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GROWTH AND SURVIVAL PERFORMANCE OF MRIGAL *Cirrhinus mrigala* FINGERLINGS IN HIGH TEMPERATURE AT LABORATORY CONDITION

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Global warming is expected to affect the aquatic ecosystem and aquaculture industry. In the current experiment, we have observed growth and water quality of Indian major carp mrigal (*Cirrhinus mrigala*) exposed to three different temperature regimes, such as 30, 33 and 36°C representing T1, T2 and T3, respectively for 60 days. One hundred and twenty fish were used, kept in 6 Aquarium, and were exposed to the different temperature. Highest body weight gain and lowest feed conversion ratio (FCR) was recorded at T2. The highest specific growth rate was recorded at T2 followed by T1 and T3. The optimum temperature range for growth was 30 to 33°C. Survival at different acclimation temperatures was between 90.00±0.00, 90.0±0.00 and 75.00±0.00%, from lower to higher acclimation temperatures. Dissolved oxygen decreased and free CO_2 increased significantly ($P<0.05$) with increasing temperature, while pH and total alkalinity significantly showed no distinct changes in any temperature conditions. On the other hand, the ammonia levels significantly increased at day 7 in 36°C. Taken altogether, this study confirmed that mrigal feel better growth at 30°C and 33°C, while high temperature is stressful to Indian major carp mrigal.

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INTRODUCTION

Temperature is an important environmental factor that plays significant role in the growth and metabolism of fish. The increase of water temperature in the consequences of global warming is alarming for aquaculture. Increased temperature affects physiological processes causing a decrease in fish abundance and even the extinction of certain species (Ashaf-Ud-Doulah *et al*., 2019). It has been reported that the survival, distribution, reproduction and normal metabolism of fish depend on aquatic environmental temperature (Shahjahan *et al.,* 2013, 2017). Being coldblooded animal, fish is affected by the temperature of the surrounding water which influences the body temperature, growth rate, food consumption, feed conversion and other body functions (Britz *et al*., 1997; Azevedo *et al*., 1998). It is a bottom feeder and thrives on decaying organic matter and vegetable debris. The effects of temperature changes on fish species may be predict through physiological studies (Somero, 2010). Almost all biochemical and physiological activity is greatly affected by rising water temperature that causes stress and alteration of blood chemistry standards because of fish being aquatic poikilothermic animal. Chatterjee et al. (2004) stated that high temperature increases the chemical reactions in fish body and greatly affect the physiological process when exceed the level of tolerance.

The rise in environmental temperature reduce the dissolved oxygen content in the water which in turn increase the fish metabolism, and the fish adjust the adverse environmental condition by raising total hemoglobin level (Brix et al., 2004). Furthermore, it is an ideal species for carp polyculture system and can be stocked with other carps like catla (*Catla catla*) and rohu (*Labeo rohita*). The purpose of the present experiment was to assess growth, feed conversion efficiency in Mrigal (*Cirrhinus mrigala*) in different temperature regimes.

MATERIALS AND METHODS

Experimental Design

Healthy Mrigal, *Cirrhinus mrigala* fry were collected from Bangladesh Fisheries Research Institute (BFRI) freshwater station, Mymensingh and placement in tanks (1000L) at ambient temperature in the Eco-physiology laboratory, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh for 30 days to recover from transportation stress. The 180 uniform size fingerlings were equally distributed among three treatments (30˚C, 33˚C and 36˚C) each with three replications following a completely randomized design, with a stocking density of 20fry/100L water. Uniform rearing conditions were maintained in all the experimental groups except for the water temperatures at 30˚C, 33˚C and 36˚C.

Rearing for growth study

Fishes were reared in reinforced glass aquaria having 100 L of water for 15 days at 30 ± 0.5°C in a controlled environment before starting the experiment. The fishes having average weight of 15.14 ± 0.70 g, respectively. The temperature were gradually increased by 1˚C /day to 30˚C, 33˚C and 36˚C for 60 days. The target temperature was achieved with the thermostat (REI-SEA, 300 watts, Japan). The aquarium was provided with filtration cum aeration device (Sebo-aquarium internal filter WP-850F) for self-cleaning and aeration throughout the study period. Water quality parameters pH, dissolved oxygen, ammonia and total alkalinity of each aquarium were maintained and recorded.

Feed and feeding

The fishes were supplied with commercial diet twice in a day and fed up to satiation.

Growth

Growth rate of fish was measured in terms of percentage weight gain, specific growth rate (SGR), and feed conversion ratio (FCR) as given below:

Percentage weight gain = final weight - initial weight/ initial weight×100

Specific growth rate = Ln final body weight-Ln initial body weight/duration of experiment (days) × 100

Feed conversion ratio (FCR) = Feed given (dry weight)/Weight gain (wet weight)

Survival = Number of fish harvested/Number of fish stocked × 100

Water quality parameters

Water quality parameters such as dissolved oxygen (mg/L), free CO_2 (mg/L), pH, Ammonia (ppm) and total alkalinity (mg/L) were measured at every sampling day over the experimental period. Temperature, DO and pH were measured using a mercury thermometer, DO meter (Model DO5509, Lutron, made in Taiwan) and portable pH meter (Model number- RI 02895, HANNA Instruments Co.), respectively. The free CO_2 of water was determined by titrimetric method using phenolphthalein indicator and 0.0227N NaOH titrant. Total alkalinity of water was determined by titrimetric method using methyl orange indicator and 0.02N H_2SO_4 titrant. Ammonia was determined by ammonia test kit solution (HANNA Instruments Co.).

Statistical analysis

All the values were represented as mean ± standard deviation. To test the statistically significant difference among the different temperature conditions, one-way analysis of variance (ANOVA) was carried out followed by Tukey's post hoc test. Mann-Whitney U test with a Bonferroni correction was used to assess the significant difference among the days of exposure to different temperature treatments. We set statistical level of significance at $p < 0.05$. Statistical analyses ware carried out using Version 14.0 for Windows (SPSS Inc., Chicago, IL).

RESULTS

Water quality parameters

Water quality parameters (Dissolved oxygen, Free CO_2, pH, total alkalinity and ammonia) were measured during the study period at different temperatures. Dissolved oxygen varied from 5.4 ± 0.18 to 7.2 ± 0.21 mg/L. The highest dissolved oxygen value was 7.2 ± 0.21 mg/L in day 60 at 30°C and the lowest value was 5.4 ± 0.18 mg/L in day 30 at 36°C. Free carbon dioxide (CO_2) varied from 6.1 ± 0.08 to 11.0 ± 0.13 mg/L. The highest free CO_2 value was 11.0 ± 0.13 mg/L in day 30 at 36°C and the lowest value was 6.1 ± 0.08 mg/L in day 7 at 30°C. The values of free carbon dioxide (CO_2) and dissolved oxygen significantly increased at different treatments and days of exposure. pH ranged from 6.60 ± 0.18 to 8.73 ± 0.25 during the study period. The highest pH value was 8.73 ± 0.25 in days 15 in 30°C while the lowest pH value was 6.60 ± 0.18 in day 60 in 33°C. There was no change in value of pH at different treatments and days of exposure. Total alkalinity varied from 109.0 ± 9.8 to 132.0 ± 7.3 mg/L. The highest value was 132.0 ± 7.3 in day 60 in 36°C while the lowest value was 109.0 ± 9.8 in day 7 in 33°C. At day 7, total alkalinity significantly decreased in T_2 (33°C) and T_3 (36°C) while at day 7, 15 and 60 there was no change in total alkalinity. Ammonia varied from 0.25 ± 0.04 to 0.50 ± 0.02 mg/L. The highest ammonia value was 0.50 ± 0.02 in day 7 in 36°C while the lowest ammonia value was 0.25 ± 0.04 in several days and temperature. At day 7 and 30, ammonia levels (mg/L) significantly ($P<0.05$) increased in T_3 (36°C) while at day 15 and 60 ammonia levels showed no change.

Growth

Growth of *Cirrhinus mrigala* fry raised at different culture temperatures is presented in Table 2. Highest body weight gain (%) and SGR was found at acclimation temperature of 33ºC, followed by 30ºC with the lowest value obtained at 36ºC. FCR was significantly different at 33°C than 30 and 36°C. Fry survival at 30ºC and 33ºC was similar but was significantly lowered 36ºC temperatures and was not lethal to the mrigal fry at the experimental acclimation temperatures.

Table 1. Water quality parameters (Mean ± SD) during the study periods

Parameter	Treatments	Days of exposure			
		7	15	30	60
Dissolved oxygen (mg/L)	T1	7.0 ± 0.50	7.1± 0.29	6.3 ± 0.12	7.2 ± 0.21
	T2	6.5 ± 0.31	5.6± 0. 18	5.5 ± 0.49	5.7 ± 0.53
	T3	6.0 ± 0.18	5.6 ± 0.47	5.4 ± 0.18	5.6 ± 0.45
Free CO_2 (mg/L)	T1	6.1 ± 0.08	7.0± 0. 08	6.2 ± 0.09	7.0 ± 0.10
	T2	8.0 ± 0.10	8.0 ± 0.12	9.0 ± 0.09	9.0 ± 0.17
	T3	8.0 ± 0.02	9.0 ± 0.07	11.0 ± 0.13	10.0 ± 0.17
pH	T1	8.50 ± 0.18	8.73 ± 0.25	7.55 ± 0.17	7.35 ± 0.09
	T2	8.40 ± 0.04	8.56 ± 0.18	7.35 ± 0.11	6.60 ± 0.18
	T3	8.30 ± 0.50	8.49 ± 0.12	7.25 ± 0.09	7.00 ± 0.11
Total alkalinity (mg/L)	T1	122.0 ± 6.1	125.0 ± 7.8	115.0 ± 5.5	118.0 ± 6.2
	T2	109.0 ± 9.8	100.0 ± 7.1	130.0 ± 3.2	116.0 ± 7.6
	T3	120.0 ± 9.3	120.0 ± 7.1	128.0 ± 7.2	132.0 ± 7.3
Ammonia	T1	0.25 ± 0.04	0.25 ± 0.07	0.35 ± 0.03	0.35 ± 0.14
	T2	0.25 ± 0.07	0.30 ± 0.02	0.35 ± 0.06	0.30 ± 0.08
	T3	0.50 ± 0.02	0.30 ± 0.10	0.40 ± 0.02	0.30 ± 0.08

Table 2. Growth responses of *Cirrhinus mrigala* in different temperature treatments for 2 months

Growth Parameters	Treatments		
	T1	T2	T3
Initial BW (g)	15.15 ± 0.63^{a}	15.13 ± 0.70^{a}	15.16 ± 0.40^{a}
Final BW (g)	35.20± 1.90^{ab}	44.73 ± 3.10^{b}	31.36± 3.43^{a}
Weight gain (g)	20.05 ± 2.26^{ab}	29.60± 1.85^{b}	16.20 ± 3.48^{a}
% weight gain	132.34 ± 19.98^{a}	195.63 ± 12.32^{b}	106.86 ± 17.20^{a}
SGR (% / day)	0.33 ± 0.06^{ab}	0.49 ± 0.04^{b}	0.27 ± 0.05^{a}
FCR	1.7 ± 0.15^{ab}	1.5 ± 0.21^{b}	1.9 ± 0.23^{a}
Survival (%)	90.00 ± 0.00^{a}	90.00 ± 0.00^{a}	75.00 ± 0.00^{a}

Values with different alphabetical superscripts in a row differ significantly ($p < 0.05$) among different salinities. All values expressed as mean ± SD

DISCUSSION

In the present study, dissolved oxygen was significantly decreased while free CO_2 were increased after rising temperature. Temperature change is also directly correlated with dissolved oxygen concentration (Boyd and Tucker, 1998). The oxygen demand of the fish increases as temperature increases (Ravichandra, 2012). CO_2 can build up to significantly high levels in systems with large numbers of fish and relatively slow water turnover. pH is a measure of the relative amount of free hydrogen and hydroxyl ions in the water. pH was positively correlated with electrical conductance and total alkalinity. The influence of alkalinity and acidity upon fish has also received some consideration, especially in reference to their reactions. But in the present study, there were no significant change at pH and total alkalinity in high temperature among treatment. There are some reasons to believe that ammonium ion can contribute significantly to ammonia toxicity under some conditions. According to Das *et al.* (2005) and Brahmane *et al.* (2014), dissolved oxygen concentration decreased and pH increased significantly ($P<0.05$) with increasing water temperatures. Dissolved oxygen decreased and free CO2 increased significantly ($P < 0.05$) with increasing temperature, while the pH and total alkalinity of the water were almost unchanged (Shahjahan *et al.,* 2018; Islam *et al.,* 2019). The growth in the fry of mrigal was significantly higher at 33°C and 30°C when compared to treatment 36°C. Probable explanation of improved feed efficiency of fish maintained at higher temperature might be the increased feed intake of the fish with increase in water temperature, which resulted in better growth of the fish, leading to better feed conversion ratio. The preferred temperature is considered to coincide with the optimum temperature for growth (Brett, 1971; Kellog and Gift, 1983). An increase in temperature increases the activity of digestive enzyme, which may accelerate the digestion of the nutrients, thus resulting in better growth (Shcherbina and Kazlauskene, 1971). The best FCR was observed in the fish kept at 33°C temperature. These results are consistent with the findings of Andrews and Stickney (1972), who reported that channel catfish, *Ictalurus punctatus*, fingerlings reared at a temperature range of 18-34°C registered improvement in FCR, with the best values obtained at 30°C.

CONCLUSION

The findings of the research indicated that water temperature had a significant effect on the growth performance and water quality parameters of mrigal. We studied the effects of temperature, growth, feed conversion efficiency in mrigal. The results indicate that the best water temperature for the growth of mrigal is 33°C and fish showed good growth performance. Taken altogether, this study settled that high temperature is stressful to Indian major carp mrigal.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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