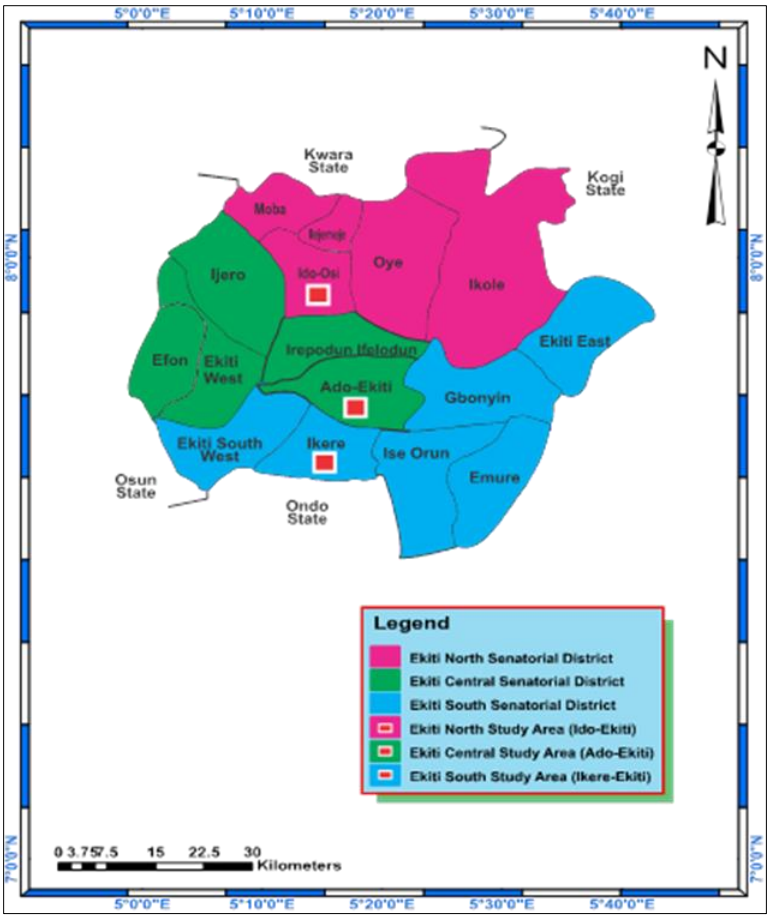

Figure 1 Study Areas in the three Senatorial Districts of Ekiti State, Nigeria (Source: Survey and Geoinformatics Department, Federal Polytechnic, Ado-Ekiti)

2.2. Experimental Site

The research was conducted at the Fish Hatchery Section, Department of Fisheries Technology, Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria.

2.3. Collection of Fish Samples

Matured Normal and deformed parent stocks of *Clarias gariepinus* were collected from the three sites above as the study area. The fish samples were transported in plastic kegs from the sites of collection to the experimental site at the Fish Hatchery Section, Department of Fisheries Technology, Federal Polytechnic, Ado-Ekiti, Ekiti State.

2.4. Fish Sorting

The fish samples were sorted according to sexes into deformed and normal i.e. Female Normal Mouth (FNM), Male Normal Mouth (MNM), Female Snout Mouth (FSM) and Male Snout Mouth (MSM). The fish were acclimatized for 25 hours as described by Fagbuaro (2009).

2.5. Collection of Water Samples and Determination of Water Quality Parameters

Water samples were collected from the ponds at the three (3) Study Areas into three labelled sample bottles and were firmly corked. The key water quality parameters were tested and recorded with the following equipments in the Laboratory at room temperature: Temperature was measured with clinical thermometer; Dissolved Oxygen (DO_2) measured with Dissolved Oxygen met and Hydrogen Ion Concentration (pH) with a pH meter.

2.6. Fish Breeding

Preparation of incubation tanks and fish breeding were done following the methods described by Awe (2017). This involved female brooders being injected intramuscularly just below the dorsal fin with synthetic ovaprim hormone, at

a dosage of 0.5 ml/kg of fish body weight. Afterwards, injected fish were left for a latency period of 8-10 hours. The male was sacrificed and the gonads were removed, the sperm sac was severed so as to release the milt into a saline solution containing 9 g of salt in 100cl of water. After the expiration of the latency period, the ovulated eggs were stripped off the female genitalia into another set of labelled petri dishes by applying slight pressure on the abdomen.

2.7. Fertilization and Incubation of Eggs

After the ovulated eggs were stripped, it was mixed with the milt released from the male gonad using a quill feather. In a bid to activate the sperms for maximum contact with the eggs, 10ml of saline water was added to the mixture (Daniel *et al.,* 2020). The fish samples collected were crossed for fertilization in the following sixteen (16) ways;

AD (♀) x AD (♂) IK (♀) x ID (♂) ID (♀) x AD (♂) IK (♂) x NM (♀)
AD (♀) x IK (♂) IK (♀) x AD (♂) AD (♂) x NM (♀) ID (♀) x NM (♂)
AD (♀) x ID (♂) ID (♀) x ID (♂) AD (♀) x NM (♂) ID (♂) x NM (♀)
IK (♀) x IK (♂) ID (♀) x IK (♂) IK (♀) x NM (♂) NM (♀) x NM (♂)

(AD = Ado-Ekiti; IK = Ikere-Ekiti; ID = Ido-Ekiti; NM = Normal Mouth; ♂ = Male: ♀=Female).

Hatching commenced after 21 hours of fertilization. 24 hours, dead eggs were siphoned out from the tank after the Kakaban has been carefully removed. Hatchlings were not fed for three days as they absorbed their yolk sac. After the expiration of the three days, the larvae were fed with Artemia twice daily until the yolk sac was completely absorbed. The daily survival rate for the larvae were recorded for the first 10 days.

The total number of hatched eggs were determined 24-30 hours after hatching and the unfertilized eggs that turned whitish were collected in a bowl and determined using the volumetric counting method. Subtracting the number of unfertilized eggs from the total number of stripped eggs estimated the total number of hatched eggs.

The fry were redistributed into group of twenty (20) for weekly survival study. On the 11th day for daily count of survival. The survival rates were recorded from the day after hatching to the 8th week. Hatchability and survival rates of the larvae were recorded according to the formula used by Awe (2017).

$$\text{Survival Rate (SR)} = \frac{\text{Initial number of Hatched Eggs} - \text{Mortality}}{\text{Total Number of Hatched Eggs}} \times 100$$

$$\text{Hatchability} = \frac{\text{Number of eggs hatched}}{\text{Total Number of Sampled Eggs}} \times 100$$

2.8. Fish Nursing/Rearing

The fry were sorted and redistributed into plastic tanks for the commencement of weekly monitoring of growth and development. Artemia feed was replaced with floating Aler Aqua feed containing 40 % crude protein, on the second week of fry rearing. Weekly monitoring continued for the next twelve weeks and data on the growth parameters (weight gain) were recorded. Water in the tanks was changed every 2 days to avoid accumulation of waste and foaming. Growth rate was recorded using the formula of Awe (2017).

$$\text{Weight gain (WG)} = \text{Final weight of fish} - \text{Initial weight of fish}$$

$$\text{Growth Rate} = \frac{\text{Weight Gain}}{\text{Number of days}} \times 100$$

2.9. Statistical Analysis

All data collected during the monitoring were processed and analyzed using Microsoft excel package (2016). The means were computed and levels of significance were tested based on one-way Analysis of Variance (ANOVA) at 5% significance level. The means were separated using Duncan's Multiple Range System.

3. Results

This research work carried out on Normal Mouth and Snout Mouth *Clarias gariepius* for thirteen weeks of maintenance under indoor hatchery produced the following results: Table 1 Shows the number of fertilized eggs ranged between 720 in the crossing of Ado and Ido strains and 1501 in the crossing of normal mouth and Ikere stains. Total number of eggs fertilized, number of hatchlings and the percentage hatchability of snout mouth and normal mouth parentals of *Clarias gariepinus* and their hybrids from the three senatorial districts of Ekiti State maintained under indoor hatchery conditions. The percentage hatchabilities ranged between 4.29 in Ado parentals AD(♀) × NM(♂) and hybrid of Ikere and Ido strain IK(♀) X ID(♂) and 8.82 in the Ado and Normal mouth strain AD(♀) × NM(♂).

Table 2 shows the mean weekly survival of progenies from the sixteen mating groups of *Clarias gariepinus* with snout mouth and normal mouth obtained from three different Senatorial Districts of Ekiti State after thirteen weeks of maintenance under indoor hatchery. By the fourth week of growth maintenance, the parental of strain with normal mouth had highest survival of the progeny while the parental of Ikere strain, hybrids of Ado and Ikere, Ado an Ido, Ikere and Ado, Ido and Ikere and Ido and Ado had the least mean survival of offsprings. By the thirteenth week of growth maintenance the normal mouth strain had highest mean survival value of seventeen (17) while the Ado-Ekiti strain, the cross of Ido and Ado recorded the least mean survival value of eight (8) each.

Table 1 Total number of eggs fertilized, number of hatchlings and percentage of hatchability obtained from sixteen mating groups of snout and normal mouth from three senatorial regions of Ekiti State

Crosses	Number of fertilized eggs	Number of Hatchlings	Hatchability (%)
AD(♀) x AD(♂)	784	348	4.29
ID(♀) x ID(♂)	908	372	4.58
IK(♀) x IK(♂)	739	429	5.28
NM (♀) x NM(♂)	1116	714	8.79
AD(♀) x ID(♂)	720	367	4.52
AD(♀) x IK(♂)	904	421	5.19
ID(♀) x AD(♂)	756	408	5.03
ID(♀) x IK(♂)	1003	471	5.80
IK(♀) x AD(♂)	812	422	5.20
IK(♀) x ID(♂)	766	348	4.29
NM (♀) x AD(♂)	1325	596	7.34
NM (♀) x ID(♂)	1446	636	7.83
NM (♀) x IK(♂)	1501	705	8.68
AD(♀) x NM (♂)	1404	716	8.82
ID(♀) x NM (♂)	931	531	6.54
IK(♀) x NM (♂)	1412	635	7.82

Key: AD(♀) x AD(♂) Ado female x Ado Male, AD(♀) x IK(♂) Ado female x Ikere male, AD(♀) x ID(♂) Ado female x Ido male, IK(♀) x IK(♂) Ikere female x Ikere male, IK(♀) x ID(♂) Ikere female x Ido male, IK(♀) x AD(♂) Ikere femalex Ado male, ID(♀) x ID(♂) Ido female x Ido male, ID(♀) x IK(♂) Ido female x Ikere male, ID(♀) x AD(♂) Ido female xAdo male, AD(♂) x NM (♀) Ado male x Normal female, AD(♀) x NM (♂) Ado female x Normal male, IK(♂) x NM (♀)Ikere male x Normal female, IK(♀) x NM (♂) Ikere female x Normal male, ID(♂) x NM (♀) Ido male x Normal female, ID(♀) x NM (♂) Ido female x Normal male and NM(♂) x NM (♀) Normal male x Normal female.

Table 2 Mean survival of the progenies from the sixteen crosses of *Clarias gariepinus* with snout and normal mouth obtained from three Senatorial Districts of Ekiti State after thirteen weeks of maintenance under indoor hatchery

WEEKS	AD(♀) x AD(♂)	ID(♀) x ID(♂)	IK(♀) x IK(♂)	NM(♀) x NM(♂)	AD(♀) x ID(♂)	AD(♀) x IK(♂)	ID(♀) x AD(♂)	ID(♀) x IK(♂)	IK(♀) x AD(♂)	IK(♀) x ID(♂)	NM(♀) x AD(♂)	NM(♀) x ID(♂)	NM(♀) x IK(♂)	AD(♀) x NM(♂)	ID(♀) x NM(♂)	IK(♀) x NM(♂)
1	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}	20^{a}
2	18^{a}	18^{a}	17^{a}	19^{c}	17^{a}	17^{a}	17^{a}	17^{a}	17^{a}	18^{a}	19^{c}	18^{a}	18^{a}	18^{a}	18^{a}	18^{a}
3	17^{a}	17^{a}	16^{a}	19^{c}	17^{a}	16^{a}	17^{a}	17^{a}	16^{a}	17^{a}	18^{a}	18^{a}	18^{a}	17^{a}	18^{a}	18^{a}
4	17^{a}	17^{a}	16^{a}	19^{c}	16^{a}	16^{a}	16^{a}	16^{a}	16^{a}	17^{a}	18^{a}	18^{a}	18^{a}	17^{a}	18^{a}	18^{a}
5	17^{a}	16^{a}	16^{a}	18^{a}	16^{a}	16^{a}	16^{a}	16^{a}	16^{a}	16^{a}	18^{a}	18^{a}	18^{a}	17^{a}	17^{a}	17^{a}
6	17^{a}	16^{a}	16^{a}	18^{c}	16^{a}	16^{a}	16^{a}	16^{a}	16^{a}	16^{a}	17^{a}	17^{a}	16^{a}	16^{a}	16^{a}	17^{a}
7	16^{a}	16^{a}	16^{a}	17^{a}	15^{a}	16^{a}	15^{a}	15^{a}	15^{a}	16^{a}	16^{a}	17^{a}	16^{a}	16^{a}	16^{a}	17^{a}
8	16^{a}	15^{a}	16^{a}	17^{c}	15^{a}	15^{a}	15^{a}	15^{a}	15^{a}	15^{a}	16^{a}	16^{a}	16^{a}	15^{a}	16^{a}	15^{a}
9	16^{a}	15^{a}	15^{a}	17^{c}	14^{a}	14^{a}	14^{a}	14^{a}	14^{a}	14^{a}	16^{a}	16^{a}	16^{a}	16^{a}	15^{a}	15^{a}
10	14^{a}	13^{a}	13^{a}	17^{c}	13^{a}	12^{a}	13^{a}	13^{a}	13^{a}	12^{a}	15^{a}	17^{a}	15^{a}	15^{a}	15^{a}	14^{a}
11	12^{a}	12^{a}	12^{a}	17^{c}	12^{a}	12^{a}	12^{a}	13^{a}	12^{a}	12^{a}	14^{a}	15^{a}	14^{a}	14^{a}	15^{a}	14^{a}
12	10^{a}	11^{a}	12^{a}	17^{c}	11^{a}	10^{a}	10^{a}	12^{a}	12^{a}	11^{a}	13^{a}	14^{a}	14^{a}	14^{a}	14^{a}	14^{a}
13	8^{b}	10^{a}	11^{a}	17^{c}	10^{a}	9^{a}	8^{b}	12^{a}	11^{a}	10^{a}	13^{a}	14^{a}	14^{a}	13^{a}	14^{a}	14^{a}

values in the same row but with different superscript are significantly different from each other (P≤ 0.05) Key: AD(♀) x AD(♂) Ado female x Ado Male, AD(♀) x IK(♂) Ado female x Ikere male, AD(♀) x ID(♂) Ado female x Ido male, IK(♀) x IK(♂) Ikere female x Ikere male, IK(♀) x ID(♂) Ikere female x Ido male, IK(♀) x AD(♂) Ikere female x Ado male, ID(♀) x ID(♂) Ido female x Ido male, ID(♀) x IK(♂) Ido female x Ikere male, ID(♀) x AD(♂) Ido female x Ado male, AD(♂) x NM (♀) Ado male x Normal female, AD(♀) x NM (♂) Ado female x Normal male, IK(♂) x NM (♀) Ikere male x Normal female, IK(♀) x NM (♂) Ikere female x Normal male, ID(♂) x NM (♀) Ido male x Normal female, ID(♀) x NM (♂) Ido female x Normal male and NM(♂) x NM (♀) Normal male x Normal female.

4. Discussion

The study revealed significant differences in reproductive and survival performance between *Clarias gariepinus* with normal and snout mouth deformities. Normal mouth strains consistently outperformed other groups in hatchability and survival rates. For instance, the Ado normal mouth parental group exhibited the highest hatchability at 8.82% and superior survival rates, reinforcing the advantage of using healthy broodstock in aquaculture. This aligns with findings by Awe (2017), who emphasized the importance of genetic health in optimizing reproductive outcomes.

Variations in hatchability rates observed across different crosses may be attributed to differences in genetic compatibility, geographical origins, and hatchery conditions. As noted by de Graaf *et al*. (1995) and Macharia *et al*. (2005), environmental factors such as water quality and substrate type can significantly influence hatchability. The comparatively higher hatchability rates in this study suggest that controlled indoor hatchery conditions and optimized management protocols played a crucial role.

The survival advantage of normal mouth strains is consistent with Ataguba *et al*. (2009), who reported similar trends in crossbreeding studies involving *Clarias gariepinus* and Heterobranchus longifilis. The observed resilience of normal mouth strains may be attributed to their robust genetic makeup and better adaptation to indoor hatchery conditions. Hybrid groups displayed intermediate performance, suggesting that while genetic diversity contributes to some resilience, pure normal mouth strains remain superior for achieving optimal productivity.

Furthermore, climatic conditions and breeding history of the broodstock have been cited as key factors influencing reproductive success (Huisman and Richter, 1987; Salami *et al*., 1993). The results of this study reinforce the importance of selecting healthy, genetically sound broodstock to enhance aquaculture efficiency and profitability.

5. Conclusion

This study underscores the reproductive superiority and survival advantages of normal mouth *Clarias gariepinus* compared to hybrids and snout mouth strains. The Ado normal mouth parental group emerged as the most viable option for hatchery operations, with the highest reproductive and growth potentials under controlled conditions. For sustainable aquaculture development, fish farmers are advised to prioritize normal mouth *Clarias gariepinus* in breeding programs. This approach promises enhanced productivity, economic viability, and the overall sustainability of aquaculture enterprises.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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