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Research Article

Effects of Background Colour on Incubation and Larval Rearing of African Catfish *Clarias gariepinus* (Burchell, 1822) in Water Recirculating System

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Abstract

The present study investigated the effects of background colour on hatchability and growth performance of *Clarias gariepinus* (Burchell, 1822) larvae in Water Recirculatory System. A simple 660 Litres Water Recirculation System (WRS) technology made of black and white rearing tanks was developed, built and evaluated for this study. The experiment was divided into two phases; artificial propagation using synthetic Ovaprim hormone and rearing the hatchlings for 14 days; and rearing the 14 days old fry for 42 days. In the first phase of the experiment, 2 grams fertilized eggs were incubated. Hatchability was estimated 24hours after incubation, while in the second phase, growth performance and feed utilization of hatchlings were investigated. Daily water replacement was maintained at 66 Litres for 42days. Hatchability results indicated that Black trough had high hatchability rate of 83.45±3.17%. Mean Weight Gain (MWG) of fry in black trough were significantly higher (4.55±0.09) than White trough (4.47±0.09). Specific Growth Rate (SGR) was observed to be lower in White trough (8.49±0.87). Food Conversion Ratio (FCR) followed a different pattern as fry in black trough (109.89±16.88) recorded low mean values. However, there were no significant difference (p>0.05) between the White and Black troughs in growth parameters investigated. Shooters (%) were observed to be higher in Black troughs (26.67%) while %Survival was high in white troughs (78.67%). Results of Water quality parameters indicated an optimum water quality for growth and survival of *Clarias gariepinus* within the facility. This study revealed that Black background tanks performed better for incubation and rearing *Clarias gariepinus*.

Keywords: *Clarias gariepinus*; Trough; Hatchlings; Fry; Ovaprim; Water Recirculatory System.

Introduction

The development and productivity of aquaculture in Africa is severely limited by water, adequate land, and environmental concern. In recent years, the inadequate water supply in required quantity and quality for aquaculture threatens the future development of aquaculture in Africa. Water conservation and reuse has become a major issue that need to be addressed for continuous and stable aquaculture. Water reuse systems have been developed for fish culture since the 1960s [1]. Water recirculating Systems (WRS) are systems used for the culture of aquatic organisms which involves the continuous cleaning of water for reuse after undergoing treatment [2]. They are system that employs intensive mechanical, biological, chemical filtration and other treatment steps to achieve high rates of water re-use. WRS are usually indoor tank-based systems. Precise environmental control also ensures that aquatic species are cultured within their normal climatic requirement, which allows operators to prioritize production goals with resource availability and market for profit maximization. This system also has the ability to maintain water quality conditions at optimal and constant rate which can bring animal welfare gains, and increased ability to meet seasonal supply and demand of aquatic species are some of the Market benefits. WRS also offers some potential advantages for aquaculture which include ability to locate the farm where water resources are limited and near to the market to reduce product transport time and costs [3].

Another key advantage is that WRS technology is species-adaptable which allows

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operators to switch species to follow market preference for seafood products [4].

WRS employ various forms of rearing tanks ranging from rectangular designs, through to circular and raceway tank designs. The developments of these tank forms have been derived following extensive engineering and hydrodynamic modelling [5], each of these attempt to optimize system performance characteristics, such as cleansing, ease of harvest, animal growth, grading operations, etc. However, in contrast to system design, comparatively little research has been undertaken to examine the potential advantages of varying tank colour on performance characteristics of African Mudfish in Water Recirculatory System. While it is possible to have tanks fabricated in any colour, commercially obtainable tanks for the on–growing of fish are generally available in black, green, dark, and light blues [6]. The origin of these colour selections remain unknown even though research during the earlier part of the last century indicated that certain colours, including black, may be problematic in terms of fish performance and health [7]. Larval fishes are generally considered to be visual feeders and it is therefore important to optimize their rearing conditions to enable them to distinguish, capture and consume prey items [8]. Several studies, with a number of species, indicate that factors such as prey density; light orientation, intensity and wavelength; tank hydrodynamics and colour, as well as the colour and orientation of prey items, affect the ability of larvae to detect, capture and ingest food items [9, 10, 11, 6]. Larval growth and survival is enhanced for many species, when black tanks are employed during rearing. It has been suggested that increased contrast between live feeds and background colour is responsible for this positive effect. In Nigeria, no documented studies have examined the impact of colour of rearing unit on the incubation and performance of *Clarias gariepinus* in WRS.

Background colour of farming media is an environmental factor that can influence a variety of parameters including growth, improvement of feeding performance, and feed intake [12, 13]. Careful selection of rearing units with appropriate colours can lead to increased success in aquaculture particularly in fish larval stage. Most of teleost fishes are visual feeders in larval stage; nonetheless, the visual system is not well-developed in most fish larvae which may result in decreased food intake, reduced growth and raised mortality [13]. A suitable tank colour makes it possible to create a contrast between the food (prey) and the tank wall, thereby increasing the chance of food capture by the fish larvae [14, 12]. This might also help reduce food consumption and feeding costs and prevent environmental pollution thereby, creating contrast between food particles and tank wall. However is of lesser importance in some fishes such as African Mudfish which possess barbels containing taste buds. Even so, the behaviour of the fish may be affected by tank colour and lead to diminished growth [13]. The African Mudfish *Clarias gariepinus* is one of the most important farmed species that is growing popularity in world aquaculture, especially in Nigeria. This experiment has been conducted to test the impact of varying colour of rearing unit on hatchability and growth performance of African Mudfish (*Clarias gariepinus*) in WRS.

Material and methods

System design and experimental setup

The WRS was designed and the same was drawn into scale by an architect. The system was constructed and installed in the Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi, Benue State, Nigeria. The WRS were made of Six Incubation/Rearing units (3 white and 3 black) with a volume of 60 litres/container. Thus, for the TSS (total suspended solids) and settable solids control, the recirculating system has been provided with submerged gravel and sand filter, biofil and screen nets (0.5mm) fixed in 120litres Sedimentation tank. The sedimentation tank has a foot flat plate with items of hard plastic material where a number of long gaps are realized; through those gaps the filtrated water passes the filtration materials. For the biological filtration, Synthetic filter block is used. For oxygen concentration supply, the recirculation system was provided with a by-pass connection for continuous return of water within the pump tank for aeration at a flow of 15L/min. Water distribution is achieved by 0.5hp DAB surface electric water pump fixed 2inches above the tank base to deliver water to the bio-tower at 20litres/min pump rate which assures the technological flow necessary for each rearing unit. The system was designed such that the flow system was regulated, to recirculate water for 10 hours (8.00hr-13.00hr, and 18.00hr- 23.00hr) daily. All connections within the system components were made of PVC pipes and fittings varying from ½ inch to 2 inches diameter. The system was powered by electric supplies from Power Holding Company of Nigeria, and SE2900 Sumec electric generating set. The layout of the WRS is presented in Figure 1. 800g gravid Female and 1000g matured Male of *C. gariepinus* was obtained from Korex-Aquatics Farm, North Bank, Makurdi, Benue State, Nigeria. The Fishes were artificially induced using Ovaprim synthetic hormone. Matured eggs were stripped from the female and milt collected from the Male by dissection of the abdominal cavity. Fertilization of the eggs was done and 2g fertilized eggs were incubated into each of the six rearing containers. Hatchability was evaluated 30hrs after hatching process was completed. The larvae were fed with starter 0.2mm-0.3mm 49%.cp Coppens feed after yolk absorption. Hatchlings were adequately fed and reared in the system for 14days before testing for growth performance of the larvae in the WRS.

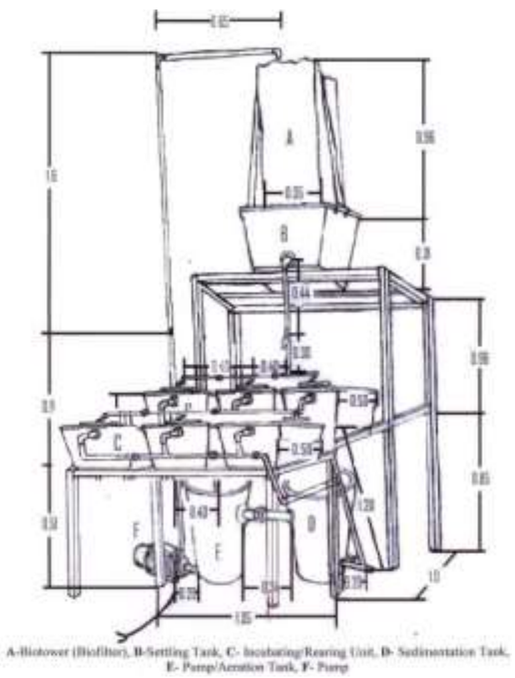

Figure 1. Layout of the 660 litres WRS used for incubation and larval rearing of *Clarias gariepinus* (Burchell, 1822) (Adapted from Alabi *et al.,* 2017)

300 hatchlings (mean weight 0.12 g) were randomly distributed into the 6 experimental rearing tanks (n = 50 per tank). Fish were fed commercial diet of 0.3mm-0.5mm 49%.cp Coppens feed at a rate of 4% body weight per day. The daily feeding rate was administered in three meals that were distributed at 6, 12 and 18 hrs. Recirculation commenced at 6hours after incubation and this was maintained at 10hrs/day for the period of 6 weeks.

Statistical analysis was done using the SPSS 17.0 for Windows. Statistical differences between variables were tested using T-test.

Results and discussion

The results of the hatchability rates of *C. gariepinus* incubated into white and black rearing troughs in Water recirculating system are presented in Table 1. The values of percentage hatchability from the fertilized eggs incubated showed that hatchlings in black trough had relatively higher mean value of 83.45±3.17, while mean values were observed to be lower for hatchlings held in white trough (81.79±1.26). However, P-value from the table indicated that, there was no significant difference ($p>0.05$) among the 2 treatments (Black and white) for the fish species investigated.

Table 1. Hatchability rates of *Clarias gariepinus* incubated in water recirculatory system

Parameters	Black Trough	White Trough	p-value
Weight of Breeders	800 g	800 g	
Weight of fertilized eggs	2 g	2 g	
No of fertilized eggs	840	840	
No of eggs hatched	701	687	
Hatchability (%)	83.45±3.17	81.79±1.26	0.73

Table 2 presents the results of the growth performance of *Clarias gariepinus* hatchlings reared in Water Recirculating System for 42 Days. The results indicated that the colour of rearing troughs did not significantly affect the growth parameters of *Clarias gariepinus* hatchlings investigated during the study. However, Mean weight gain (MWG) was higher (4.55±0.09 g/fish) for hatchlings held in Black trough than in White trough (4.47±0.09) expressing significant weight increase. However, no significant differences were recorded for weight increase between rearing trough colours. The values for Specific growth rate (SGR), Food conversion rate (FCR), Food conversion efficiencies (FCE) and Protein efficiency ratio (PER) recorded were 8.72±1.09, 109.89±0.05, 0.91±16.88, and 0.08±0.02 respectively for Black troughs while hatchlings in white troughs had 8.49±0.87, 111.86±0.01, 0.89±19.11, and 0.08±0.02 respectively.

Table 2. Growth performance of *Clarias gariepinus* hatchlings reared in water recirculating system for 42 days

Parameters	*Treatments*		*p-value*
	Black trough	white trough	
MIW (g)/fish	0.12±0.04	0.13±0.04	0.49
MFW(g) /fish	4.67±0.63	4.60±0.58	0.42
MWG (g) /fish	4.55±0.09	4.47±0. 09	0.52
SGR (%/day)	8.72±1.09	8.49±0.87	0.79
Fcr	109.89±0.05	111.86±0.01	0.24
Fce (%)	0.91±16.88	0.89±19.11	0.79
Per	0.08±0.02	0.08±0.02	0.47
%Shooters	26.67	14.67	0.0079
%Survival	70.00	78.67	0.0022

*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

The values indicated that the SGR and FCE were higher for fry reared in black troughs compared to those recorded for white troughs. FCR followed a different trend as the Highest (111.86±0.01) were observed in hatchlings kept in white troughs than in black troughs (109.89±0.05). However, Survival (%) was given at 70% and 78.67% in Black and white troughs respectively, Shooters (%) were also higher (26.67%) in Black troughs than in white troughs (14.67%). There was significant between the Black and white troughs in Survival (%) and Shooters (%).

The mean water quality values measured during the 42 days evaluation trial of *C. gariepinus* in WRS are presented in Table 3. The results indicated that all water quality variables were within the acceptable levels for optimal growth and survival of *C. gariepinus* hatchlings. Mean values for water temperature (^{o}C), nitrate and nitrite showed no significant difference ($p>0.05$) throughout the experimental period. Of the 8 water quality parameters evaluated, the values for pH, D.O, Ammonia, TDS and E.C were significantly different ($P<0.05$). Dissolved Oxygen (mg/l) ranged between 4.86±0.37 - 6.47±0.18 which was sufficient enough for healthy performance of the fish held in the facility. The TDS obtained was 122.33±1.76 at week 1 and 99.67±2.03 at week 6. Results from Table 4 also indicated that Nitrite and Ammonia were at safe level and observed to decrease from 0.56±0.05 and 0.04±0.00 to 0.41±0.09 and 0.01±0.00 respectively in 6weeks of the trial. Nitrate levels tested during the study was highest at week 3 (3.38±0.11) and lowest at week 6 (3.69±0.26) which is an indication that the filtration process was efficient.

Table 3. Mean weekly water quality parameters of water recirculatory system used to rear *Clarias gariepinus* hatchlings for 42days

Parameters	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	p-value
Temperature(°C)	29.27±0.43ab	28.10±0.44a	29.53±0.65ab	30.53±0.50b	30.27±1.04b	29.53±0.43ab	0.17
pH	7.23±0.18bc	7.30±0.29c	7.93±0.09d	6.77±0.09ab	6.83±0.12abc	6.63±0.09a	<0.05
Dissolved Oxygen	6.00±0.05b	6.47±0.18b	5.96±0.14b	4.86±0.37a	5.07±0.47a	5.64±0.17ab	0.01
Total Dissolved Solid	122.33±1.76bc	132.33±5.36c	120.00±3.46b	101.67±3.28a	105.00±3.51a	99.67±2.03a	<0.05
Electrical Conductivity	213.00±4.04b	209.67±5.61b	165.67±5.24a	164.67±8.69a	158.00±5.51a	167.33±0.88a	<0.05
Nitrate	3.38±0.11a	3.84±0.20abc	4.48±0.38c	4.27±0.26b	3.57±0.18ab	3.69±0.26ab	0.06
Nitrite	0.56±0.05b	0.52±0.06b	0.52±0.06b	0.54±0.04b	0.32±0.02a	0.41±0.09ab	0.06
Ammonia	0.02±0.00a	0.03±0.00b	0.04±0.00b	0.03±0.01b	0.02±0.01a	0.01±0.00a	0.01

*Values in the same row and with the same superscript are not significantly different (p>0.05)

Figure 2 present the results of the weekly mean weight increase of *C. gariepinus* reared in WRS for 42 days. The results indicated a gradual increase in mean body weight of hatchlings reared in WRS throughout the experimental period. However, hatchlings held in black troughs recorded a higher mean weight increase than in white troughs.

Many Aquaculture systems has been developed and tested for fish culture over the years. Some of these systems have been able to culture fish in a sustainable manner while others have failed [15]. Optimizing the environment for rapid growth at the minimum cost of capital and resources is a determinant factor for the success of aquaculture business. The development and production success of WRS for fish culture has been able to address this problem. Most water re-circulating systems are designed to replace 5-10% of the total water volume in the system each day with clean water [15]. The arrangement and size of components within the system facility were done appropriately to take care for the daily amount of feed provided and welfare for the fish within the system, this agrees with a previous study [16]. In this study, faecal solids, dissolved particles and Settleable solids produced within the rearing units are removed rapidly within few minutes of settling as the water jets-in from the water control valve into culture units and transported through the regulatory/recirculating pipe into the Biofilter chamber and sedimentation units where it is retained.

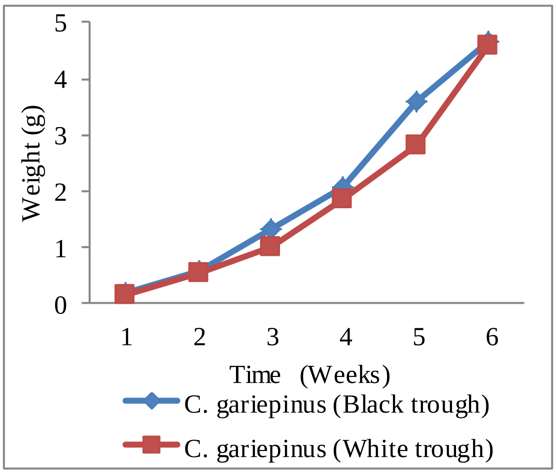

Figure 2. Weekly mean weight increase of *Cyprinus carpio* and *Clarias gariepinus* hatchlings reared in water recirculatory system for 42 days

The continuous removal of solid and dissolved particles prevents the buildup of nitrites and soluble organic matter that may eventually cause problems to the fish hatchlings held within the facility [15]. The WRS used for this study was typically enclosed. In the components design, the water inflow and discharge engaged is by gravitational flow, as appropriate elevation were maintained and the components are placed at relative to one another for adequate water flowing. The pumping machine adopted for the WRS recycles water within a complete unit as earlier reported [17, 18]. Rearing units used in this design were Rectangular, and has been supported [19, 20].

Water quality parameters were maintained at optimal level by sedimentation and filtration mechanism. These components manage the wastes generated within the WRS unit. However, the previously reported systems and the one used for this study may significantly differ in systematic operation mechanism, capacity of pumping machine and the oxygenation method.

Background colour did not significantly affect the growth performance of *C. gariepinus* ($p>0.05$) though the hatchlings reared in the black troughs showed the highest growth rates. An increased growth performance on *Cyprinus carpio* incubated and reared in WRS was reported by [15] which agree with the results of this study. Also, a study conducted by [21] revealed that tanks with white, green and black colours did not reflect any effect on growth performance of Common Carp fingerlings (100-160 g) which is in agreement with those found in this study.

The lower growth rates in the white troughs as opposed to the black troughs may be attributed to Increased light penetration between the background and food which can lead to diminished food consumption by fish and consequently reduced fish growth. However, inconsistent results of black background colour on growth performances and feed utilization of aquatic animals has been previously reported. Previous studies have revealed that antagonistic effects of black tanks affect growth performance of fishes [21,22]. Rearing *C. gariepinus* hatchlings in white troughs led to lower final body weights, SGR and weight gain compared to Black troughs. Hatchlings held in rearing units with black backgrounds presented higher SGR (8.72±0.43) than hatchlings in white troughs. Nevertheless, no considerable differences in SGR was observed among treatments ($p>0.05$). The results of this study revealed that background colour influenced the number of shooters (%) in black troughs by 26.67% and 14.67% in white troughs. The survival rate was also observed to be high in White rearing troughs (78.67%), than those reared in Black troughs (70.00%). The high percentage survival in both treatments however, indicated that the facility was able to maintain water quality at optimal level which agrees with some authors [23,15].

Conclusions

The results of the current study indicated that *Clarias gariepinus* can be incubated and reared in WRS facility. Nevertheless, variation in growth parameters revealed fish–specific reaction to background color exists. This suggests that greater attention to tank color is needed during production. It is likely that other background colour can achieve categorical effects on growth and future research should examine different background colour on production–length and growth trials with the species of interest at different stages of the life cycle in WRS.

Conflicts of interest

The authors declare no conflict of interest.

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