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Influence of Different Levels of Water Aeration on Growth Indices and Mortality Rates of *Heteroclarias* Hybrid under Laboratory Conditions in Minna Nigeria

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A B S T R A C T

Study was carried out to determine the influence of different water aeration levels; 0 (control), 6, 12, 24 h, respectively on growth indices and mortality rate of *Heteroclarias* freshwater hybrid fish fingerlings under laboratory condition for a period of 12 weeks. Commercial diet (coppens) of 56.0% Crude Protein (CP) was fed twice daily to satiation. Growth indices and physiochemical parameters were determined weekly based on standard procedures while the mortality rates were recorded daily. Results showed that the fingerlings cultured in 6 h of aeration were significantly ($p<0.05$) higher in final body weight, weight gain and percentage weight gain except specific growth rate. The mortality rates of the fingerlings cultured in 24 h of aeration were significantly ($p<0.05$) highest (70+19.38%) at the end of the study. The physicochemical parameters of the fingerlings cultured in all the treatments were all within the range documented for fish growth in the tropics. The findings of this study indicated that growth indices and survival rates of *Heteroclarias* fish hybrid can be enhanced by using 0-12 h of water aeration.

Key words: *Heteroclarias* hybrid, water aeration, growth indices, physicochemical parameters and mortality

INTRODUCTION

Aeration is the process of adding oxygen and decreasing dissolved carbondioxide or nitrogen gas to levels closer to atmospheric saturation in a given pond with the use of mechanical aerators or through natural processes (Losordo *et al*., 1999). Sources of Dissolved Oxygen (DO) include aeration by the flow through riffles, rapids, waterfalls, inflow of turbulent water and photosynthesis by aquatic plants (Losordo *et al*., 1999). Dissolved oxygen can be depleted through respiration (from fish and aquatic plants), decay of organic matter, direct chemical oxidation and out flow of water (Brown, 1985).

At the management level when fish are fed nutritionally with complete diets, the limiting effect of feed metabolism and dissolved oxygen levels is overcome through aeration (www.ag.auburn.edu/fish). Fish ponds can be aerated with mechanical aerators such as fountain pond, venture tubes and diffusers (Poon *et al*., 2002) and

Nordgarden 2000). Aeration will results in increased levels of dissolved oxygen, because its helps to oxidize ammonia to nitrates and reduce the build-up of carbondioxide (www.ag.auburn.edu/fish). The authoralso added that running an aerator requires power for the period when the aeration is required. Therefore, the use of aeration should be prudent at management levels because there are cheaper and more effective ways of managing DO levels in ponds.

An adequate supply of DO is important to fish during all stages of life. If DO levels are inadequate during incubation, the embryos may be smaller, dies, hatch late or prematurely during their developmental stages (Bjornn and Reiser, 1991). Mallya (2007) reported that oxygen level requirement depends on the fish species, fish size and the activity of the fish. To support the above submission, Buentello *et al*. (2000) and Pichavant *et al*. (2001) also reported that channel catfish (*Ictalurus punctacus* and common carp (*Cyprinus carpio* L.) when exposed to low oxygen levels showed reduced growth rates. Food and Agricultural Organisation (FAO, 2006) alsoreported that DO within the range of 3.00-5.00 mg L^{-1} or near saturation (80-100%) is suitable for fry, fingerlings and adults. Similarly, Svobodova *et al*. (1993) recommended DO of about 5 mg L^{-1} as suitable for fish growth, health and tissue repairs in the tropics. However, when the DO levels are lower than the recommended range, the growth of the fish can be highly affected by increase in stress, tissue hypoxia and a decrease in swimming activities (Tom, 1998).

Udomkusonsri *et al*. (2004) and Choi *et al*. (2007) also added that aeration stress, low temperature and lack of rest may result in high mortalities in grow out ponds or larviculture.

Fish culture with particular reference to Heteroclarias is a hybrid from two African cat fish viz: *Clarias gariepinus* (female) and *Heterobranchus bidorsalis* (male). Heteroclarias hybrid has been known to be the most wide-spread and accepted fish in Africa, especially in Nigeria. This is because of its disease resistance, tolerance to high stocking density and is the main stake of family income (Khaleg, 2000) and Ayanwale *et al*., 2014). Khaleg (2000) also stressed that farmers should take Heteroclarias culture as the main stake of their family income because it is profitable business which is capable of assisting people to alleviate poverty and get extra income.

Therefore, the present study was carried out to evaluate the influence of water aeration levels viz: 0 (control), 6, 12 and 24 h on some growth indices, mortality rates and physicochemical parameters of Heteroclarias fingerlings under laboratory conditions.

MATERIALS AND METHODS

The study was conducted at the Biology laboratory of the School of Life Sciences, Bosso Campus, Federal University of Technology, Minna. Niger State, Nigeria

Source of the experimental fish: One thousand eight hundred four weeks old Heteroclarias fingerlings with average weight of 1.40 g were purchased from a private fish farm in Lagos, Lagos state, Nigeria.

The fingerlings were transported to the Biology laboratory in 50 L jerican with well aerated water through openings at the top for ventilation.

Acclimatization of the fingerlings: The Heteroclarias fingerlings were acclimatized in rearing tanks for a period of seven days to allow them to recover from transportation stress. They were also visually observed to ensure that there were no infections from the source and also to select average weight of the fish to be cultured together (Adewolu *et al*., 2008, Ayanwale *et al*., 2014). During this period, the fish were fed on a commercial diet (Catco fish concentrate) by coppens international, Holland. They were fed to satiation, morning and evening following the method of Ayanwale *et al*., 2014. Water exchange was done when necessary in the morning. The left overfeed and faecal samples were siphoned immediately after feeding (Ghanbari *et al*., 2012).

Experimental design: A Completely Randomised Design (CRD) with a total of 4 treatments replicated 3 times was adopted in this experiment.

Experimental set-up: The experiment consisted of four treatments with three replicates per treatment, each with stocking density of one hundred and fifty fingerlings per replicate. The diffused aeration method was used for the study (Poon *et al*., 2002). Treatment 1 was the control; no additional air was pumped into the aquarium water (no aeration) while treatments 2, 3 and 4 were aerated for 6, 12 and 24 h, respectively. Twelve plastic indoor aquaria tanks of 25 L capacity (55×35×35 cm^3) were filled with bore-hole water up to 20 cm level. The aeration of the water in the aquarium was maintained by a constant supply of air by the use of compressor operated electricity-powered air pump, working continuously for 24 h daily throughout the duration of the experiment, with the aid of inverter as an alternative source of electricity in case of power outage (Odunze *et al*., 2006). The fingerlings were fed on a commercial diet (Catco fish concentrate) to satiation, morning and evening following the methods of Ayanwale *et al*. (2014). These experimental units consisted of a closed system, without water recirculation. Therefore, tanks were drained twice a week and replaced with fresh bole water between 8 and 10 h. The left overfeed and faecal samples were siphoned immediately after feeding (Ghanbari *et al*., 2012). The experiment was monitored for a period twelve weeks before termination.

DETERMINATION OF SOME PHYSICO-CHEMICAL PARAMETERS

Water temperature: Water temperature of the control treatment was determined with mercury in bulb thermometer (10-110°C range). Temperature was determined by lowering the thermometer into the tanks in an inclined position for about 5 min to allow for equilibrium before taking the reading at 10 am in the morning throughout the duration of the experiment.

Dissolved oxygen: This was determined by using Winkler Azide method (American Public Health Association, 1995). Water samples from the control and treatment tanks were collected by inserting 250 mL water sample bottles into the tanks and sampled water was fixed right in the laboratory with 1ml of reagent (I) (Manganous sulphate) and 1 mL of reagent (II) Alkaline iodide solution (KOH+KI). About 2 mL of concentrated sulphuric acid was added to each sample and 10 mL of the sample was titrated with 0.025 N sodium thiosulphate using starch as indicator until it turns colourless.

Calculation was based on the formula described by Boyd (1979) as follows:

$$\text{Dissolved oxygen } (\text{mg L}^{-1}) = \frac{\text{Volume}(\text{Na}_2\text{SO}_3) \times \text{Normality} \times 8 \times 1000}{\text{Sample volume}(\text{mL})}$$

Where:

Normality = 0.025 mL of sodium sulphite (Na_2S0_3)
8 = Equivalent weight of oxygen in water
1000 = Conversion to mg L^{-1}

Biochemical Oxygen Demand (BOD): Water samples collected from the control and treatment tanks were incubated for 5 days in the dark before the titration for oxygen using Winkler Azide method (APHA, 1992).

$$BOD_5 \text{ mg L}^{-1} = \text{Dissolved oxygen at day 1-Dissolved oxygen at day 5}$$

Hydrogen ion concentration (pH): The pH of the water samples were determined with Jenway 3305 pH meter model at room temperature. The pH meter probe was inserted into the sampled water for about 5minutes until it stabilized before the reading was taken. The meter was standardized with buffer solutions of pH 4, 7 and 9 before the readings were taken.

Ammonia (NH_3): About 100 mL of the water sample from control and treatment tanks was pipetted into a Markham distillation apparatus (Kjeldal flask) and there after 5 mL of 40% NaOH was added. The flask was connected to the condenser and the cooling water was turned on. About 10 mL of 40% boric acid (H_3BO_3) solution was placed under the condenser ensuring that the tip of the condenser was immersed in the receiving solution and distilled slowly until 50 mL of the distillate was collected in the receiving flask. The ammonia was determined from the distillate by titrating with 0.01M HCl until the colour at the end point changed from green to pink (APHA, 1995). Calculation was based on the formular below:

$$NH_3\ (mgL^{-1}) = \frac{\text{Titre value} \times 14 \times 0.01x1000}{V}$$

Where:
0.01 = Molarity of HCl used as titrant
14 = Molecular mass of nitrogen
1000 = Conversion to mg L^{-1}
V = Volume of sample used

Determination of growth performance indices

Standard length and total length: At the end of every week, ten fingerlings from each tank were randomly sampled as described by Kerdchuen and Lengendre (1994). Each fish was sampled one by one using a piece of fine mesh net and gently placed on blotting paper to absorb the adhering water. The Standard Length (SL) was determined by measuring the length between the mouth and the caudal peduncle while the Total Length (TL) was determined by measuring the interval between the mouth and the tail fin. They were individually measured with a graduated transparent meter ruler in centimeters. This method of manipulation and measurement was safe for the fish and they were returned to their respective tanks without any loss (Kerdchuen and Lengendre, 1994).

Weight: The weight of the fish was determined weekly by taking the individual weight of ten randomly sampled fingerlings. Weight was determined by using a sensitive compact scale, model CS 2000 HAUS, following the method of Kerdchuen and Lengendre (1994).

Weight gain: Weight Gain was calculated as: Weight Gain (WTG) = Final mean weight-initial mean weight (Adewolu *et al*., 2008).

Percentage weight gain:

$$\text{Percentage Weight Gain } (\text{PWG}) = 100\frac{y-x}{x} \text{ as described by Adewolu } et\ al.\ (2008)$$

Where:
Y = Final mean body weight (g)
X = Initial mean body weight (g)

Specific Growth Rate (SGR): The SGR was calculated as:

$$SGR = \frac{\log e\, W_2 - \log e\, W_1}{T_2 - T_1}$$

Where:
W_2 = Weight of fish at time T_2 in days
W_1 = weight of fish at time T_1 in days
T_1 = Day zero
T_2 = Eighty four days
Log_e = Natural log to base e as described by Dong Han *et al*. (2005)

Mortality rate: The experimental tanks were monitored daily to remove dead fish and the mortality was recorded; using the formular of Adewolu *et al*. (2008). Mortality Rate (MR) was calculated as:

$$MR = \frac{N_O - N_t}{N_O} \times 100\%$$

Where:
N_o = Number at the start of the experiment
N_t = Number at the end of the experiment

Data analysis: The data collected were analysed for significant differences ($p<0.05$) by the analysis of variance (ANOVA) using a Computer Statistical Package for Social Sciences (SPSS). Duncan Multiple Range Test (Duncan, 1955) method was used to separate the means where there were statistically significant differences ($p<0.05$)

RESULTS

The results of some physico chemical parameters of the water medium in which the *Heteroclarias* fingerlings were exposed to different water aeration levels are depicted in Table 1. The water temperature (22.37±0.61°C) of the fingerlings exposed to 24 h of aeration was significantly ($p<0.05$) reduced when compared with those of other water aeration levels (12-0 h) and ranged from 24.61±0.60 to 26.34±0.67°C. The dissolved oxygen concentration (4±0.47 mg L^{-1}) consumed by the fingerlings cultured in non-aerated water (control) was also significantly lower ($p<0.05$) when compared with those of higher water aeration levels (6.00-12.00 hours) ranged from 4.55±0.53 to 4.92±0.61 mg L^{-1}. Similarly, the biochemical oxygen demand concentration (0.95±0.54 mg L^{-1}) was also significantly ($p< 0.05$) lower when compared with those of higher aeration levels(24.00 to 12.00 hours) ranged from 1.42±0.41 to 1.45± 0.48 Mg L^{-1}. Table 1 also indicated that there were no significant differences ($p>0.05$) in the ammonia concentration (range = 0.26±0.05 to 0.28±0.05 mg L^{-1}) and water pH (7.29±0.34 to 7.58±0.49) of the *Heteroclarias* fingerlings cultured in all the water aeration treatments.

The results of the mean ± standard deviation of growth performance indices of *Heteroclarias* fingerlings exposed to different water aeration levels are presented in Table 2. There were no significant differences ($p>0.05$) in the Total

Table 1: Mean standard deviation of physicochemical parameters measured during experiment on influence of different water aeration levels on *Heteroclarias* fingerlings

Duration of aeration (h)	Temperature (°C)	DO (mg L^{-1})	Ammonia (mg L^{-1})	pH	Biochemical oxygen demand (mg L^{-1})
0	26.34±0.67^{b}	4.00±0.47^{a}	0.28±0.05^{a}	7.29±0.34^{a}	0.95±0.54^{a}
6	25.48±0.64^{b}	4.55±0.53^{ab}	0.26±0.05^{a}	7.40±0.35^{a}	1.28±0.41^{a}
12	24.61±0.60^{ab}	4.92±0.61^{b}	0.27±0.06^{a}	7.53±0.44^{a}	1.45±0.48^{b}
24	22.37±0.61^{a}	4.78±0.48^{b}	0.26±0.05^{a}	7.58±0.49^{a}	1.42±0.41^{b}

Values are Mean±Standard deviation, Values followed by the same superscript(s), in the same column, are not significantly different at ($p>0.05$) tested by DMRT

Table 2: Mean±standard deviation of growth performance indices of *Heteroclarias* fingerlings exposed to different water aeration levels for a period of 12 weeks

	Water aeration levels (h)			
Indices of growth performance	0	6	12	24
Total length (cm)	15.44±0.55[b]	15.20±0.33[b]	15.01±0.31[ab]	14.07±0.62[a]
Standard length (cm)	13.28±0.53[b]	13.26±0.19[b]	12.93±0.26[ab]	12.39±0.29[a]
Initial Body weight (g)	1.40[a]	1.40[a]	1.40[a]	1.40[a]
Final body weight (g)	24.36±2.20[b]	29.82±9.34[c]	21.42±1.14[a]	18.88±1.35[a]
Weight gain (g)	22.96[a]	28.42[c]	20.02[a]	17.48[a]
Percentage weight gain (%)	1640.00[c]	2030.00[d]	1430.00[b]	1248.57[a]
Specific growth rate (day%)	1.48[a]	1.58[a]	1.41[a]	1.35[a]

Values followed by the same superscript, in the same row, are not significantly different at (p>0.05) tested by DMRT

Table 3: Final mean cumulative percentage mortality rates of *Heteroclarias* fingerlings exposed to different water aeration levels for a period of 12 weeks

Duration of aeration (h)	Mortality (%)
0	40.33±3.30[b]
6	44.00±2.83[b]
12	34.00±7.87[a]
24	70.00±19.38[c]

Values are Mean±Standard deviation, Values followed by the same superscript(s), in the same column, are not significantly different at (p>0.05) tested by DMRT

(range = 15.01±0.31 to 15.44 ± 0.55cm) and Standard (range = 12.93±0.26 to 13.28±0.53 cm) lengths of the fingerlings exposed to 0, 6 and 12 h of water aeration at the end of the study. However, the mean total (14.07±0.62 cm) and standard lengths (12.39±0.29 cm), respectively were significantly ($p<0.05$) lower in the fingerlings exposed to 24 h of water aeration. The final body weight (29.32±9.34 g), weight gain (28.42 g) and percentage weight gain (2030%) were significantly higher ($p<0.05$) in the fingerlings exposed to 6 h of water aeration. There was no significant different ($p>0.05$) in the specific growth of *Heteroclarias* fingerlings among all the water aeration levels investigated (range = 1.35% day at 24 h of water aeration to 1.58% day at 6 h of water aeration.

Table 3 also showed the results of final mean cumulative percentage mortality rates of *Heteroclarias* fingerlings exposed to different water aeration levels for a period of 12 weeks. The final mean cumulative percentage mortality (70.00±19.38%) rates of the fingerlings exposed to 24 h of water aeration were significantly higher ($p<0.05$) than those of other water aeration treatments (range = 34±7.87% at 12 h to 44.00±2.83% at 6 h of water aeration. However, there were no significant differences ($p>0.05$) in the final mean cumulative percentage mortality rates of the fingerlings exposed to 0 and 6 h of water aeration, (range = 40.33±3.30 at 0 h to 44.00±2.83% at 6 h of water aeration, respectively.

DISCUSSION

This study revealed that increasing hours of water aeration (24 h) of water medium of *Heteroclarias* fingerlings could increased the air (Dissolved Oxygen Concentration) and thus decreasing dissolved carbondioxide or nitrogen gas in a given pond (Lorsordo *et al*., 1999). This observation resulted into decrease in water temperature of the fingerlings exposed to 24.00 hours of water aeration. This process may occur in nature by flow thorugh water falls, rapids and photosynthesis by aquatic plants (Losordo *et al*., 1999). Although the water temperature (22.37±0.61°C) still fell within the range of 22-35°C tolerated for optimum fish growth in the tropics (Howerton, 2000). The lower value of dissolved oxygen concentration available to the controlled fingerlings during the study indicated that lack of water aeration might reduce the dissolved oxygen concentration in the controlled fingerlings. To support the above submission, it was documented that aeration will always increase levels of dissolved oxygen because its help to oxidize ammonia to nitrates and reduce the build-up of carbondioxide (www.ag.auburn.edu/fish). Although, the dissolved oxygen concentration of 4.00±0.47 mg L^{-1} consumed by the controlled fingerlings was within the range of 3-5 mg L^{-1} for fry, fingerlings and adults as reported by Food Agriculture Organisation (FAO, 2006). The findings of this study showed that ammonia concentration was not influenced by water aeration. Although, the ammonia concentration of 0.26±0.05 to 0.28±0.05 mg L^{-1} were within the range of 0.01-1.55 mg L^{-1} for fresh water fingelings

as documented by Kohinoor *et al*., (1994). This could be attributed to daily removal of left overfeed and faecal samples from experimental tanks. Thus, preventing or reducing the risk of buildup of ammonia from all the treatments (Ayanwale *et al*., 2014). Similarly, water pH was also not influenced by water aeration. The changes in water pH values (range = 7.28±0.34 to 758±0.49) from all the treatments were within the tolerance range of 6-8 documented for juvenile of *H. bidorsalis* and *C. gariepinus* (Ivoke *et al*., 2007 and Ayanwale *et al*., 2014).The biochemical oxygen demand of the controlled fingerlings (0.95±0.54 mg L^{-1}) was below the acceptable range of 1-5 mg L^{-1} recommended for fish growth in the tropics. This submission also agreed with the findings of Ayanwale *et al*. (2014) who reported that daily removal of left over feed and faecal samples from experimental tanks might reduce the bacterial load of the non-aerated water. The study also indicated that total and standard lengths of the Heteroclarias fingerlings were not influenced by water aeration from 0-12 h. This is an indication that fish (*Heteroclarias* fingerlings) could regulate their metabolic rate (growth rate) over a range of 3-5 mg L^{-1} of dissolved oxygen concentration and will not affect its physiological or metabolic activity (Verheyen and Decleir, 1994; Wedemeyer, 1996). The significant lower values of total and standard lengths of the Heteroclarias fingerlings exposed to 24 h of water aeration may be attributed to the works of Kramer (1987) who documented that laboratory studies showed that the expected minimal levels of DO are not lethal but reduced growth rate and activity of the fish. The significant increase in the indices of growth performance except Specific Growth Rate (SGR) of the fingerlings exposed to 6 h of water aeration were in conformity with the works of Pichavant *et al*. (2001) and Nordgarden *et al*. (2003). They reported that fingerlings exposed to oxygen saturation expressed high appetite, better feed intake, better feed utilization and unstressed environment which ultimately leads to better growth performance indices.

Water aeration had no influence on the Specific Growth Rate (SGR) of *Heteroclarias* fingerlings, in all the treatments during the study period. This finding was in agreement with the reports of Mallya (2007) who observed no influence in the SGR of Atlantic Halibut juveniles exposed to different oxygen levels (60-140%) which was approximately 3-5 mg L^{-1} of DO concentration recorded in this study. The high cumulative mortality rates recorded in the Heteroclarias fingerlings exposed to 24 h of water aeration may be attributed to aeration stress, low temperature and lack of rest (Udomkusonri *et al*., 2004 and Choi *et al*., 2007).

CONCLUSION

Water aeration had no effect on the ammonia concentration, water pH and specific growth rate of the Heteroclarias hybrid during the study period. However, 24 h of water aeration results into higher cumulative mortality rates. The heteroclarias fingerlings exposed to control (non aerated water) and 6 h of water aeration had higher TL, SL, final body weight, weight gain and percentage weight gain. Therefore, for Heteroclarias hybrid culture, it is essential to expose the fish to water aeration between 0-12 h of aeration when necessary.

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