**Growth and survival performance of *Labeo rohita* fingerlings under temperature gradients**

**Abstract:**

Worldwide heating is expected to affect the aquatic environment and aquaculture industry. In the current experiment, we have observed growth and water quality of Indian major carp (labeo rohita) exposed to three different temperature regimes, 28°C, 30°C, and 32°C on the growth and development of *L. rohita* fingerlings housed in aquariums for 31 days were examined. The fish were given pelletized food continuously. Fish kept in water at 32°C grew significantly (P<0.05) more rapidly (SGR and FCR) than fish kept at other temperatures. This simple growth model produced a consistent growth (SGR 2.27%/day) between 28 and 32°C. At 30 to 32°C, the highest body weight increase and lowest feed conversion ratio (FCR) were observed 30 to 32°C was shown to have the highest specific growth rate. A temperature rise of around 28 °C is optimum, with 30 °C and 32 °C being the ideal range for manufacturing. Survival rate 100.00±0.00, 100.0±0.00 and 100.0±0.00. This further implies that suitable measures must be implemented to maintain the optimal temperature in aquaculture farms in order to avert the adverse consequences of climate change.

**Key words:**

**Aquaculture, Environmental temperature, *Labeo rohita*, survival, Growth,**

**I. Introduction:**

Temperature has a significant impact on the biological systems of all aquatic species and influences the growth and survival of organisms. When fish are exposed to less-than-ideal temperature fluctuations, their unique biological characteristics are altered, which negatively impacts their life cycles and aquaculture productivity. The freshwater Indian major carp (Labeo rohita) is a prominent aquaculture species on the Indian Subcontinent, with temperatures ranging from 28°C to 32°C. Climate change has been a global issue since the mid-1800s. Extreme weather events and sudden environmental changes are the result of climate change and are becoming more frequent in the future (Islam *et al*. 2020). Anthropogenic activities have accelerated major changes in climatic indices, such as temperature and precipitation rates, causing abrupt changes in the temperature and salinity of water bodies (Shahjahan *et al*., 2021; Yilmaz *et al*., 2021). The freshwater aquaculture industry will be particularly affected since the majority of freshwater species need consistent environmental conditions and high-quality water (Phuc *et al*., 2017; Ninawe *et al*., 2018; Rahman *et al*., 2022). Temperatures between 25 and 30 °C are ideal for the development of most freshwater fish. Hossain *et al*.. (2015) claim that higher temperatures raise metabolic activity and rate, which in turn raises food intake. The reverse is true in the winter, though, when it's colder. Wintertime low temperatures affect fish behavior, resulting in stressful conditions and decreased production (Alfonso *et al*., 2021). When the temperature of the open ocean rises, wild fish can migrate to higher latitudes in a way that is unique to their species, according to several studies (Fogarty *et al*., 2017; Kleisner *et al*., 2017; Alabia *et al.*, 2018). Knowing *L. rohita's* different temperature tolerance and growth performance in connection to different acclimation temperatures would be essential to determining the extent of stress reaction in a developing aquaculture environment.

**II. Materials and Method**

**2.1 Fish Sample collection:**

Freshwater fish *Labeo rohita* weighing 4.10-4.20 g were collected from the Surya fish farm in Kallidaikuruchi, Tirunelveli. The fishes were then transported to the laboratory in polythene bags containing oxygenated ten-liter water with the least disturbance temperature. Then, they were acclimatized to the ambient laboratory room temperature (27°C) in the FRD tank. An automated thermostat (REI-SEA, 300 watts, Japan) was set in each tank to maintain 27 ◦C (as the control temperature) for acclimating the experimental fish to the tank setting for 7 days before the experimentation commenced.

**2.2 Experimental setup:**

The fish had an average weight of 4.14 ± 0.02 g, respectively. The temperatures were gradually increased by 2°C /day to 28°C, 30°C, and 32°C for 31 days. The target temperature was achieved with the thermostat (REI-SEA, 300 watts, Japan). temperature was raised by 2 ◦C per day (temperature was increased by 1 ◦C at every 12 h interval to achieve the target temperature levels (Three different treatments). To achieve the target temperature treatments, it took 24 h for 28 ◦C, 48 h for 30 ◦C, and 60 h for 32 ◦C. The temperature was raised 2 days before 30 ◦C and 1 day before 32 ◦C to achieve the target temperatures simultaneously. After reaching each temperature threshold, the experiment was carried out for 31 days. 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, and ammonia of each aquarium were maintained and recorded. To maintain clean water, the fish were stored in carefully monitored laboratory tanks equipped with filtration and aeration systems.

**2.3 Experimental diet:**

The experimental pellet diet was prepared following the standard method. The conventional feed ingredients such as fish meal, groundnut oil cake, soya meal, rice bran, wheat bran, fish oil, vitamin, and mineral mix were used in the diet. The proximate composition of the experimental feed was recorded as protein (37.85%), carbohydrate (17.84%), fat (10.62%), and moisture content (8.45%). The experimental feed was offered to the fishes twice daily to satiation (Morning 7.00 am and Evening 5.00 pm). The unfed remains were collected daily and measured

**Table 1: Analysis of water quality parameters in the experimental group at different temperatures of *labeo rohita***

|  |  |  |  |
| --- | --- | --- | --- |
| Water quality parameter | Temperature treatment | | |
| 28°C | 30°C | 32°C |
| pH | 7.96±0.15 | 7.96±0.05 | 7.83±0.20 |
| Dissolved oxygen(*mg/l*) | 5.71±0.28 | 5.81±0.32 | 5.99±0.28 |
| Ammonia(*mg/l*) | 0.25±0.01 | 0.27±0.01 | 0.28±0.01 |

Note: Each value is the Mean ±SD

**(Table 2): Effect of different temperature levels on growth parameters (mean± SD) of Rohu (*Labeo rohita*)**

|  |  |  |  |
| --- | --- | --- | --- |
| Growth parameter | 28 ◦C | 30 ◦C | 32 ◦C |
| Initial Weight*(g)* | 4.14±0.02 | 4.23±0.01 | 4.27±0.01 |
| Final weight *(g)* | 6.51±0.03 | 7.12±0.04 | 7.34±0.01 |
| Weight gain *(g)* | 2.37±0.04 | 2.89±0.04 | 3.07±0.02 |
| % Wight gain | 57.32±1.14 | 68.28±0.93 | 71.82±0.85 |
| (SGR) *(% /day)* | 2.09±0.008 | 2.21±0.009 | 2.25±0.005 |
| (FCR) | 1.46±0.01 | 1.43±0.06 | 1.41±0.01 |
| Survival *(%)* | 100.0±0.00 | 100.0±0.0 | 100.0±0.0 |

Note: Each value is the Mean ±SD

**3. Result and Discussion:**

**3.1 Water quality parameter**

Average water quality parameter register in the culture systems are given in Table 1. The data indicated the existence of variation between culture systems expect pH showed (7.73±0.20,7.83 ±0.20 and 7.96±0.15). Dissolved Oxygen shows very little variation (5.71 ± 0.28 to 5.99± 0.28 mg/L). The total ammonia content was exposed to three different temperature regimes, 28°C, 30°C, and 32°C, which is favorable for fish development. It was reported that a temperature range of 28 to 32°C is favorable for fish development (Jhingran,1968). The temperature recorded in the present experiment falls within the optimal range of temperature that supports the growth response and other vital physiological activities of the cultivable fishes (Boyd and Tucker). Also, the pH value recorded was at a neutral level (7.73 to 7.96), which is conducive for cultivable organisms. In the aquatic environment, ammonia irons play a major role, and it will adversely affect the fishes when it exceeds the optimal level. In the present study, the ammonia level was high in the 32°C culture system (0.28±0.01*mg/L*), and this raise may be attributed to the raise in temperature and related metabolic activities. However, the range of ammonia ions registered in this study falls within safe levels. Das *et al*., (2005) reported that a rais in temperature led to a rise in pH and a fall in dissolved oxygen in the culture system. In this study, the pH and dissolved oxygen recorded have not deviated much, and it may be due to the low range of variation in temperature between culture systems. Also, this minimal variation is enough to bring out the change in ammonia (Islam et al.,2019; Shahjahan *et al*.,2018)

3.2 Growth performance

While growth rates differed little among the grouped fish at 28°C, 30°Cand 32°C, the current study indicated that they considerably increased. However, the optimal temperature for *Labeo rohita* growth is reported to be between 31°C and 33 °C by Das et al. (2005). Fish grow in response to temperature; they usually rise until they achieve a perfect temperature, at which point they fall once more. Temperature has a major effect on the specific growth rates of *L. rohita* fingerlings. During each temperature, the growth rates of the fish in our study varied, ranging from 2.09 to 2.25% body weight daily, showing that the range of temperatures between 30 and 32 °C is optimal for the growth of *L. rohita*. Fish typically reach their ideal temperature when they increase, piercing it before sinking again (Myrick and Cech,2000). The percentage of weight gain, SGR, and feed intake of *L. rohita* grown at 30–32 °C were significantly reduced in the water (Table 2). In a similar vein, slower growth and reduced feed intake were associated with water temperatures above or below the thermal limits (25–32 °C) (Stickney, 1994). In contrast, the more the metabolic rate rises over the optimal range, the less space there is for development. Fish eat feed at a rate that is only required for their physical maintenance (Stickney, 1994). Therefore, as compared to fish grown in water that was 34°C, fish raised at ambient temperatures of 29°C and 31°C showed better growth performance. Furthermore, (Phuc, 2017) a rise in temperature increases the activity of intestinal enzymes, which may accelerate the absorption of nutrients, resulting in improved growth (Shcherbina and Kazlauskene, 1971). This resulted in increases in growth and FCR. However, this study found that temperatures as high as 28 to 30 °C increased FCR; these may not yet be indicative of stress conditions in rohu farming, except for a slower rate of development. In culture systems, however, warmer water is advantageous for fish species in their early life stages. Desired outcomes were obtained within the ideal temperature range of 28–32 °C.

**IV. Conclusion:**

The results of the study demonstrated that the growth performance and survival were impacted by the water temperature. We looked at how *L. rohita* was affected by temperature, growth, and feed conversion efficiency. The results showed that 30°C was the ideal water temperature for *L. rohita* growth; nonetheless, fish grew well at 32°C.

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1.

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**5. References**

Alabia, I.D., Molinos, J.G., Saitoh, S.I., Hirawake, T., Hirata, T., Mueter, F.J., 2018. Distribution shifts of marine taxa in the Pacific Arctic under contemporary climate changes. *Diversity and Distributions*, 24, 1583–1597.

Alfonso, S., Gesto, M., Sadoul, B., 2021. Temperature increases and its effects on fish stress physiology in the context of global warming. *Journal of Fish Biology*, 98 (6), 1496–1508. <https://doi.org/10.1111/jfb.14599>.

Boyd CE, Tucker CS. Water quality and pond soil analyses for aquaculture, Agricultural Experiment Station, Alabama; 1992.

Das T, Pal AK, Chakraborty SK, Manush SM, Ahu NP, Mukherje SC, 2005. Thermal Tolerance, Growth and Oxygen Consumption of Labeo rohita Fry (Hamilton, 1822) Acclimated to Four Temperatures. *Journal of Thermal Biology*, 30: 378-383.

Fogarty, H.E., Burrows, M.T., Pecl, G.T., Robinson, L.M., Poloczanska, E.S., 2017. Are fish outside their usual ranges early indicators of climate-driven range shifts? *Global Change Biology*, 23, 2047–2057.

Hossain, Md.I., Khatun, M., Kamal, B.M.M., Habib, K.A., Tumpa, A.S., Subba, B.R., Hossain, Md.Y., 2015. Effects of seasonal variation on growth performance of mirror carp (*Cyprinus carpio Ver. Specularis*) in earthen nursery ponds. *Our Nature* 12, 8–18. <https://doi.org/10.3126/on.v12i1.12252>.

Islam MA, Uddin MH, Uddin MJ, Shahjahan M. Temperature changes influenced the growth performance and physiological functions of Thai pangas Pangasianodon hypophthalmus. Aquaculture Reports. 2019;13: 100179. Available:https://doi.org/10.1016/j.aqrep.2019. 100179

Islam, M.J., Slater, M.J., Bogner, M., Zeytin, S., Kunzmann, A., 2020. Extreme ambient temperature effects in European seabass, *Dicentrarchus labrax*: Growth performance and hemato-biochemical parameters. *Aquaculture* 522, 735093.

Jhingran VG. Synopsis of biological data on Catla, Catla catla (Ham. 1822). *FAO Fish*. Synopsis, 1968; 32: Rev. 1: Pag. Var.

Kleisner, K.M., Fogarty, M.J., McGee, S., Hare, J.A., Moret, S., Perretti, C.T., Saba, V.S., 2017. Marine species distribution shifts on the U.S. northeast continental shelf under continued ocean warming. *Progress in Oceanography*, 153, 24–36.

Myrick CA, Cech JJ., 2000. Temperature influences on California rainbow trout physiological performance. *Fish Physiology and Biochemistry* 22: 245-254.

Ninawe, A.S., Indulkar, S.T., Amin, A., 2018. Impact of climate change on fisheries. In Biotechnology for Sustainable Agriculture. *Woodhead Publishing,* pp. 257–280.

Phuc, N.T.H., Mather, P.B., Hurwood, D.A., 2017. Effects of sublethal salinity and temperature levels and their interaction on growth performance and hematological and hormonal levels in tra catfish (Pangasianodon hypophthalmus). *AQUAINT*, 25, 1057–1071.

Rahman, M.M., Salin, K.R., Tsusaka, T.W., Anal, A.K., Rahi, M.L., Yakupitiyage, A., 2022. Effect of stocking density on growth performance and gonadal maturity of all-female giant freshwater prawn, *Macrobrachium rosenbergii*. Journal of the World Aquaculture Society, doi: org/ 10.1111/jwas.12888.

Shahjahan M, Uddin MH, Bain V, Haque MM. Increased water temperature altered hemato-biochemical parameters and structure of peripheral erythrocytes in striped catfish Pangasianodon hypophthalmus. Fish Physiology and Biochemistry. 2018;44: 1309-1318. Available:https ://doi.org/10.1007/s10695 018-0522-0 22.

Shahjahan, M., Zahangir, M.M., Islam, S.M.M., Ashaf-Ud-Doula, M., Ando, H., 2021. Higher acclimation temperature affects growth of rohu (*Labeo rohita*) through the suppression of GH and IGFs genes expression actuating stress response. *The Journal of Theoretical Biology,* 100, 103032.

Shcherbina MA, Kazlauskene OP, 1971. Water Temperature and Digestibility of Nutrient Substances by Carp. *Hydrobiologia,* 9: 40-44

Stickney, R. R. 1994. *Principles of aquaculture*. New York, NY: John Wiley and Sons

Yilmaz, S., Ergun, S., Celik, E.S., Banni, M., Ahmadifar, E., Dawood, M.A.O., 2021. The impact of acute cold-water stress on blood parameters, mortality rate and stress-related genes in *Oreochromis niloticus*, *Oreochromis mossambicus* and their hybrids. *The Journal of Theoretical Biology*, 100, 103049.