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Influence of Temperature on Survivorship and Growth Performance of Heteroclarias Fingerlings under Laboratory Conditions

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A B S T R A C T

The need for a beter understanding of the environmental factors that influence productivity of artificial culture of Heteroclarias fish species informed this study. To this end, the effects of different temperature levels, ranging from 27.00 - 32.00°C, on the survival and growth of the fish species was monitored over a period of 12 weeks, under laboratory conditions; following standard procedures. The results showed that temperature had no significant (P>0.05) effects on total and standard lengths (range = 8.16±0.28cm at 30.00^{0}C, to 8.68±0.40cm at 26.91°C; and 7.30±0.23 at 28.00/32.00^{0}C to7.63±0.67 at 26.91^{0}C, respectively). Body weight (BW), on the other hand, reduced significantly (P<0.05) with increasing water temperature (range = 190.55±31.50g at 26.91°C, to 154.37°C±15.25g at 32.00°C). Likewise, the indices of weight gain namely, Final Body Weight Gain and Percentage Weight Gain reduced significantly with increasing temperature. However, the mortality of the fishes was not significantly different (P>0.05) among the temperature-treatment groups. The findings of this study should aid the fine-tuning of field management protocols of Heterclarias artificial culture for optimum productivity.

Key words: *Body Weigth, Heteroclarias, Standard Length, Total Length and Weigth Gain*

Introduction

The hybrid Clarias species, Heteroclarias, has been adjudged the most wide-spread and accepted fish in Nigeria, for reasons including its relative faster growth rate, better feed conversion efficiency compared with either of its parental stock, i.e., Clarias gariepinus and Heterobranchus bidorsalis. Other attributes of the species include it's been voracious, ability to inter-breed, resistance to diseases, attributed to its improved hybrid vigour (Ivoke et al., 2007; Ojutiku, 2008). To support the above submissions, Adewolu et al. (2008) reported that fingerlings of Clariid catfish species have varied growth performance and differential food utilization efficiency under culture systems. Literature reports have shown that the parental Clarias gariepinus species does not grow as big and as rapidlyly as Heterobranchus bidorsalis. On the other hand, the Heterobranchus species does not possess the high survival rates of Clarias gariepinus (Madu et al., 1999). This development resulted in a motivation in aquaculture in Nigeria, for the production of hybrid of Clarias gariepinus and Heterobranchus bidorsalis, commonly called the Heteroclarias, in which the traits of Heterobranchus bidorsalis is dominant (Ivoke et al., 2007) .

Temperature of aquatic environment is important for ensuring survival, distribution and normal metabolism of fish. Failure to adapt to temperature fluctuations is generally ascribed to the inability of the fish to respond physiologically with resultant mortality, which is related to changes in the metabolic pathway (Forghally et al., 1973). The result is a collapse in osmo-regulatory functions during temperature extremes (Gubbins et al., 2000). Nair and Lipton (2012) reported temperature as a critical factor among the myriad of environmental conditions affecting the aquatic environment as well as the metabolism of ectotherms. Generally, rise in atmospheric temperature, due to natural variations including the global warming, have been found to directly influence water temperature as well as the biological activities of fishes (Currie et al., 1998). Thus, fishes engage in costly biological processes to regulate their internal body temperature in order to optimize physiological processes necessary for survival and growth (Bellgraph et al., 2010). Ross and Ross (2002) also observed that water temperature affects

all aspects of fish metabolism; and at high temperatures, metabolic rate increases. Similarly, Houlihan et al. (1993) opined that temperature significantly effects food intake, maintenance requirement, metabolic rates, enzyme processes, diffusion of small molecules, membrane functions and protein synthesis rates in fishes. On their part, Gumaa and Salih (1986) found that young Oreochromis niloticus preferred water temperature between 30 - 36°C while, higher temperatures of about 41°C proved lethal to the fishes.

Several challenges constrain optimum fish production in Nigeria. One of such constraints is that most tropical fish species succumb to death when water temperature drops below 10°C (Weirich et al., 1993). Therefore, the present study was carried out to determine the influence of different temperature levels on some growth parameters and survival rates of Heteroclarias fingerlings under laboratory conditions, so as to provide necessary baseline for field application in sustainable optimum culture of the fish species under prevailing relatively high and dynamic tropic temperature conditions.

Materials And Methods

Study Area

This study was carried out indoor in the Laboratory of the Department of Biological Sciences, Federal University of Technology, Minna, Nigeria.

Source and Pre-study Handling of Heteroclarias Fingerlings

Four weeks old Heteroclarias fingerlings, with initial mean weight of 0.38g, were obtained from a private commercial fish farm at New Bussa, Nigeria. The fingerlings were homogeneous in size, body weight and apparently healthy. They were fed to satiation with commercial fish feed (Coppens), in the morning and evening, during the hours of 0800 and 2000, respectively. The fishes were allowed to acclimatize in the laboratory for seven days, during which dead and weak specimens were eliminated daily (Dong et al., 2005).

Source of Experimental Aquaria and Water Medium Conditions

Twelve transparent indoor plastic aquaria (55×35×35cm) were obtained from a scientific equipment store and used for rearing the Heteroclarias fingerlings. Borehole water in aquaria was aerated by a constant supply of compressed air from a pressure pump, powered by an electric inverter for constant power supply throughout the experimental period. Water exchange was done twice in a week during the morning hours (Randall, 1976).

Experimental Design and Feeding of Fingerlings

The aquaria were set up and maintained at four temperature levels namely, 26.91°C (Control), 28.00°C, 30.00°C and 32.00°C, using thermoregulators (Model: LifeTech, 2009) (El-sherif and El-feky, 2009). The Control experiment had no thermoregulator but maintained at ambient Laboratory temperature. The aquaria tanks, holding 25litres of water, were stocked with 150 fingerlings each and set up in three replicates for each temperature treatment including the Control. The experiment was maintained for 90 days (i.e., 12 weeks), during which mortality and growth performance indices were monitored weekly.

The fishes were maintained on commercial fish feed (Coppens), of mean pellet size of 1.20mm and 2.00mm during the first seven weeks and post seven weeks, respectively. The diet was stored at low temperature and were not exposed during the experimental duration to avoid nutrient deterioration (Jauncy and Ross, 1982). The fingerlings were fed to satiation in the morning and evening of each day (Dong Han et al., 2005). The experimental diet was offered by hand-spreading at one side of the aquarium (El-Sherif and El-Feky, 2009).

Data Analysis

Mortality and growth performance data collected were processed into means±SD, using Microsoft Excel. Differences in mean values of the temperature treatments investigated were compared for statistical significance, using ANOVA at P=0.05

Measurement of Growth Parameters

At the end of each week, ten fingerlings from each experimental tank were randomly selected for measurement of growth indices. Each of the selected fish specimens was briefly taken out of the aquaria, using a piece of fine mesh net, gently placed on paper towels in order to absorb most of the adhering water. The specimens were then individually measured with a graduated meter rule, for the standard and total lengths, in centimeters. The same procedure was also repeated for the determination of body weight, using a sensitive electronic compact scale (Model: CS200HAUS) (Kerdchuen and Lengendre, 1994).

The following parameters were used to evaluate Heteroclarias fingerlings growth performance, using the formulae of Adewolu et al. (2008):

Body Weight gain (WG) = $W_1 - W_0$

Where, W_0 = initial body weight,
W_1 = final body weight.

Percentage Weight (PWG) = $\frac{100(Y-X)}{X}$

Where, Y = final mean body weight in grams
X = initial mean body weight in grams

Specific Growth Rate (SGR) = $Log_e\ W_2 - W_1/\ T_2$

Where, W_2 = Weight of fish at later time T_2 in days
W_1 = Weight of fish at initial time T_1 in days
Log_e = Natural log to base e

Survival Rate (%), SR = $\frac{N1 \times 100}{N0}$

Where, N_1 = number at the end of the experiment
N_0 = number at the start of the experiment

Results

The results of the mean±standard deviation of some growth parameters of Heteroclarias fingerlings raised at different temperature levels are shown in Table 1. There was no significant difference (P>0.05) in the standard and total lengths of the fingerlings among all the temperature levels investigated (range = 7.30±0.34 to 7.63±0.67cm and 8.16±0.28 to 8.68±0.40cm, respectively). However mean body weight was significantly (P<0.05) highest (i.e., 190.55 ±31.56g) in the Control fishes (i.e., those raised at 26.91°C) than those cultured at the higher test temperatures levels of 28.00, 30.00 and 32.00°C (range = 154.37±15.25g at 32°C to 166.49±17.50g in 30.00°C treatment. Also, apparent from Table 1 is the fact that there was no significant difference (P>0.05) in the mean body weight of Heteroclarias fingerlings exposed to temperature levels of 28.00°C and 30°C.

The results for growth performance indices and cumulative survival rates of the fingerlings are presented in Table 2. While, Final Body Weight (FBW) was significantly (P<0.05) lowest (12.04g) in the highest temperature tested (i.e., 32.00°C), Weight Gain (WG) was significantly highest (16.39g) in the group of fishes cultured at the lowest temperature, i.e., 26.91°C (Control). However, both FBW and WG were not significantly (P>0.05) different between the groups of Heteroclarias fishes raised at 28.00 and 30.00°C. On the other hand, the pattern of distribution of Percentage Weight Gain (PWG) across the water temperature range differed distinctly from those of the other indices of growth performance evaluated. PWG was found to reduce significantly with increasing temperature (range = 4272.98% at 26.91°C to 3211.21% at 32.00°C). The Specific Growth Rate (SGR) of the fishes (range = 0.0311g at 32.00°C to 0.0371g at 26.91°C) did not differ significantly (p>0.05) among fishes cultured in the different water temperatures. Characteristically, Survival Rates (SR) (range = 54.60% at 30.00°C to 64.37% at 26.91^{O}C (i.e. Control), were significantly higher in the lowest two water temperatures tested than the higher ones.

Discussion

The results of the study showed that increasing water temperature had no significant influence on Total Length (TL) and Standard Length (SL) of Heteroclarias fingerlings. This observation was contrary to the findings of Schcherbina and Kazlauskene (1971) who reported that increase in temperature increased the activity of the digestive enzymes, which may accelerate the digestion of nutrients, inturn, resulting in better growth parameters. The high survivorship, as well as, good growth of the fishes at the tested temperatures in this study, may be attributed to the fact that such water temperatures, though significantly different, still fell within the range of 22.00 to 35.00°C tolerated for optimum growth by fishes in the Tropics (Howerton, 2001). However, varied water temperature may not be expected to influence fish lengths (whether total or standard) significantly, as these morphometric variables tend to be species-related and conditioned more by genetic influences than extraneous physico-chemical parameters of the water in which the fish lives. According to Turan (2004), phenotypic and genetic differences usually characterize fish populations, and the expression of morphometric attributes including the Total and Standard Lengths, have been found to be strongly influenced by fish species' genetics (Yakubu and Okunserbor, 2011).

On the other hand, temperature significantly affected the Body Weight (BW) of the fishes; a result that is consistent with those of similar studies on other fish species (Decroux et al., 2004; El-Sherif and El-Feky, 2009). These studies, respectively, reported temperature-dependent body weight performance in Tilapia fingerlings, and significantly better fish BW at 25.00°C than 30.00°C. On their parts, Saber et al. (2004) reported temperature range of 26.00 – 34.00°C as optimum for enhanced fish weight attainment. Fish BW probably responded significantly to differential temperature regimen in this study, and others earlier reported, because body weight attainment in animals is largely dependent on food intake and assimilation efficiency. Feeding efficiency is, in turn, regulated by enzymatic and metabolic mechanisms that are very sensitive to temperature.

The indices of weight gain namely, Final Body Weight (FBW), Weigth Gain (WG) and percentage Weight Gain (PWG), of the Heteroclarias fishes were all significantly highest and lowest when cultured at 26.91°C (i.e., Control) and 32.00°C, respectively. This finding contradicts that of El-Sherif and El-Fecky (2009), who observed significantly lower weight gain in

Tilapia fingerlings at lower than higher water temperatures. The disparity in responses of weight gain to increasing temperature may be due to differences in fish species investigated. However, the significantly lower weight gain recorded at higher temperatures in this study may be due to hyper-metabolic and physical fish activities elicited by higher temperature but which utilized nutrients that would have been otherwise assimilated.

Differential temperature levels did not affect fish mortality significantly. Much earlier, El-Sayed et al. (1996) and Howerton (2001), documented insignificant effects of varied water temperature on the survival of fishes. Fish mortality wouldn't have been significantly affected by the temperature levels to which the Heteroclarias fingerlings were exposed, as according to Howerton (2001), such temperatures fell within the optimum range for good fish growth and survival.

Table 1. Mean ± Standard Deviation of growth parameters of Heteroclarias fingerlings, cultured at different temperature levels, for a period of 12 weeks

Growth Parameters	Water Temperature (°C)			
	26.91	28.00	30.00	32.00
Total Length (cm)	$8.68 \pm 0.40^{a*}$	8.32 ± 0.25^{a}	8.44 ± 0.86^{a}	8.16 ± 0.28^{a}
Standard Length (cm)	7.63 ± 0.67^{a}	7.30 ± 0.23^{a}	7.48 ± 0.43^{a}	7.30 ± 0.34^{a}
Body Weight (g)	190.55 ± 31.50^{c}	165.65 ± 9.36^{b}	166.49 ± 17.50^{b}	154.37 ± 15.25^{a}

*Values followed by same superscript alphabets, in a row, are not significantly different at P = 0.05

Table 2. Growth Performance indices and cumulative Survival rates of Heteroclarias fingerlings exposed to different water temperature levels for 12 weeks

Indices of Growth Performance	Water Temperature (°C)			
	26.91	28.00	30.00	32.00
Initial Body Weight (g)	0.38^{a*}	0.38^{a}	0.38^{a}	0.38^{a}
Final Body Weight (g)	16.78^{b}	13.82^{ab}	13.74^{ab}	12.04^{a}
Weight Gain (g)	16.39^{c}	13.44^{b}	13.35^{b}	12.32^{a}
Specific Growth Rate (g)	0.0371^{a}	0.0363^{a}	0.0349^{a}	0.0311^{a}
Survival Rate (%)	64.37^{b}	63.50^{b}	54.60^{a}	59.50^{a}
Percentage weight gain (%)	4272.98^{d}	3503.13^{c}	3480.36^{b}	3211.21^{a}

*Values followed by same superscript alphabets, in a row, are not significantly different at P = 0.05

Conclusion

The results of this study have shed more light on the influence of temperature on survival and growth of Heteroclarias fingerlings. While, water temperature has no significant influence on the less important morphometric variables such, as Total Length and Standard Length, it however significantly reduced the weight gain indices (which are the critical determinants of profitability in artificial fishery), when increased above the ambient water temperature. Therefore, the findings of this study should aid the fine-tuning of field management protocols for optimum productivity of the relatively recent Heteroclarias species integration into artificial fish culture.

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