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Suitability Assessment of Two Different Culture Systems for the Rearing of *Clarias gariepinus* Fingerlings

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Abstract

This paper presents an experiment in which two different fish culture system types were evaluated for the short-term commercial culture of fingerlings of *Clarias gariepinus* maintained at half the recommended stocking rate; 82.5/m^3 in 2 m^3 water volume in indoor blue fiber-glass tanks (IFT) and outdoor black plastic tanks (OPT). The research objectives were to assess the suitability and commercial viability of the tanks. The initial mean body weight of graded fingerlings of *C. gariepinus* for IFT and OPT were 11.32±2.25 g and 10.92±2.44 g (mean±standard deviation) respectively. The study lasted for eight weeks with the fish attaining post-juvenile sizes of 174.95±74.30 g and 178.84±52.04 g (mean±standard deviation) in the IFT and OPT respectively which were not significantly different at $p > 0.05$. Survival at termination was 81.21±0.0% and 81.21±2.5% for IFT and OPT respectively. As fish attained larger sizes of 100 g and above between weeks 6 and 8, skin lesions and frayed fins were observed in comparatively more of the indoor-reared fish than the outdoor-reared fish. It may be concluded that the systems are not vastly different in terms of resultant survival and growth performance of the African catfish, however, the culture duration may be halved when maintaining the reported stocking rate to prevent distress as a fallout of aggression as they increase in size.

INTRODUCTION

In Nigeria, production systems for the African catfish *Clarias gariepinus* are varied and include earthen ponds, concrete, fiber-glass, and plastic tanks with different levels of intensification (FAO, 2022). Comparative studies investigating the impact of some of such systems on the performance of *C. gariepinus* include Anwa-Udondiah and Ogbolu (2019), Oluwalola *et al*. (2019) and Ninwichian *et al*. (2022).

Although the versatility of the African catfish in many of these systems has contributed to increased aquaculture production in the country, allowing for small-scale to high-level production, to such an extent that Nigeria has significantly become the highest major producer of *C. gariepinus* in Sub-Saharan Africa (Kaleem and Sabi, 2021), there are documented constraints with some of the aquaculture systems regarding the effects of color and shape on growth, survival and stress response of the catfish' early life stages (Okomoda *et al*., 2017; Amponsah *et al*., 2021).

Howbeit, it is noteworthy that aquaculture food fish production figures for Nigeria in the years 2000 and 2018 were 25 700 tons and 291 300 tons respectively, and is projected to reach 418 000 tons by 2030 (FAO, 2018; FAO, 2020). To facilitate this projection and increase aquaculture practitioners, Institutions and organizations such as Nigerian Institute for Oceanography and Marine Research (NIOMR) and Food and Agriculture Organization (FAO), have over the years, been engaged in the training of unemployed youths and women in different aspects of fish farming (Williams *et al*., 2008; FAO, 2020).

Hence, to encourage the participation of more farmers in the commercial culture of fish to increase internal production for Nigeria, different fish culture systems have been recommended by facilitators of training programs in the country, many of which are readily available and sold by distributors or easily constructed at the behest of an investor.

The beneficiaries who are usually encouraged to form cooperatives following the intensive workshops are each given starter items; such as 3 m^3 plastic tanks, fish feed, fingerlings or juvenile catfish, basins, weighing scale, etc. to commence their initial aquaculture production. At other times, new members of the cooperatives are supported with credit for capital and operating costs for one crop (Anetekhai, 2013; Edwards, 2013; FAO, 2020).

The research objectives, therefore, were to assess the suitability and commercial viability of the popularly purchased system types. Also, the set-up requirements necessitated productivity testing to elucidate the pros and cons associated with their usage.

METHODOLOGY

Place and Time

This research was conducted from December 2020 to February 2021 at the Catfish Laboratory in Badore Research Centre of the Nigerian Institute for Oceanography and Marine Research, Lagos.

Research Materials

The equipment used in this research was Mettler Toledo electronic balance (ME1002E) determined to an accuracy of 0.01 g and Pond Lab test kit 200. The materials used were 2 blue circular fiber-glass tanks for treatment 1 and 2 black circular plastic tanks for treatment 2 with individual water volume maintained at 2 m^3. Additionally, 3 storage tanks with a combined capacity of 15, 000 liters and an industrial bore-hole were also utilized. The experimental fish were *C. gariepinus* fingerlings obtained from a reputable supplier located at Ikorodu, Lagos State, Nigeria.

Research Design

The experiment which utilized a mixed model research design consisted of two treatments, each with two replicates. Treatment 1 was set up indoors while Treatment 2 was outdoors. At study commencement, each tank was stocked with 165 graded fingerlings of *C. gariepinus* in 2 m^3 water volume which was a halving of the recommended stocking rate by FAO (2020). The fingerlings measured 11.32±2.25 g and 10.92±2.44 g (mean±standard deviation) for the indoor fiber-glass tanks (IFT) and outdoor plastic tanks (OPT) respectively.

To reflect their decreasing metabolic rate as the catfish grew (Craig, 2017), the fingerlings were fed a commercially available diet of 2 mm pellet size containing 45% protein and 10% fat at 7% body weight for the first four weeks while in the second month, they were given 4 mm sized pellets that had 42% protein and

12% fat at 5% body weight, thereby totaling a study period of eight weeks.

Work Procedure

Fish Samplings and Data Analysis

Fortnightly, fish samples were randomly scooped out of each tank and individually weighed. The dietary feeding rate was then recalculated using their new mean weight and the feeding was adjusted following the weight of the growing fish.

Water Quality Parameters

Bi-weekly water samples from each system type were tested for temperature using a mercury-in-glass thermometer while pH, dissolved oxygen, ammonia, nitrite, and nitrate were analyzed with Pond Lab test kit 200.

Fish Performance

Mortalities were removed and subtracted from records during the study.

Data Analysis

A mixed model analysis using IBM SPSS Statistics version 20 was used to compare treatment effects on the growth performance of the experimental fish. Obtained data violated Mauchly's Test of Sphericity, therefore the degrees of freedom were corrected using the Greenhouse-Geisser estimates of sphericity. All other assumptions were met prior, for instance, the significance of all values for the Kolmogorov-Smirnov Statistic Test of Normality was non-significant therefore it was determined that the assumption of normality was not violated. Data in the text are presented as mean ± standard deviation of the mean. Differences between treatment means were considered not significant at $p > 0.05$.

RESULTS AND DISCUSSION

Growth Performance of Experimental Fish

At study termination, there was no significant difference at $p > 0.05$ between *C. gariepinus* post-juveniles reared in the IFT (174.95±74.30 g) and those reared in OPT (178.84±52.04 g). However, there was a significant difference across the five sampling times, F (1.494, 56.758) = 203.785, $p < .001$ (Table 1).

Table 1. Growth performance of *C. gariepinus* in different culture systems – IFT and OPT.

System Type	Week 0 (g)	Week 2 (g)	Week 4 (g)	Week 6 (g)	Week 8 (g)
Indoor blue fiber-glass tanks	11.32±2.25	30.14±0.15	54.69±4.26	105.98±4.43	174.95±74.30
Outdoor black plastic tanks	10.92±2.44	26.55±1.28	58.23±8.01	107.30±10.85	178.84±52.04

McLean (2021) noted that tanks offer significant flexibility for aquaculture production and in an optimally operated configuration enable farming of many fish species, indicating that a potential benefit of tanks was that they could be manufactured in a wide variety of colors. Studies such as Boaventura *et al*. (2021) and Morshedi *et al*. (2022) have shown that certain species of fish perform differently, in terms of growth, when maintained in certain colored tanks, however, the result obtained in this experiment showed no significant difference at $p > 0.05$ between the treatments unlike in Okomoda *et al*. (2017) where tank color caused significantly different outcomes at $p < 0.05$ for the growth performance of *C. gariepinus* fingerlings with higher growth in black tanks than in blue colored tanks.

Percentage Survival of Experimental Fish

The percentage survival of the catfish from the two treatments (IFT and OPT) both averaged 81.21 g and are depicted in Figure 1.

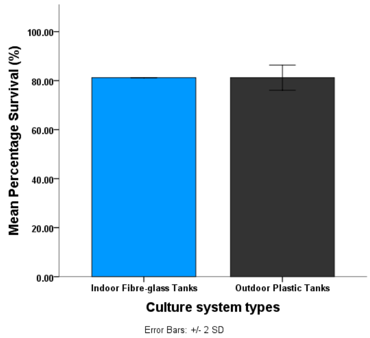

Figure 1. Survival of fish in IFT and OPT.

The survival rates from this study were highly uniform irrespective of culture system type, tank background color, or the different rearing conditions. This was probably due to the similarities in the shape of the culture systems which were both circular and the constant maintenance of uniform water volume to reduce bias between treatments. This result agrees with Okomoda *et al*. (2017) where survival of *C. gariepinus* in experimental tanks of various colors; white, blue, green, red, and black, was not affected by tank color.

Aggressive Behavior at Weeks 6 to 8

Aggressive behavior of the experimental fish when they had attained larger sizes of 100 g and above at weeks 6 to 8 was noted by direct observation with the outcome of multiple lesions on the skin and fraying of portions of the pectoral, pelvic, dorsal, and caudal fins for comparatively more of the fish reared indoor than those reared outdoor.

In terms of aggressive behavior, the observation during the concluding weeks of the study showed that fish in the blue-colored indoor tanks reared in comparatively clearer water exhibited apparent levels of stress-related issues than the fish reared in the outdoor black-colored tanks. This aligns with the review by McLean (2021) that differently colored tanks impacted fish health, stress level, and aggression level.

Fish have been shown to possess excellent vision and can be profoundly influenced by the visual properties of their environment, with ambient colors sometimes being found to affect growth, survival, and aggression. Gaffney *et al*. (2016) showed evidence that darker or black tanks were preferred by and decreased aggression in salmonids, which supports the health benefits of housing the experimental catfish in the black-colored tanks for this study.

Reasons proffered for fish preference for darker colors are that there may be an innate predilection for darker environments (Maximino *et al*., 2007) and that bright environments elicit a physiological stress response such as increased plasma cortisol levels (Karakatsouli *et al*., 2008). Thus, as noted by Gaffney *et al*. (2016), fish affinity for darker backgrounds may also be related to protective escape behaviors.

According to van de Nieuwegiessen *et al*. (2008), fish welfare is an area of increasing interest and the stocking densities adopted for commercial aquaculture have been identified as a subject of specific welfare concern. Observations of aggression as a behavioral response in farmed African catfish reared at densities exceeding those of the current study of 82.5/m^3 has been corroborated. It was found that subjecting *C. gariepinus* to acute stress challenge at densities of 500 and 3000 fish/m^3 resulted in signs of chronic stress. Other anomalies included increased skin lesions and fin damage which were also observed between weeks 6 to 8 in this study, albeit at a much lower stocking density.

Water Quality Parameters

Water quality data collected in the course of the study are presented in Table 2. Temperature ranges were 29-32 and 31-35 °C for IFT and OPT respectively. Mean dissolved oxygen (DO) and pH were 2.5 mg/L and 7 for both culture systems. Minimum and maximum nitrite values of 0 and 40 mg/L were obtained in both systems. Ammonia did not exceed 5 mg/L in both IFT and OPT while nitrate ranged from 0-1 and 0-10 in IFT and OPT respectively.

Table 2. Water quality range comparisons from the indoor and outdoor tanks.

Treatment	Temperature (°C)	DO (mg/L)	pH	Ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)
IFT	29 - 32	3.0	7.0	2.0 - 5.0	0.0 – 40.0	0.0 – 1.0
OPT	31 - 35	2.0	7.0	0.5 - 5.0	0.0 – 40.0	0.0 – 10.0

Measurements of water quality from water samples drawn from the culture tanks were within the desirable range of 6.5 – 9.0 for pH (Bhatnagar and Devi, 2013). As regards temperature, Boyd (2020) reiterates that water temperature is in response to diurnal changes in solar radiation where the penetration of light into bodies of water regulates the depth to which photosynthesis takes place and is influenced by water clarity. The foregoing is in agreement with this study where the outdoor systems presented with a higher temperature range of 31-35 °C with proliferation of phytoplankton on alternate days when water was not renewed unlike the lower temperature of 29-32 °C and absence of phytoplankton in the indoor tanks with same renewal times throughout the study's duration.

The maximum values for both ammonia and nitrite were 5.0 and 40 mg/L and aligns with previous report that catfish acclimate to high ammonia levels of 2 to 5 mg/L over time in commercial systems (Hargreaves and Tucker, 2004; Stone *et al*., 2013) which in the presence of low dissolved oxygen (2 to 3 mg/L in this study) indicated that bacteria actively converted ammonia to nitrite via nitrification. Nitrate differed in both systems with the maximum values being 1 and 10 mg/L in the IFT and OPT respectively.

CONCLUSION

From the outcome of the eight-week culture of fingerlings of *C. gariepinus* in both systems, it may be concluded that the systems are not vastly different in terms of resultant survival and growth performance of the African catfish, however, it is recommended that culture duration be halved when maintaining the reported stocking rate in order to prevent distress as a fallout of aggression as they take up spatial distribution because of size increment.

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