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INFLUENCE OF DURATION OF WATER AERATION ON GROWTH INDICES AND MORTALITY RATES OF *HETEROCLARIAS* HYBRID UNDER LABORATORY CONDITIONS IN MINNA, NIGERIA

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ABSTRACT

Study was carried out to determine the influence of water aeration duration ; 0.00(control), 6.00, 12.00, 24.00 hours on growth indices and mortality rate of Heteroclarias freshwater hybrid fingerlings under laboratory condition for a period of 12 weeks. Commercial diet of Crude protein (56%),Fat(15%),Crude fibre (0.4%), Ash (10.9%), Preservatives (E280), Antioxidants (E324 and E321), Vitamin A (22.50 µ/kg), Vitamin D_3 (2.50 µ/kg), Vitamin E (200.00 mg/kg), Vitamin C stable (300.00 mg/kg), Phosphorus (1.8%), Calcium (2.6%) and Sodium (0.7%), respectively was fed twice daily to satiation. Growth indices and physiochemical parameters were determined weekly while the mortality rates were recorded daily. Results showed that the fingerlings cultured in 6.00 hours of aeration were significantly ($P<0.05$) higher in final body weight (29.82±9.34 g), weight gain (28.42 g), percentage weight gain (2030.00%) and specific growth rate (3.6% day). Mortality rates of the fingerlings cultured in 24.00hours of aeration were significantly ($P<0.05$) highest (70.00 $\pm$ 19.38%). Water temperature (22.37±0.61^{0}C) of the fingerlings exposed to 24.00 hours of aeration was significantly ($P<0.05$) reduced when compared with those of 12.00-0.00 hours. Dissolved oxygen concentration (4.00±0.47 mg/L) and Biochemical oxygen demand concentration (0.95±0.54 mg/L) in control were also significantly reduced ($P<0.05$) when compared with those of higher treatments. Ammonia concentration (range = 0.26±0.05 to 0.28±0.05 mg/L) and water pH (7.29±0.34 to 7.58±0.49) indicated no significant differences ($P>0.05$) in all the treatments. The findings of this study indicated that growth indices and survival rates of Heteroclarias fish hybrid can be enhanced by using 6 hours of aeration per day.

Keywords: 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 (fish and aquatic plants), decay of organic matter, direct chemical oxidation. (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 (Boyd, 1998). 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 (Boyd, 1998).

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) also reported that DO within the range of 3.00-5.00 mg/l or near saturation (80-100%) is suitable for fry, fingerlings and adults. Similarly, Svobodova *et al.* (1993) recommended DO of about 5 mg/L as suitable for fish growth, health and tissue repairs in the tropics. However, when 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 reported 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); 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, in this study the researcher intend to evaluate the influence of water aeration duration (0.00 (control), 6.00, 12.00 and 24 hours) on some growth indices, mortality rates and physicochemical parameters of Heteroclarias fingerlings under laboratory conditions.

MATERIALS AND METHODS

Experiment and Procedures

The study was conducted at the Biology laboratory of the School of Life Sciences, Bosso Campus, Federal University of Technology, Minna. Niger State. One thousand eight hundred 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 litres jerican

with well aerated water through openings at the top for ventilation.

The Heteroclarias fingerlings were acclimatized in rearing tanks for a period of seven days to allow them to recover from transportation stress and room or air temperature was maintained at 28 ± 1^0C. 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 twice a week in the morning. The left overfeed and faecal materials were siphoned immediately after feeding (Ghanbari *et al.*, 2012).

A Completely Randomised Design (CRD) with a total of 4 treatments, three replicates was adopted in this experiment. Stocking density was 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 hours respectively. Twelve plastic indoor aquaria tanks of 25 litres capacity ($55x35x35cm^3$) 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 hours 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 bore- hole water between 08.00 and 10.00hours. The left overfeed and faecal materials 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 of the control treatment was determined with mercury in bulb thermometer ($10\text{-}110^0$C range). Temperature was determined by lowering the thermometer into the tanks in an inclined position for about 5 minutes to allow for equilibrium before taking the reading at 10.00 am in the morning throughout the duration of the experiment.

Dissolved Oxygen 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 1ml of reagent (II) Alkaline iodide solution (KOH + KI). About 2 ml of concentrated sulphuric acid was added to each sample and 10ml of the sample was titrated with 0.025N sodium thiosulphate using starch as indicator until it turns colourless.

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

$$\text{Dissolved Oxygen (mg/L)} = \frac{\text{Volume}(Na_2SO_3) \times \text{Normality} \times 8 \times 1000}{\text{Sample volume (ml)}}$$

Where, normality= 0.025 ml of sodium sulphite (Na_2S0_3)

8 = Equivalent weight of oxygen in water

1000 = Conversion to mg/litre

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

BOD5mg/L = Dissolved oxygen at day 1 – Dissolved oxygen at day

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 4.0, 7.0 and 9.0 before the readings were taken.

Determining Ammonia (NH_3) level of water 100ml of the water sample from control and treatment tanks was pipetted into a Markham distillation apparatus (Kjeldal flask) and there after 5ml of 40% NaOH was added. The flask was connected to the condenser and the cooling water was turned on. About 10ml 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 50ml 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 formula below

$$NH_3(\text{mg/L}) = \frac{\text{Titre value} \times 14 \times 0.01 \text{ x } 1000}{\text{V}}$$

Where 0.01 = molarity of HCl used as titrant; 14 is the molecular mass of nitrogen; 1000 is the conversion to mg /litre and V is the 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 & 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 of the Fish

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 = Final mean weight – initial mean weight (Adewolu *et al*., 2008).

Percentage Weight Gain

Percentage Weight Gain (PWG) = $100\ \frac{Y-X}{X}$ as described by Adewolu *et al*. (2008).

Where:

Y= final mean body weight (g)

X= initial mean body weight (g)

Specific Growth Rate (SGR)

SGR was calculated as:

SGR= $\frac{\log e\ W_2 - \log e W_1}{T_2 - T_1} \times 100$

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 (84) 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 formula 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 of the Experiment

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 are shown in Table 1. The water temperature (22.37±0.61^{0}C) of the fingerlings exposed to 24.00 hours of aeration was significantly (P<0.05) reduced when compared with those of other water aeration levels (12.00-0.00 hours) and ranged from 24.61±0.60 to 26.34±0.67^{0}C.The dissolved oxygen concentration (4.00±0.47mg/L) 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 duration (6.00-12.00 hours) ranged from 4.55 ± 0.53 to 4.92 ± 0.61 mg/L. Similarly, the biochemical oxygen demand concentration (0.95± 0.54mg/L) was also significantly (p< 0.05) lower when compared with those of higher aeration duration (24.00 to 12.00 hours) ranged from 1.42± 0.41 to1.45± 0.48Mg/L. 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) and water pH (7.29 ± 0.34 to 7.58 ± 0.49) of the Heteroclarias fingerlings cultured in all the water aeration treatments.

Table 1: Mean Standard Deviation of Physicochemical Parameters measured during the Experiment

Duration of Aeration (Hrs)	Temperature (^{o}C)	DO (Mg/L)	Ammonia (Mg/L)	pH	Biochemical Oxygen demand(Mg/L)
0.00	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
6.00	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
12.00	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
24.00	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

The results of the mean ± standard deviation of growth performance indices of Heteroclarias fingerlings exposed to different water aeration duration are presented in Table 2. There were no significant differences (P>0.05) in the Total (range = 15.01±0.31 to 15.44 ± 0.55cm) and Standard (range = 12.93± 0.26 to 13.28 ± 0.53cm) lengths of the fingerlings exposed to 0.00, 6.00 and 12.00 hours of water aeration at the end of the study. However, the mean total (14.07 ± 0.62cm) and standard lengths (12.39 ± 0.29cm) respectively were significantly (P<0.05) lower in the fingerlings exposed to 24.00 hours of water aeration. The final body weight (29.32 ± 9.34g), weight gain (28.42g) percentage weight gain (2030.00%) and specific growth rate (3.6% day) were significantly higher (P<0.05) in the fingerlings exposed to 6.00 hours of water aeration. There was no significant different (P>0.05) in the specific growth of Heteroclarias fingerlings among other water aeration investigated (range = 3.1% day at 24.00 hours of water aeration to 3.4% day at 0.00 hours of water aeration.

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

Indices of Growth Performance	Water aeration levels(hours)			
	0.00	6.00	12.00	24.00
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)	3.4^a	3.6^b	3.2^a	3.1^a

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

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 24.00 hours of water aeration were significantly higher (P<0.05) than those of other water aeration treatments (range = 34.00±7.87% at 12.00 hours to 44.00 ± 2.83% at 6.00 hours 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 0.00 and 6.00 hours of water aeration, (range=40.33±3.30 at 0.00 hours to 44.00 ± 2.83% at 6.00 hours of water aeration, respectively.

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 (Hrs)	Mortality (%)
0.00	40.33 ± 3.30^{b}
6.00	44.00 ± 2.83^{b}
12.00	34.00 ± 7.87^{a}
24.00	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

DISCUSSION

This study revealed that increasing hours of water aeration (24.00 hours) 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^{0}C) still fell within the range of 22.0 to 35.00^{0}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 (Boyd, 1998). Although, the dissolved oxygen concentration of 4.00 ± 0.47mg/L in the control was within the range of 3.00 – 5.00 mg/L 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 ± 0.05mg/L were within the range of 0.01 to 1.55 mg/L for fresh water fingelings as documented by Kohinoor *et al.*, (1994), but it was controlled by 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 6.0 to 8.0 documented for juvenile of *H. bidorsalis* and *C. gariepinus* (Ivoke *et al*., 2007; Ayanwale *et al.,* 2014). The biochemical oxygen demand of the control (0.95±0.54mg/L) was below the acceptable range of 1.00 to 5.00 mg/L 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 materials from experimental tanks reduces the bacterial load of the non-aerated water. Total and standard lengths of the Heteroclarias fingerlings of water aeration from 0.00 to 12.00 hours, indicated that Heteroclarias fingerlings could regulate their metabolic rate over a range of 3.00 – 5.00 mg/L 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 24.00 hours 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 of the fingerlings exposed to 6.00 hours 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, and better feed utilization and unstressed environment which ultimately leads to better growth performance indices. Aeration of 6.00 hours is most desirable for growth according to the findings of this study, however increasing the duration of aeration above 6.00 hours lead to decrease in weight gain.

The high cumulative mortality rates recorded in the Heteroclarias fingerlings exposed to 24.00 hours 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

The Heteroclarias fingerlings exposed to 6.00 hours 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 0.00 to 6.00 hours of aeration.

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