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EFFECTS OF DISSOLVED OXYGEN CONCENTRATION ON HATCHABILITY AND SURVIVAL RATE OF AFRICAN CATFISH (*Clarias gariepinus*)

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ABSTRACT

This study evaluated the effects of dissolved oxygen concentration on the hatchability and survival rate of African catfish (*Clarias gariepinus*). Broodstock were induced using pituitary gland extract, and the fertilized eggs were subjected to four experimental treatments: T1 (flow-through with aerator), T2 (flow-through only), T3 (aerator only), and T4 (control, no flow-through or aerator), each in replicate. A Completely Randomized Design (CRD) was employed, and water quality parameters were monitored weekly. Results showed that hatchability was generally low across treatments, with percentage hatchability values of 14.55 ± 1.60% (T1), 18.29 ± 1.19% (T2), 15.15 ± 1.28% (T3), and 32.98 ± 3.21% (T4), with significant difference among treatments ($p < 0.05$). Fry survival followed the sequence T2 (60%) > T4 (50%) > T3 (40%) > T1 (30%). Water quality parameters remained within acceptable range for the culture of African catfish fry (temperature: 30.95–33.15°C, DO: 6.06–6.53 mg/L, pH: 6.41–6.58). The findings showed that flow-through systems enhance fry survival by maintaining adequate oxygen levels and reducing the accumulation of waste, whereas aeration treatments were less effective, due to unstable power supply. Overall, hatchability was below average across all systems; however, survival rates were higher in flow-through setups. Therefore, it is recommended that hatcheries adopt gravity-fed flow-through systems as a cost-effective strategy to improve fry survival.

Keywords: Aeration; aquaculture; broodstock; fish hatchery; water quality

INTRODUCTION

The production of fish seed in Nigeria remains the backbone of its rapidly expanding aquaculture sector, driven by continuous innovation in artificial propagation. Hormone-induced spawning with synthetic and GnRH analogue [D-Arg⁶, Pro⁹, NEt]-sGnRH is now standard practice in private hatcheries, enabling year-round fry production independent of seasonal rainfall or temperature cues (Ayuba & Ochenje, 2019). Despite these advances, survival at the fry stage is still low — typically below 50% largely because many operators lack the technical skills to manage brood-stock, monitor water quality, or prevent cannibalism (Awoke et al. 2020). Water quality control has therefore become the most critical management variable; fry survival is tightly linked to hardness, alkalinity and dissolved-oxygen levels, with bore-hole water consistently outperforming rainwater in Nigerian hatcheries (Awoke et al. 2020). While *Clarias gariepinus* is the country's most economically important species, annual fingerling output estimated at < 50 million in 2019 meets only a fraction of the 346 million fry required to stock existing ponds, cages and pens (FAO 2017). Consequently, farmers still rely on a mix of small- and medium-scale hatcheries, whose variable seed quality and erratic supply remain a primary bottleneck for the intensification of Nigerian aquaculture (FAO, 2022).

Dissolved oxygen is among the most critical parameters in fish culture. Its concentration in water is determined primarily by atmospheric diffusion and photosynthetic activity (Bhatnagar & Gary, 2006). Oxygen availability is often limited because its solubility decreases with rising temperature, low atmospheric pressure, high humidity, and dense plankton blooms. Hatchlings are especially vulnerable since their higher metabolic rate demands a greater oxygen supply. At 25°C, dissolved oxygen levels in freshwater systems typically average 6 mg/L, but this may be insufficient for hatchlings without additional aeration (Najiah et al., 2008).

Aeration enhances oxygen concentration in both natural and artificial environments. Techniques include surface aeration and bottom aeration using pumps or aerators. However, in Nigeria, the high cost and unreliability of electricity make continuous mechanical aeration challenging. An alternative low-cost approach involves using water drops or showers from elevated storage tanks, which increases oxygenation without significant energy costs. Effective aeration not only sustains fish growth and prevents mass mortality but also improves water quality by reducing organic buildup, controlling odors, and limiting algal blooms (Bhatnagar & Devi, 2013). Therefore, this research aims to evaluate the hatchability, survival rate, and mortality of *Clarias gariepinus* at different dissolved oxygen concentrations.

MATERIALS AND METHODS

Study Area

The study was conducted at the Hatchery Complex of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Federal University Dutse, Jigawa State, Nigeria located on latitude 11°70′ N, longitude 9°33′ E, and at an altitude of 431 m above sea level (Google, 2023).

Source of Experimental Fish

Broodstock of *Clarias gariepinus* were sourced from the Teaching and Research Fish Farm of the Department of Fisheries and Aquaculture, Federal University Dutse. A female broodstock weighing approximately 1,500 g and a male broodstock 3,100 g were selected for the experiment.

Experimental Design

A Completely Randomized Design (CRD) was adopted for the experiment. The setup is comprised of eight plastic bowls, each with a capacity of 50 L. All bowls were thoroughly washed before stocking. The experiment consisted of four treatments with one as a control, each in triplicate:

- **T1:** Flow-through system with aerator
- **T2:** Flow-through system only
- **T3:** Aerator only
- **T4:** No flow-through or aerator (Control)

Pituitary Extraction and Preparation

The male broodstock was sacrificed for pituitary extraction. The head region was cut vertically, and soft tissue was removed using a sterilized cutter. The brain cavity was opened ventrally, and the pituitary gland was excised with a sterilized needle. The gland was crushed and homogenized in 0.9% saline solution to prepare the pituitary suspension, following the method of Olaniyi & Akinbola (2013).

Injection of Pituitary Hormone

The female broodstock was injected intramuscularly with 1 mL of the prepared pituitary suspension. The injection site was located on the dorsal muscle, just above the lateral line below the anterior part of the dorsal fin. To minimize stress, the fish's head was covered with a wet towel during injection. The syringe was cleared of air bubbles, and the injection was administered intramuscularly (IM) at a 45° angle.

The injection was performed at 10:55 a.m. under an average water temperature of 31°C and air temperature of 41°C. The female was then kept in a separate bowl for a latency period of 8 hours.

Stripping of the Eggs

After the latency period, the female was carefully removed from the holding bowl and gently restrained with a wet towel. Manual stripping was carried out by applying slight abdominal pressure to release ovulated eggs through the genital opening. The eggs were collected into a clean, dry plastic bowl (Adebayo, 2006). Stripping was performed at 7:20 p.m of the same injection day.

Removal of Milt

The male was sacrificed, and its gonads were carefully removed by abdominal dissection with a sterile razor blade. The gonads were rinsed with normal saline to remove blood and impurities, then placed in a dry plastic bowl. Using sterilized scissors, the gonads were gently lacerated to release milt (Akombo et al., 2018).

Fertilization of Eggs

Dry fertilization was carried out by weighing the stripped eggs and mixing them with freshly collected milt in a clean dry plastic bowl. The mixture was gently agitated for 30–60 seconds to ensure even contact between eggs and spermatozoa.

Incubation of Fertilized Eggs

Fertilized eggs were incubated in 50 L plastic bowls filled with fresh borehole water from the hatchery complex. Hatching nets with fine mesh size (1.5mm) were used as egg collectors, and the fertilized eggs were evenly spread on the nets of each treatment.

Care of the Hatchlings

Unfertilized eggs and empty egg shells were removed gently by siphoning tube to prevent water pollution.

Feeding of Fry

Feeding of fry commenced 72 hours after yolk sac absorption. Hatchlings were fed *ad libitum* with 0.2 mm crumble-sized Alar Aqua fish feed.

Water Quality Monitoring

Debris and uneaten feed were removed daily by siphoning, and one-third of the tank water was changed with pre-aerated, temperature-matched system water. Key water quality parameters, including pH, temperature (°C), and dissolved oxygen (mg/L) were monitored weekly using a calibrated pH meter, thermometer, and dissolved oxygen meter, respectively.

Determination of Fertilization Rate

Fertilization rate was determined after yolk absorption. Samples of eggs were collected into petri dishes containing water, and fertilized eggs were counted under observation. Fertilization rate was calculated as follows (Adebayo, 2006):

$$\text{Fertilization Rate (\%)} = \frac{\text{Number of fertilized eggs}}{\text{Total number of eggs counted}} \times 100 \text{ ………. I}$$

Determination of Hatchability Rate

Hatchability was determined using the formula (Adebayo, 2006):

$$\text{Hatchability Rate (\%)} = \frac{\text{Number of hatched eggs}}{\text{Total number of eggs in a batch}} \times 100 \text{ ………. II}$$

Determination of Survival Rate

Survival was assessed over a 4-week period, following the method of Bagenal (1978) as adopted by Yisa (2008):

$$\text{Survival Rate (\%)} = \frac{\text{Total number of hatched fry} - \text{Number of dead fry}\text{Total number of hatched fry}}{\text{Total number of hatched fry}} \times 100 \text{ ..III}$$

Statistical Analysis

Data were analyzed using One-Way Analysis of Variance (ANOVA) to compare the effects of dissolved oxygen concentrations on the hatchability, survival, and mortality rates of African catfish. Duncan's multiple range test was employed to separate means where significant differences occurred at p = 0.05. All analyses were performed using IBM SPSS Statistics version 27 (SPSS Inc., Michigan Avenue, Chicago, IL, USA). Chart was made using Microsoft excel.

RESULTS AND DISCUSSION

Hatchability Rate

The hatchability rate of *Clarias gariepinus* eggs incubated under different dissolved oxygen concentrations is presented in Table 1. Mean percentage hatchability ranged from 14.55 ± 1.60% in T1 (flow-through with aerator) to 32.98 ± 3.21% in the control (T4). Treatments T2 (flow-through only) and T3 (aerator only) yielded hatchability rates of 18.29 ± 1.19% and 15.15 ± 1.28%, respectively. Statistical analysis revealed significant differences ($p < 0.05$) among treatments.

These findings indicate that hatchability in *C. gariepinus* remained generally low across all treatments, with slightly higher rates in the control. Previous studies have reported higher hatchability values (>50%) in recirculatory and flow-through systems (Alabi et al., 2017). The relatively low hatchability in this study may be attributed to environmental stress factors, handling procedures, or the efficiency of aeration systems used. Similar observations were reported by Oyelese (2006), who linked poor hatchability to fluctuations in dissolved oxygen levels during incubation.

Table 1: Hatchability Rate of *Clarias gariepinus*

Parameter	T1	T2	T3	T4	*p*-value
No. of Incubated eggs	2400 ± 0.00^{a}	2400 ± 0.00^{a}	2400 ± 0.00^{a}	2400 ± 0.00^{a}	
No. of Hatched eggs	349 ±59.80^{c}	439 ± 77.80^{b}	363.5 ± 62.71^{c}	791.5 ± 58.32^{a}	0.012
% Hatchability	14.55 ± 1.60^{b}	18.29± 1.19^{b}	15.15 ± 1.28^{b}	32.98 ± 3.21^{a}	0.041

Survival Rate

The survival rates of fry subjected to different treatments are shown in Figure 1. Survival percentages followed the sequence T2 (60%) > T4 (50%) > T3 (40%) > T1 (30%). Survival was highest in the flow-through system (T2) and lowest in the flow-through with aerator (T1). The higher survival rate in T2 suggests that continuous water exchange improved dissolved oxygen concentration and reduced the buildup of metabolic wastes, enhancing fry performance. Similar findings were reported by Akinwole & Faturoti (2007), who observed that flow-through systems promote oxygen availability while flushing out nitrites and soluble organic matter detrimental to fry. In contrast, the low survival in T1 may be explained by power disruptions affecting aeration efficiency, a common technical constraint that leads to dissolved oxygen crashes and mortality in small-scale aquaculture (Boyd, 2015; Kam et al., 2016).

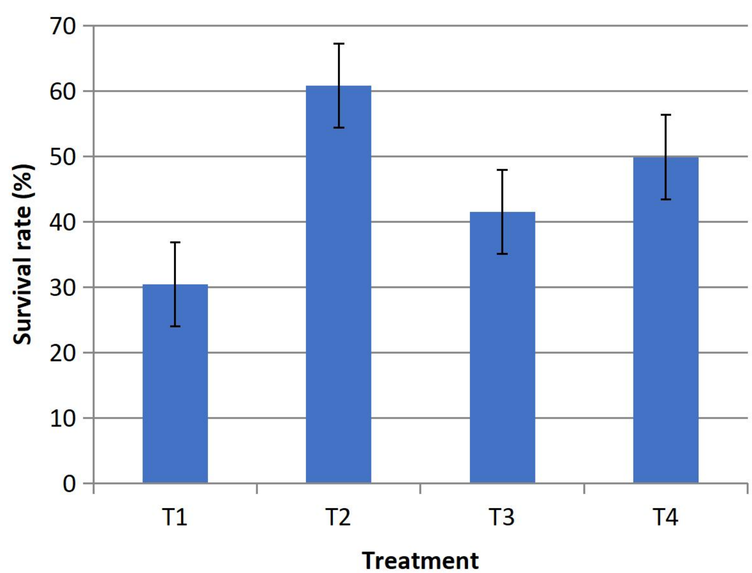

Figure 1: Percentage Survival Rate of Fry at Different Dissolved Oxygen Concentrations

Water Quality Parameters

The mean values of water quality parameters during the experiment are presented in Table 2. Water temperature ranged between 30.95°C and 33.15°C across treatments, while dissolved oxygen values ranged from 6.06 to 6.53 mg/L. The mean pH values were between 6.41 and 6.58. No significant differences ($p > 0.05$) were observed among treatments.
These values fall within the acceptable ranges for *C. gariepinus* culture, as reported by Owodeinde et al. (2011) and Alabi & Ocholi (2019), who found optimal hatchery conditions at DO levels of 6.0–6.5 mg/L, pH of 6.5–7.5, and water temperature of 27–32°C. The results indicate that, while water quality was adequate, variations in survival and hatchability rates were likely due to the interaction of dissolved oxygen levels with incubation and management practices rather than poor environmental conditions.

Table 2: Mean Water Quality Parameters at Different Dissolved Oxygen Concentrations.

Parameter	T1	T2	T3	T4
pH	6.47 ± 0.05[a]	6.41 ± 0.03[a]	6.51 ± 0.72[a]	6.58 ± 0.21[a]
Dissolved oxygen (mg/l)	6.45 ± 0.38[a]	6.48 ± 0.49[a]	6.53 ± 0.21[a]	6.06 ± 0.06[a]
Temperature (°C)	32.15 ± 1.20[a]	30.95± 0.92[a]	31.55 ± 1.91[a]	33.15 ± 0.21[a]

CONCLUSIONS

Based on the findings of this study, the following conclusions are drawn:

1. Hatchability rates of *Clarias gariepinus* eggs were generally low across all treatments, with the T4 (control; no aeration or flow-through) recording the highest value.
2. Fry survival was highest in the flow-through system (T2), indicating that continuous water exchange enhanced oxygen availability and improved fry performance. Aerator-assisted treatments (T1 and T3) did not improve hatchability or survival, partly due to power supply interruptions affecting aeration efficiency.
3. Water quality parameters (temperature, pH, and dissolved oxygen) remained within the acceptable range for African catfish culture, suggesting that management practices rather than poor water quality contributed to observed differences in hatchability and survival.

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CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

AUTHORS' CONTRIBUTION

Maryam Muhammad Kabeer managed data collection, experimental procedures, analysis, and writing of the first draft of the manuscript. Muhammad Auwal Haruna developed the methodology, and reviewed the manuscript. Ibrahim Mu'azzam Mukhtar contributed to literature review, methodology support, and manuscript editing. Umar Babagana Zannah managed data analysis and interpretation, and reviewed the manuscript. All authors read and approved the final manuscript.

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