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Alabi Korede Isaiah
1) Department of Agricultural Extension and Management, Federal College of Forestry, Jos. Plateau, Nigeria
2) Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi. Benue, Nigeria

Ocholi Oyigene Shauntell
Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi. Benue, Nigeria

Correspondence
Alabi Korede Isaiah
(1). Department of Agricultural Extension and Management, Federal College of Forestry, Jos. Plateau State. Nigeria
(2). Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi. Benue State. Nigeria

Studies on the hatchability, growth performance and survival of African catfish (*Clarias gariepinus*) in different aquaculture production systems

Alabi Korede Isaiah and Ocholi Oyigene Shauntell

Abstract
This study was conducted to evaluate the effects of three different aquaculture production systems on hatchability, growth performance and survival of African Catfish (*Clarias gariepinus*). The production systems tested in this study are stagnant system (SS), Flow-through System (FTS) and Recirculation Aquaculture System (RAS). The experiment was divided into two phases; artificial induced breeding using synthetic hormone (Ovaprim) and rearing the hatchlings for 21 days; and rearing the 21 days old fry for 42 days. Hatchability was estimated 48 hours after incubation, while in the second phase, growth performance and feed utilization of hatchlings were investigated. Percentage hatchability in all production systems were relatively above average with the highest mean value of 82.8% in FTS and RAS. Survival of Hatchlings after 3weeks was high (1768) in RAS. Mean weight gain (35.61g) and Specific growth rate (3.61) were observed to be high in FTS. Food conversion ratio was High (23.91) in SS and low (14.04) in FTS. Shooters were observed to be more in FTS (38). Survival rate of fry was high in RAS (82.8%), and lowest in FTS (58.3). Mean water quality parameters tested were within the range of acceptable limits for *C. gariepinus* culture. This study has demonstrated the benefits of different aquaculture production systems for fish production under controlled environmental conditions.

Keywords: African catfish (*Clarias gariepinus*), fry, stagnant system (SS), flow-through system (FTS), recirculatory aquaculture system (RAS)

1. Introduction

In Nigeria, the prominence of aquaculture as fish food source is growing in recent times while supply from capture fisheries is dwindling due to undue fishing pressure and climate change among other factors. African catfish, *Clarias gariepinus*, is the most popularly cultured fish in Nigeria [1]. Aquaculturists developed special interest in this species because of its biological attributes that include resistance to diseases, faster growth rate, and possibility of high stocking density [2]. The availability of healthy fish seed in the required quantities is one of the prerequisite of intensive fish culture technology. In the last decade, spectacular growth has been recorded in Catfish fingerlings production through artificial propagation, despite this breakthrough, the demand for the seeds still outstrips the supply [3]. The shortfall in fish seed supply could be linked to inappropriate selection of the best culture medium for fry-fingerling interphase which remained intractable over the years. The farming of catfish is important to many large producing countries more evidently in Nigeria such that it provides a source of income, create employment opportunities, contributes towards Gross Domestic Product (GDP), fetches higher price than other domesticated species due to the fact that it can be sold live at the market [4]. The cultivation of African catfish can be achieved using different culture systems such as Cameroon and locally known as Mbeuth Traditional flooded ponds (Commonly used in Nkam Valley,); Catfish holes in Bangladesh and Nepal; Polyculture ponds in earthen ponds; Peri-urban concrete tanks and raceways (Flow-through systems) in Nigeria; Recirculation aquaculture systems (RAS) in Netherlands and in Belgium and cages in some Asian countries [5]. In an attempt to hatch and manage fry-fingerling stage effectively different culture systems are presently in use. Some of these include cage, pens, hapa, fibre tank, concrete tank, plastic tank, wooden trough, and earthen pond which are operated as either Stagnant system, Flow-through System or recirculating System [5] but with varying level of success. In recent times, the challenges of shooters, water availability in required quantity and quality and economy of available space had changed the focus of fish seed producers to search for productive aquaculture systems that support fish wellbeing, increased growth performance and high survival rate [6]. The increase in importation of frozen fish in the domestic market has made fish industry the most virgin investment in Nigeria [7]. Solving the demand-supply gap is a sure means of substantially and this can be achieved by embarking on widespread homestead/small scale fish production. Also, considerable efforts have been directed at examining productive efficiency of different fish culture medium for fish production in Nigeria. This is exclusively focused on technical efficiency of these systems in general and profitability of fish farming [7]. Consequent upon the increment in awareness of catfish farming and a substantial increase in percentage of small scale catfish farmers in Nigeria, it has prompted the interest of researchers to understand the best aquaculture production system suitable for each species of fish cultured [8]. This study is aimed to evaluate the hatchability, growth performance and survival of African catfish (*Clarias gariepinus*) in different aquaculture production systems.

2. Materials and Methods

The experiment was carried out in the Fisheries Unit of Federal College of Forestry Jos. Plateau state. Nigeria. Jos is situated between latitudes 9° 50' N and 10° 05' N and Longitudes 8° 50' E and 8° 55' E is an highland area that projects from the plains of Central and Northern Nigeria. The city consists of climatic condition that differs from that of neighboring plains as a result of periodic movement of the Inter-Tropical Convergence Zone (ITCZ), which has given rise to three distinctive sequence of seasons in the city. That is a cool dry season that commences from October to February, a hot season from March to April and a wet season between May to September. There is a mean annual temperature of 21.8 °C and a mean monthly temperature ranging from 20.2°C to 24.3 °C. Mean annual rainfall is 1413 mm characterized by an estimation of 200-300 mm mean monthly rainfall between May and September, while the pick period (July) is characterized by mean monthly rainfall of about 321 mm and outside of these months, rainfall declines rapidly [9]. The materials used for the study include A 700 litres capacity indoor Aquaculture System setup (Figure 1), A pair each of male and female African catfish (*Clarias gariepinus*) brood stocks, Synthetic hormone (Ovaprim), Digital Weight scale, Testlab Water quality test kit, Hatching tray, Siphoning pipe and Dissecting kit. A complete indoor Aquaculture system installed with 9 incubation/rearing units (Three rows of 3 each of white 60 litres rectangular tanks), flow lines, solid removal tanks, pump/settling unit, sand bed biofilters, as presented in Figure 1. Three (3) of the incubation/rearing units were closed (SS), 3 were connected to 60litres rectangular overhead storage tank to supply water to the unit designated as flow-through, while the remaining 3 incubation/rearing units were connected to recirculate treated water at 15litres/minutes. A pair of male and female African catfish (*Clarias gariepinus*) brood stock were purchased from a Korex Aquatics farm in Makurdi, Benue state. Nigeria. The female was induced artificially using Ovaprim synthetic hormone. Fertilization was achieved by mixing the sperm collected from the male by dissection and eggs from the female by stripping process. 15grams weight of fertilized eggs was incubated into each of nine (9) incubating tanks. Three (3) of the tanks were recycled (Treatment3), Three (3) where operated as flow-through (Treatment 2), while Three (3) were left stagnant (Treatment 1). Hatchability (%) was evaluated 48 hours after incubation. Fish hatched were left for 3 days for yolk absorption while first feeding of hatchlings with artificial starter feed 0.2mm coppens (49%cp) was done after the third day and this lasted for 14 days. Two thousand, eight hundred and sixty nine (2,869) fry of 0.09g mean weight were randomly distributed into Nine (9) rearing troughs (n= 318 per tank). Fish were fed 0.3-0.5mm coppens feed at 4% body weight per day for 6 weeks. Daily feed were administered in three meals and distributed at 8:00hr, 13:00hr and 18:00hr. Basic water quality parameters tested include; Dissolved Oxygen (DO), Temperature, pH and Ammonium. Data on hatchability (%) was collected immediately at 48 hours of incubation. Data on Water quality parameters (Dissolved Oxygen (DO), Temperature, Nitrate, Nitrate, pH and Ammonia) and mean weight gain of experimental fish was also recorded. These data were collected on 7 days intervals (Weekly). Other parameter includes Mean Weight Gained, Specific Growth Rate, Feed Conversion Ratio, Protein Efficiency Ratio, Feed Conversion Efficiency and Survival rate (%).Hatchability index, growth performance and feed utilization indices of the fish were determined as: Percentage hatchability = total number of hatched eggs/total number of fertilized eggs x 100.Mean Weight Gained = Mean Final Weight – Mean Initial Weight. Specific Growth Rate = In mean Final Weight – In Mean Initial Weight/ Duration of Experiment (42days) X 100. Feed Conversion Ratio = Weight of Feed Fed/Weight Gained. Protein Efficiency Ratio = Weight Gained/Protein Fed. Feed Conversion Efficiency = Weight Gained/Weight of Feed fed. Survival rate (%) = Total number of fish – Mortality / Total number of Fish X 100. The data collected was subjected to statistical analysis using IBM SPSS 23. Statistical differences between variable was tested using ANOVA.

Table 1: Proximate composition of Coppens feeds (0.2-0.5mm) used during the study

Nutrients	Percentage (%)
Crude protein	49
Fat	12
Crude fibre	6.0
Ash	8.0
Calcium	1.5
Moisture	8.0
Phosphorous	1.5

3. Results

The results of the hatchability rates of *Clarias gariepinus* incubated into rearing units of different Aquaculture production Systems is presented in Table 2. The mean values of percentage hatchability from the fertilized eggs incubated shows that hatchlings had relatively high mean value of 82.8% in FTS and RAS and low value of 59.4 obtained in SS. Survival of Hatchlings were observed to be high (1768) in RAS compared to the low (291) number recovered from SS.

Table 2: Hatchability rates of *Clarias gariepinus* incubated in different Aquaculture production System

Parameters	Stagnant System (Ss)	Flow-Through System (Fts)	Recirculating Aquaculture System (Ras)
Weight of Breeders	1000g	1000g	1000g
Weight of fertilized eggs (g)	15	15	15
Estimated Number of fertilized eggs	10500	10500	10500
Estimated Number of eggs hatched	6233	8670	8692
Hatchability (%)	59.4	82.8	82.8
Survival at 3weeks	291	820	1768

Results of the growth performance of *Clarias gariepinus* reared in different aquaculture production systems for 42 days are presented in table 3. The result indicated that fry reared in Flow-through system (FTS) had the highest mean weight gain (35.61g) while lowest (20.91g) was obtained for fish held in the stagnant System (SS). Specific growth rate followed the same trend as it was observed to be high in FTS (3.61%/day), compared to the low mean value recorded in the SS (3.12%/day). High (23.91) food conversion ratio was observed in SS and low (14.04) in FTS. Protein efficiency ratio evaluated during the 42days trial was observed to be high in RAS (53.23) and at its lowest in SS (25.61). Shooters were observed to be more in FTS (38), while few (15) were obtained from SS. Survival rate of fry was high in RAS (82.8%), and lowest in FTS (58.3).

Table 3: Growth Performance of *Clarias gariepinus* Fry reared in different aquaculture Production Systems for 42 Days

Parameters	Treatments			
	Stagnant System (Ss)	Flow-Through System (Fts)	Recirculating Aquaculture System (Ras)	P-Value
MIW (g)/fish	0.09	0.09	0.09	0.48
MFW(g) /fish	21.00	35.7	34.3	0.12
MWG (g) /fish	20.91	35.61	34.21	0.29
SGR (%/day)	3.12	3.61	3.58	0.27
FCR	23.91	14.04	14.62	0.27
FCE (%)	53.13	43.20	43.93	0.41
PER	25.61	33.30	53.23	0.14
Shooters	15	38	23	0.22
%Survival	66.9	58.3	82.8	0.31

*MIW= Mean Initial weight, MFW= Mean Final Weight, MWG= Mean Weight Gain, SGR = Specific Growth Rate;
FCR = Food Conversion Ratio; FCE= Food Conversion Efficiency, PER = Protein Efficiency Ratio

Results of the mean water quality parameters tested during the 42days growth trial of *C. gariepinus* post fry in different Aquaculture production systems are presented in Table 4. The water quality maintained within the Aquaculture production systems during the 42days of operation was used to evaluate system performance. Mean water quality parameters were within the range of acceptable limits for *C. gariepinus* culture. Mean temperature was at its lowest (21.92 ^{o}C$\pm$0.48) in SS and the highest (23.33 ^{o}C$\pm$0.25) recorded in FTS. However, there were no significant differences ($p>0.05$) in temperature values between the treatments throughout the study period. Mean pH values ranged between 7.33±0.11 and 7.42.

Table 4: Mean water quality parameters of different Aquaculture Production Systems used to rear *Clarias gariepinus* fry for 42days

Parameters	Aquaculture Systems			
	SS	FTS	RAS	P-Value
Temperature (^{O}c)	21.92$\pm$0.48	23.33$\pm$0.25	23.17$\pm$0.46	0.05
PH	7.42$\pm$0.24	7.33$\pm$0.11	7.42$\pm$0.30	0.96
DO (mg/l)	6.17$\pm$0.31	8.42$\pm$0.37	7.17$\pm$0.54	0.01
NH_3 (mg/l)	0.08$\pm$0.01	0.05$\pm$0.00	0.05$\pm$0.00	0.02

4. Discussion

The success of aquaculture business depends on optimizing the environment for rapid growth at the minimum cost of capital and resources. In aquaculture, water's physical and chemical properties (herein referred to as water quality) are strongly influenced by the technological approach and indirectly by the fish wastes, flow or exchange rate. Poor water quality, as determined by species can prompt the reallocation of energy from secondary (non-essential) physiological processes (e.g., growth, reproduction) towards primary (essential) processes (e.g., metabolism, immune function). Thus, adequate, or preferably ''optimal'', water quality is essential for fish culture in an environment that will either enhance or retard their growth. The evaluation of the major aquaculture production systems is important to establish the best production systems for hatching and growing of *C. gariepinus* at the early stage of production. The results of Percentage hatchability obtained from this study indicated that all production systems were above average (>50%) [6]. Reported a higher percentage hatchability of *C. gariepinus* in RAS which was in agreement with the result obtained in this study. The higher survival of fry at 3 weeks in RAS (1768) compared to the lowest number of fry recovered in SS (291) may be attributed to the constant aeration which add oxygen and continuous removal of solid and dissolved particles which prevents the buildup of nitrites and soluble organic matter that may eventually cause problems to the fish hatchlings held within the facility. This was in agreement with the report documented by [10].

The results obtained in this study indicated a gradual increase in mean body weight of *C. gariepinus* fry in all production systems examined. However, fry in FTS recorded a higher mean weight increase than hatchlings held in SS. A study conducted by [11] reported that an Aquaculture FTS can lead to an increase of fish production, higher stocking densities, ease of feeding, easier and more effective disease treatments, ease of harvest, good water quality, and less labor which was in agreement with the result obtained from this study. The different aquaculture productions systems did not significantly affect the growth performance of *C. gariepinus* (p>0.05) though the fry reared in the RAS performs better than the FTS and SS in terms of survival. In a study by [12] on incubation and larvae rearing of *C. gariepinus* in RAS, it was revealed that a production system can have a significant effect on survival which was not in agreement with those found in this study. The methods of flow pattern and oxygenation of water have been used and recommended by [13]. Thus, design of the production systems studied were similar in mechanism to some earlier designed [14]. Therefore, considering the design of water flow from the water inlet into the culture tank down to the effluent pipeline as well as the water filtration unit suggested that the designed system was effective and flexible, this agrees with the studies conducted by [10, 15]. The production systems were able to maintain water quality at optimal level for the incubation and culture of *C. gariepinus* throughout the trial period. While pond producers are used to diurnal swings in Dissolved oxygen, the production systems were able to largely eliminate these detrimental fluxes in oxygen levels, this agrees with the study conducted by [11] on catfish in in-pond Raceway system. Indeed, dissolved oxygen remained above the tolerable limit throughout the study and never dropped to a critical level (Table 4). The results also indicated that, there were significant difference in D.O (mg/l) and NH4 (mg/l) in all the aquaculture production systems tested during the study. Highest mean Dissolved Oxygen recorded in FTS (8.42±0.37) and the lowest in SS(6.17±0.31), However, mean ammonia were observed to be lower than 0.1mg/l in all treatments which is within the tolerable limits for *C. gariepinus*. The study has revealed that all the production systems evaluated can be used for hatching and rearing of *C. gariepinus*. However, RAS is recommended where it is feasible because of its support for increased growth rate and high survival.

4. Conclusion and Recommendation
4.1 Conclusion
This study has established knowledge on the hatchability and growth performance of *Clarias gariepinus* in different aquaculture production systems to determine the best production system for optimum hatchability, growth and survival of fish hatchlings. The result obtained from this study shows that % hatchability and early fry survival was higher in RAS than in other production systems. Mean weight gain and percentage shooters were observed to be high in FTS and low in SS. At the end of the 42 days trial, Survival in all treatments is above average and highest in RAS. All water quality tested show that the systems were able to deliver optimum water quality for *Clarias gariepinus*. This study has demonstrated the benefits of different aquaculture production systems for fish production under controlled environmental conditions. The knowledge and experience gained will be useful in hatching and management of *Clarias gariepinus* in any production system.

4.2 Recommendation
In order to realize the full potential of aquaculture in Nigeria, it is recommended that incubation and hatching of *Clarias gariepinus* be done in RAS since it enhance shooters production, growth performance, high survival of hatchlings and low water requirement than other production systems tested.

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