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INFLUENCE OF TEMPERATURE AND PH ON CRITICAL WATER QUALITY PARAMETERS OF LABORATORY-REARED CULTURE MEDIA OF THE ECONOMICALLY IMPORTANT *HETEROCLARIAS* FISH FINGERLINGS

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ABSTRACT

The attainment of species-specific conducive water quality environment is crucial to optimum production of fishes in captivity. This need therefore, informed the study of relationships between temperature, pH, and physicochemical parameters of *Heteroclarias* fingerlings under laboratory conditions. The fingerlings were raised at water temperature regime (Ambient (26.91°C), 28.00, 30.00 and 32.00°C); and pH of 5.00, 7.00 (i.e. ambient), 9.00 and 11.00. The water quality parameters (Dissolved Oxygen (DO); Biochemical Oxygen Demand (BOD); Ammonia; and Conductivity), of fish culture media were monitored weekly for three months. The results indicated that water temperature had no significant ($P>0.05$) effect on Ammonia concentration (range = 0.15 – 0.17mg/l) and pH condition (range = 6.78 at 26.91°C, to 6.95 at 28.00°C) of the culture media. Water temperature significantly ($P<0.05$) reduced DO from 6.16±0.91mg/l at 26.91°C, to < 5.00mg/l at temperatures above 28.00°C; but no significant difference in BOD at all temperatures levels. Conductivity increased significantly with rising temperature above the ambient condition (range = 251.02±59.73µS/cm at 26.91°C to 352.89±79.09µS/cm at 28.00°C). pH had no significant effects on the parameters at pH conditions tested; temperature, DO, BOD, and Ammonia. With the exception of significant difference in conductivity ($P<0.05$) of rearing media of *Heteroclarias* (range = 304.42±47.20µS/cm at pH 7.00, to 380.94±38.40 µS/cm at pH 9.00). pH 11.00 could not support survival of the fingerlings. The findings of this study have provided useful information for effective water quality management in artificial culturing of the fish *Heteroclarias*.

Keywords: Physicochemical Parameters, Dissolved Oxygen, Biochemical Oxygen Demand, Ammonia, Conductivity, and Aquaculture.

INTRODUCTION

The *Heteroclarias* hybrid from *Clarias gariepinus* (female) and *Heterobranchus bidorsalis* (male) has been reported to be the most widespread and accepted fish in Africa especially in Nigeria, for reasons attributed to their faster growth rate, ability to withstand diseases, increase in stocking density and possession of accessory breathing organs when compared with their parent stocks (Adewolu *et al.,* 2003). Khaleg (2000) reported that the farmers should be encouraged to culture *Heteroclarias* as the major source of family income because its rearing is a means of poverty alleviation and a source of an extra income. This background information had motivated farmers in Nigeria to culture *Heteroclarias* on a large scale more than its parent stock (Ayanwale *et al.* 2014).

Water quality determines not only how well fish grows in an aquaculture operation, but whether or not they survive (Joseph *et al.,* 1993). Fish, like *Heteroclarias* influence water quality through processes like nitrogen metabolism and respiration. Therefore, knowledge of testing procedures and interpretation of critical water quality parameters are important to the fish farmers (Boyd and Tucker, 1998). All biological and chemical processes in fish are influenced by water temperature (Ross, 2000). This is because fish are exothermic, which means their body temperature is close to and fluctuates with temperature of their environment. Some water quality parameters are known to be associated with fish mortalities such as dissolved oxygen, temperature and ammonia. Parameters such as pH, alkalinity, hardness and clarity influence fish, but not harmful (Boyd, 1990). Similarly, Bhatnagar and Sangwan (2009) reported that water quality parameters like biochemical oxygen demand, chemical oxygen demand, chlorides, phosphates and ammonia are said to be considered as pollution indicators, which might result in fish losses, when above tolerable levels. Pond water temperatures can be managed by using simple methods, such as covering the ponds with shade-cloth or allowing cooling water to enter when the temperature gets too warm and planting of banana trees around the pond (Ayanwale *et al.,* 2012). Carp and Catfish are tolerant of wide temperature ranges (25.00 – 33.00°C) as reported by Afzal *et al.* (2007). Water pH is crucial to vertebrates in water because its affects the fish and other aquatic organisms to control osmoregulatory processes in and out of water in which they lived. Inability to control these processes can result in sub-lethal effects such as reduced growth and fish mortality (Bryan, 2004). The author added that, pH levels of water can alter depending on the amount of oxygen available in the water and percentage of poisonous waste-products (ammonia). Alabaster and Lolyd (1980) in his works identified the pH range of 5.0-9.0 to support growth of fresh water fish.

Several challenges hinder the maximum optimum production of fish in Nigeria, such as poor water quality parameters from urbanization, industrialization, agriculture and oil exploitation. The convergence of pollutants may kill fish directly in aquaculture facilities or affect the quality and consumer acceptability of the product (Akolisa and Okonji, 2005). This study was carried out to elucidate the influence of temperature and pH on critical water quality parameters of Heteroclarias fingerlings under laboratory conditions, in order to provide necessary baseline information for the optimum productivity of *Heteroclarias* under fluctuating environmental condition.

MATERIALS AND METHODS

Study Area

This experiment was done indoor at the laboratory of the Department of Biological Sciences, Federal University of Technology, Minna, Nigeria.

Source of Experimental fingerlings

One month old *Heteroclarias* fingerlings, with initial mean weight of 0.38g, were purchased from a private fish farm in

New-Bussa, Nigeria. The fishes were acclimatized in a rearing tank in the laboratory for seven days, during which dead and weak specimens were eliminated (Adewolu *et al.,* 2008).

Source of Experimental Aquaria and Water Medium Conditions

Twenty four transparent indoor plastic aquaria (55x35x35cm) were used for rearing *Heteroclarias* fingerlings. Borehole water in aquaria for rearing under different temperature levels were aerated by a constant supply of compressed air from LP-100 air pump, powered by an electric current and inverter as a standby source of power in case of power failure, throughout the experimental period. However, the water media for rearing *Heteroclarias* at different pH-levels were not aerated during the experimental period. Water media exchange was carried out twice in a week during the morning hours (Ayanwale *et al.,* 2014).

Experimental Design and Management

Twelve aquaria were used and fixed at temperature regimes; 26.91^{0}C (control), 28.00, 30.00 and 32.00^{0}C using thermoregulators (Model: Life Tech, 2009) (El-sherif and El-feky, 2009). The control experiment was fixed at ambient laboratory temperature. Simultaneously, another set of twelve aquaria tanks were also set up to culture *Heteroclarias* at different water pH levels of 5.0, 7.0 (control), 9.0 and 11.0 respectively. The different pH levels of the media were maintained by siphoning of faecal samples, uneaten food. The pH of the experimental tanks was retained with the aid of pH meter on daily basis (Ghanbari *et al.,* 2012). The initial pH of the borehole water was adjusted to pH 5.0 by the addition of 3% concentrated hydrochloric acid, while the water was made alkaline by the addition of 0.4g of sodium hydroxide granules in 100mls of distilled of water (Ivoke *et al.,* 2007). The aquaria tanks, holding 25litres of water each, were stocked with 150 fingerlings and each set up were replicated for each temperature and pH treatments including their control. The experiments were monitored for a period of 12 weeks, during which other water quality parameters such as dissolved oxygen, biochemical oxygen demand, conductivity and ammonia in all the treatments were measured weekly between 8.00-10.00 a.m. (Rahman *et al.,* 2009).

The fishes were maintained on commercial fish diet (Coppens), of mean pellet size of 1.20mm and 2.00mm during the first seven weeks and post seven weeks respectively, (Ayanwale *et al.,* 2014). The fingerlings were fed to satiation in the morning and evening of each day (Dong Han *et al.,* 2005). The commercial diet was administered by spot feeding (El-sherif and El-feky, 2009).

Determination of Water quality parameters

Water Temperature;

Temperatures of culture media were determined by using mercury-in bulb thermometer. Temperature levels of 28.0, 30.0 and 32.0^{0}C were maintained by thermo regulators, respectively.

Water pH

An electrode digital probe pH-meter (Jenways 3305Model) was calibrated with buffers 4.0, 7.0, 9.0 before using the pH meter. This was determined by inserting the pH meter probe in to the sampled water media for 5minutes until it stabilizes before the reading was taken.

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 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

Ammonia (NH_3)

100 ml 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 0.01 M HCl until the colour at the end point changed from green to pink (APHA, 1995). Calculation was based on the formula below

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

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.

Electrical Conductivity

The battery- operated electrical conductivity metre (CD 4303 Lutron) probe was placed into the sampled water for 5 minutes until it stabilizes before the reading was taken. The readings were expressed in microseimen (µs/cm).

Data Analysis

The data collected were analyzed 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 adopted to separate the means where there were statistically significant differences ($P < 0.05$).

RESULTS

The results of mean ± standard deviation of critical water quality parameters of *Heteroclarias* fingerlings reared at different temperature regimes are depicted in Table 1. There were no significant differences ($P>0.05$) in the ammonia concentration and pH of the fishes in all the treatments studied (range = 0.15±0.09 to 0.17±0.09 mg/L and 6.78±0.89 to 6.95±0.37, respectively). However, temperature significantly ($P<0.05$) reduced dissolved oxygen concentration from 6.16±0.91 mg/L at ambient

temperature to 4.58 ± 0.97 mg/L at temperatures above 28^{0}C; but indicated no significant effect (P>0.05) in the biochemical oxygen demand at all temperature levels (range = 2.76±1.27 to 3.00±1.59 mg/L). Table 1 also showed that the conductivity of the fish cultured media increased significantly (P<0.05) with increase in temperature above the ambient condition (range 251.02± 59.73 $\mu s/cm$ ambient temperature, to 352.89±7.09$\mu s/cm$ at 28.00^{0}C).

Table 1: Mean ± Standard Deviation of Critical Water quality Parameters of *Heteroclarias* Fingerlings cultured at different temperature levels for a period of 12 weeks

Temperature levels (^{0}C)	Dissolved oxygen (mg/L)	Ammonia (mg/L)	pH	Biochemical Oxygen demand (mg/L)	Conductivity ($\mu s/cm$)
26.91 (control)	6.16± 0.91^b	0.17 ± 0.09^a	6.78±0.89^a	2.89±0.69^a	251.102±59.73^a
28.00	5.57±0.73^{ab}	0.15±0.09^a	6.95±0.37^a	2.76±1.27^a	352.89±79.09^b
30.00	4.85±1.01	0.16±0.08^a	6.88±0.27^a	2.92±1.58^a	330.94±65.24^b
32.00	4.58±0.97^s	0.15±0.09^a	6.82±0.27^a	3.00±1.59^a	334.17±74.30^b

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 mean ± standard deviation of critical water quality parameters of *Heteroclarias* reared at different pH levels of water are showed in Table 2. pH indicated no significant influence (P>0.05) on most parameters investigated: Temperature (ranged from 26.21 ±1.00 at pH 9.0 to 26.51±0.77 at pH 5.0,DO(ranged from 4.64±3.73 at pH 5.0 to 5.90±3.92 mg/L at pH7.0),BOD(ranged from2.00±1.13 at pH5.0 to 2.84±1.13 mg/L at pH 9.0 and Ammonia concentration (ranged from 0.06±0.01 at pH5.0 to 0.06±0.01 mg/L at pH 9.0). However, the study recorded significant effect (P<0.05) of pH on the conductivity of culture media of *Heteroclarias* fingerlings (ranged from 304.42±47.20 at pH 7.0 (control) to 380.94±38.40 $\mu s/cm$ at pH 9.00. Interestingly, the culture media of *Heteroclarias* fingerlings maintained at pH 11.00 could not support their growth as 100% mortality was achieved under 24hours of study.

Table 2: Mean ± standard deviation of critical water quality parameters of *Heteroclarias* fingerlings cultured at different pH levels for a period of 12 weeks.

pH levels	Biochemical oxygen (mg/L)	Temperature (^{0}C)	Dissolved oxygen (mg/L)	Ammonia (mg/L)	Conductivity $\mu s/cm$
5.0	2.00± 1.13^a	26.51±0.77^a	4.64±3.73^a	0.06±0.01^a	369.44±41.54^b
7.0 (control)	2.14±1.47^a	26.22±0.90^a	5.90±3.92^a	0.06±0.01^a	304.42±47.20^a
9.0	2.84±1.13^a	26.21±1.00^a	5.20±3.37^a	0.06±0.01^a	380.94±38.40^b
11.0	-	-	-	-	-

Values followed by the same superscript(s), in the same column, are not significantly different at (P > 0.05) tested by DMRT
* Not applicable as 100% mortality was achieved under 24 hours of the study

DISCUSSION

The present study revealed that temperature had no influence on water pH and ammonia concentration of cultured media of *Heteroclarias* fingerlings. This may be attributed to constant exchange of water, removal of faecal samples and uneaten feed after feeding on daily basis which prevent ammonia build up in the system (Ghanbari *et al.*, 2012). This study indicate that the range of ammonia concentration (0.15±0.09 to 0.17±0.09 mg/L) in all the treatments were low when compared with the available maximum value of unionized ammonia of about 0.45mg/L in fish culture (Boyd, 1990). This corroborate with the work of Ayanwale *et al.* (2014). The pH range of 6.78±0.89 to 6.95±0.37 recorded in this study fell within the range of 6.50 to 9.00 recommended for optimum fish growth (Bryan, 2004). Similarly, temperature had no influence on pH of cultured media of *Heteroclarias* fingerlings during the study period.

However, the reduction in dissolved oxygen concentration at higher temperature levels (30-32°C) was in conformity with the works of Mallya (2007) and Krishnamoorthy *et al.*, (2008) who reported that temperature increase metabolic activities such as reproduction, feeding, protein synthesis and subsequent oxygen demand in aquatic animal like fish. This might lead to low oxygen levels in the cultured media at high tested temperature levels, because the available DO was constantly used up by the fish. Krishnamoorthy *et al.* (2008) support the observation that the rate of oxygen consumption of *Alepes djidaba* exposed to higher temperature levels (33-40^{0}C) was found to increase with increasing temperature. Temperature had no influence on BOD of cultured media of *Heteroclarias* fingerlings during this period because of constant exchange of water, siphoning of uneaten feed, and faecal samples. Thus, preventing accumulation of organic load and resulted to low BOD concentration (Ghanbari *et al.*, 2012). The BOD range (2.76±1.27 to 3.00 ±1.59 mg/L) recorded in this study was favourable for good fish growth performance when compared with the recommended range of 1.00 to 5.00mg/L as reported by CIESE (2010).

The influence of temperature on conductivity of cultured media of *Heteroclarias* fingerlings at higher tested temperature levels agreed with the findings of Ayanwale *et al.*, (2012) that water temperature might probably influenced the mineral or ion concentrations (conductivity) of the cultured media. However, the conductivity range (251.02±59.27 to 352.89±79.09 $\mu s/cm$ was higher when compared with the range of 120 to 340 $\mu s/cm$ recommended for fish growth by Kolo (1996).

The findings of this study also showed that water pH had no influence on the tested water temperature levels of *Heteroclarias* fingerlings. Although, the values were within the range of 24.00-32.00^{0}C documented for fish culture in the tropics (Ayanwale *et al.,* 2014). Similarly, water pH also had no influences on the BOD, DO and Ammonia concentration of the rearing media of *Heteroclarias* fingerlings during the study. These observations were similar to the works of CIESE (2010) and Ghanbari *et al.* (2012).

The lowest value of water conductivity of *Heteroclarias* fingerlings cultured at pH 7.00 was expected since the medium was devoid of acid and base (Ivoke *et al.,* 2007). Although, the water conductivity ($304.42\pm47.20\mu cm$) of the fingerlings cultured at pH 7.00 was within the range of 120 to $340\mu cm$ recommended for fish growth by Kolo (1996).

However, the water conductivities of the fingerlings cultured at pH 5.0 and 9.0 were higher than the recommended range of 120 to $340\mu s/cm$ as documented for fish growth by Kolo (1996).

The study also revealed that the cultured media at pH 11.00 could not support the growth and survival of the fingerlings. This observation agreed with the works of Gaunder (2005) who opined that acid and alkaline death points for fresh water fish were pH 4.00 and 11.00 respectively while at these pH levels, reproduction and growth of fish diminished with increase in acidity or alkalinity.

CONCLUSION

Water temperatures between 26.91^{0}C (control) to 32.00^{0}C had no influence on ammonia concentration, pH and biochemical oxygen demand of media of *Heteroclarias* fingerlings. However, temperature reduced dissolved oxygen concentration at the highest tested temperature levels (30-32^{0}C); while water conductivity increased with increase in temperature.

pH also had no influence on water temperature, dissolved oxygen concentration, biochemical oxygen demand and ammonia concentration of the culture media of *Heteroclarias* fingerlings. Moreover, the fingerlings cultured at pH 7.00 indicated reduction in the water conductivity, but showed higher values at pH 5.0 and 9.0 respectively. The pH 11.0 treatment could not support the culture of *Heteroclarias* fingerlings.

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