



## Impact of temperature on the growth performance of freshwater fishes, *Labeo rohita* and *Oreochromis niloticus*

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### Abstract

Global warming is a universal issue and it attain a great attention in the aquatic ecosystem and aquaculture suntist. The present study investigates the impact of temperature on the growth and development of two freshwater fishes *Labeo rohita* and *Oreochromis niloticus* exposed with three different temperature regimes viz., 30, 33 and 36°C. During the experimental period highest feed conversion ratio (FCR) and highest specific growth rate was recorded at 33°C. Highest survival rate of *L.rohita* & *Oreochromis niloticus* was (90.00±00) observed at 30°C and 33°C whereas the lowest survival rate (70.00±00) was recorded as *Labeo rohita* and *Oreochromis niloticus*. Highest percentage of Dissolved Oxygen (DO) recorded in 6.37±0.16 mg/ L on 10<sup>th</sup> and 30<sup>th</sup> days after treatment at 30°C but no significant variation of pH level among all the experimental temperature. Altogether, this study confirmed that both fresh water fishes have attained an optimum growth at 33°C, whereas high survival risk for *L.rohita* and *O.niloticus* were recorded at 36°C.

**Keywords:** Climate change, growth response, *Labio rohita*, *Oreochromis niloticus*

### Introduction

Temperature is vital environmental component that has play a great impact on fish development and metabolism. major factor affecting aquaculture global warming is a reduce the fish growth develop metabolism and production. With the physiological effects of rising temperatures, fish populations deteriorate and some species could become extinction. (Ashaf-Ud-Doulah *et al.*, 2019) [4]. Optimal fish production requires an understanding of the local environmental factors and how managing tactics may be combined with them to enhance fish harvest. Furthermore, one of the primary environmental factors influencing fish growth and metabolism is temperature. Aquaculture is concerned about the rising water temperatures brought on by global warming (Sathiamoorthi and Palavesam, 2024) [41].

Fish are cold-blooded animals; thus, the temperature of the water they live in affects their body temperature, growth rate, ability to consume food, ability to convert feed, and other physiological functions (Britz *et al.*, 1997; Azevedo *et al.*, 1998) [8,5]. Somero (2010) [48] observed the physiological changes of fish by exposing the experimental fish changes of fish by at various temperature. Climate change's effects on biodiversity loss are well-established (Cochrane *et al.*, 2009) [13]. It is crucial to find species that are climate-resilient, even while their significance to aquaculture is not immediately clear (Shapawi *et al.*, 2018) [46]. As are the creases in temperature on account of their evolution in a relatively stable thermal environment (Munday *et al.*, 2012) [33]. Changes in temperature can alter the physiological state of fishes associated with digestion, health, and, ultimately and growth performance (Bendiksen *et al.*, 2002; Shapawi *et al.*, 2018) [6,46]. Any alteration to the environment that goes beyond what ectothermic organisms, particularly tropical species, can withstand might have detrimental effects on their physiological and biochemical functions (Fu *et al.*, 2018) [23]. Research suggests that compared to sub-tropical or temperate marine species, tropical marine species are more susceptible to changes in water temperature and ph.

Tropical species generally live-in environmental temperatures at their upper tolerance limit; thus, changes in temperature beyond this limit could severely impact their growth and development (Deutsch *et al.*, 2008; Ehrl'en and Morris, 2015; Sunday *et al.*, 2012) [19,21,49]. Temperature is the major driving factor of the growth and survival of aquatic organisms as it directly affects their immunity, metabolic rate and the capacity to absorb oxygen in addition to raising oxygen consumption and causing metabolic changes, changes in the ambient temperature above the organism's thermal threshold will also lower feed intake (FI) and impair immunity. (Dawood *et al.*,2021) [17]. This is due to increasing water temperatures affect the solubility and availability of oxygen which negatively affects aerobic metabolism (Cheng *et al.*, 2017; Cook *et al.*1998; Martins *et al.*,2011; Roth *et al.*2010; Sepp'al' and Jokela, 2011; Sun *et al.*, 2019;) [12,14,35,39,42,50]. The Iberian Peninsula's air temperatures are predicted to range from 4 to 7 °C by 2100, making southern Europe one of the regions with the most severe global warming, according to the Intergovernmental Panel on Climate Change report (IPCC 2001) [27] (Madeira, Vinagre *et al.*, 2016) [34]. More specifically, climate change models have predicted an increase in tropical water temperatures reaching 3 °C for the coming century (Campos *et al.*,2019; Ganachaud *et al.*, 2011)[11,25], 3–4 °C in the Mediterranean (Fischer & Sch'ar, 2010; Madeira *et al.*, 2016)[22,34], and 2–3 °C in the Portuguese waters (Madeira *et al.*, 2016)[34].The study of fish physiology, behaviour, and the impact of modifications to the environment on it, aquaculture production must be increased in order to meet the always increasing demand for fish Although they can tolerate a wide variety of temperatures, fish have a preferred range for growth. Most freshwater fishes thrive at temperatures between 25 and 30 degrees Celsius. Higher temperatures raise metabolic activity and rate, which leads to higher food intake (Hossain *et al.*, 2015) [26]. In winter, the opposite is true at lower temperatures. Periods of low temperatures prevailing during winter affect fish behaviour,

resulting in stressful conditions and reduced production (Ali *et al.*, 2021) [1]. Since fish cannot regulate their internal body temperature, they have a body temperature that is constant with their environment. This indicates that fish are ectothermic. One of the most important environmental elements influencing fish physiology and energetics is water temperature (Gallant *et al.*, 2017; Qiang *et al.*, 2017; Nivellet *et al.*, 2019; Lee *et al.*, 2021) [24,37,36,31]. Fish adapt to changes in water temperature by controlling the rate of metabolic activities, and the fish must maintain their biological activity within tolerable thermal limits. Temperatures above tolerance thresholds can lead to changes in growth rate (Hossain *et al.*, 2020) [26]. For fingerlings of Nile tilapia, a thermal optimum of 25–30 °C has been reported, while juveniles it was 27–32°C (Leonard and Skov, 2022) [32]. 26 °C was reported to be the optimal temperature for the growth of Nile tilapia. (Dela Cruz *et al.*, 2020) [19] investigated how the Nile tilapia's physiological features, particularly colour of the body score and respiration rate, change when the ambient temperature increases. The specifics of this significant species' adaptation responses still require a great deal of research, especially the changes in growth response that come with high temperature tolerance. Assessing the high temperature tolerance and growth performance of *L. rohita* and *Oreochromis niloticus* with regard to different acclimation temperatures will prove crucial in order to determine the intensity of stress response in a changing aquaculture environment.

## Materials and Methods

### Experimental Site

Fresh water fish *Labeo rohita* weighing 3.50 to 4.15 g and were (*Oreochromis niloticus*) weighing  $3.35 \pm 4.25$ g procured from t Suriya Fish Farm, Kallidaikuruchi, Tirunelveli. The fish were transported to the lab in oxygenated polythene bags with optimum-temperature, oxygenated water with least disturbance. Then they were acclimatized to the ambient laboratory room temperature range ( $28^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ) in 200l capacity of FRP tanks. During the study period of acclimatization, which was lasted for two weeks, fed with lab prepared pellet diets and 30% dank water exchange daily made to maintain the optimal water quality.

### Experimental Diet and Feeding

The fish were acclimatized separately for two weeks prior to the experiment in the fibre glass reinforced plastic tanks (FRP) of 200 L capacity. The experimental fishes were fed with lab prepared pellet diets. The diet was prepared by using the conventional feed ingredients such as fish meal, groundnut oil cake, soya meal, rice bran, wheat bran, fish oil, vitamin and mineral mix. By the method of biochemical composition of the experimental feed was analysed as protein (37.85%), carbohydrate (17.84%), fat (10.62%) and moisture content (8.45%).

### Experimental Design

The temperature 30°C, 33°C and 36°C) was maintained and measured by the digital thermostats keep in water tank till the completion of experiment. Totally, 20 numbers of fingerlings were acclimation rearing a FRD tank capacity of 200 L. temperature regimes 30°C, 33°C, and 36°C three replicates were maintained in each experimental category. (30°C, 33°C and 36°C) with the variation of 3°C in each group, until the completion of experiment. Digital Thermostat (BO7KSGRLYF), 200 W, china) with digital displayer temperature recorder was used to increase the temperature and carefully monitored throughout the process. Moreover, the temperature was measured for cross-check using a Celsius thermometer. The water parameters were examined on the initial day of the experimentation and on every alternate day interval till the completion experimental. During experiment, fluctuation in water quality parameters (Temperature, DO, pH and Ammonia) were monitored and recorded following the method of APHA (1980)[3]. The water exchange level was done at the rate of 30% per day. During the experiment, period the following growth parameter were recorded such as Initial weight, Final weight, Weight gain, FCR, SGR and percentage of survival.

### Growth Parameter of *L.rohita*

The following formulas were used to get the feed intake (FI), feed conversion ratio (FCR) weight gain (WG), and specific growth rate (SGR). (In Final Body Weight - In Initial Body Weight)  $\times 100$ / Expressing duration is SGR(%). The formula for WG (%) is [(Final body weight - Initial body weight)/ Initial body weight]. The survival percentage (No. of fish survived post experimental period/Initial no. of fishes stocked  $\times 100$ ), of *Labeo rohita* and *oreochromis niloticus* was measured post experimentation period.

**Table 1:** Analyse of water quality parameters in the experimental fish of group rearing at different temperature of *L.rohita*

Water parameter	Temperature	Days of exposure		
		10	20	30
Dissolved oxygen(mg/l)	30°C	4.28±0.28	4.85±0.49	4.37±0.16
	33°C	4.66±0.43	5.23±0.16	4.66±0.16
	36°C	5.14±0.28	5.33±0.16	4.95±0.16
ph	30°C	7.93±0.15	7.83±0.15	7.93±0.05
	33°C	7.83±0.11	7.86±0.05	8.06±0.05
	36°C	8.03±0.20	8.06±0.05	7.86±0.01
Ammonia(mg/l)	30°C	0.248±0.002	0.282±0.002	0.293±0.003
	33°C	0.259±0.002	0.286±0.002	0.302±0.004
	36°C	0.262±0.004	0.288±0.002	0.302±0.004

**Note:** Each value is the Mean  $\pm$  SD

**Table 2:** Analyse of water quality parameters in the experimental group at rearing different temperature of *Oreochromis niloticus*

Water parameter	Temperature	Days of exposure		
		10	20	30
Dissolved oxygen(mg/l)	30°C	6.37±0.16	6.18±0.16	5.99±0.28
	33°C	6.28±0.28	6.09±0.16	5.90±0.16
	36°C	5.90±0.16	5.80±0.16	5.33±0.16
ph	30°C	8.13±0.11	8.26±0.05	8.46±0.05
	33°C	8.53±0.05	8.43±0.05	8.46±0.05
	36°C	8.43±0.05	8.56±0.05	8.76±0.05
Ammonia(mg/l)	30°C	0.342±0.002	0.343±0.002	0.347±0.001
	33°C	0.350±0.001	0.357±0.002	0.358±0.001
	36°C	0.349±0.004	0.357±0.001	0.364±0.002

Note: Each value is the Mean ± SD

**Table 3:** Growth response of *Labeo rohita* in different temperature treatments for one month

Growth parameter	30 °C	33°C	36°C
Initial weight(g)	4.27±0.01	4.30±0.02	4.21±0.04
Final weight(g)	6.34±0.04	7.11±0.05	6.68±0.04
Weight gain(g)	2.40±0.04	2.80±0.07	21.11±0.75
% Weight gain(g)	56.20±1.08	65.04±1.95	50.56±1.95
Feed intake dry weight(g)	1.54±0.02	1.49±0.01	1.63±0.01
(SGR) (%)	1.47±0.02	1.65±0.03	1.36±0.04
(FCR)	1.25±0.01	1.30±0.06	1.47±0.07
Survival (%)	90.00±00	90.00±00	70.00±00

Note: Each value is the Mean ± SD

**Table 4:** Growth response of *Oreochromis niloticus* in different temperature treatments for one month

Growth parameter	30 °C	33°C	36°C
Initial Weight(g)	4.27±0.01	4.33±0.01	4.42±0.02
Final weight(g)	7.34±0.01	7.90±0.03	7.0±0.11
Weight gain (g)	3.07±0.02	3.56±0.04	2.58±0.11
% Weight gain	71.82±0.85	82.27±1.22	58.31±2.80
Feed intake dry weight(g)	1.62±0.01	1.53±0.009	1.84±0.01
(SGR) (%) /	2.25±0.005	2.35±0.007	2.17±0.02
(FCR)	1.41±0.01	1.39±0.01	1.73±0.03
Survival (%)	90.00±00	90.00±00	80.00±00

Note: Each value is the Mean ± SD

## Results

### Water quality parameter *L.rohita* and *Oreochromis niloticus*

The impact of temperature fluctuation on the growth response of *labeo rohita* and *oreochromis niloticus* were presented in (Table 1 & Table 2), respectively. During the study significant growth was observed in Table (1) *labeo rohita* gained maximum average value of dissolved oxygen varied from  $4.28 \pm 0.28$  to  $5.99 \pm 0.28$  mg/L. The highest dissolved oxygen value was  $5.99 \pm 0.28$  mg/L in day 30 at 36°C and the lowest value was  $4.28 \pm 0.28$  mg/L in day 30 at 30°C. pH ranged from  $7.93 \pm 0.15$  to  $8.46 \pm 0.05$  during the study period. The highest pH value was  $8.46 \pm 0.05$  in days 30 in 36°C while the lowest pH value was  $7.93 \pm 0.15$  in day 30 in 33°C. There was no change in value of pH at different treatments and days of exposure. Ammonia varied from  $0.248 \pm 0.002$  to  $0.3021 \pm 0.004$  mg/L. The highest ammonia value was  $0.302 \pm 0.004$  in day 30 in 36°C while the lowest ammonia value was  $0.248 \pm 0.002$  in several days and temperature. At day 10 and 30, ammonia levels (mg/L) significantly ( $P < 0.05$ ) increased in (36°C) while at day 20 and 30 ammonia levels showed change. Table (2) *oreochromis niloticus* gained maximum increase dissolved oxygen varied from  $5.33 \pm 0.16$  to  $6.37 \pm 0.16$  mg/L. The highest dissolved oxygen value was  $6.37 \pm 0.16$  mg/L in day 30 at 36°C and the lowest value was  $5.33 \pm 0.16$  mg/L in day 30 at 30°C. pH ranged from  $7.73 \pm 0.05$  to  $8.56 \pm 0.05$  during the study period. The highest pH value was  $8.73 \pm 0.05$  in days 30 in 36°C while the lowest pH value was

$5.33 \pm 0.16$  in day 30 in 33°C. There was no change in value of pH at different treatments and days of exposure. Ammonia varied from  $0.342 \pm 0.002$  to  $0.364 \pm 0.002$  mg/L. The highest ammonia value was  $0.364 \pm 0.002$  in day 30 in 36°C while the lowest ammonia value was  $0.342 \pm 0.002$  in several days and temperature. At day 10 and 30, ammonia levels (mg/L) significantly ( $P < 0.05$ ) increased in (36°C) while at day 20 and 30 ammonia levels showed change.

### Specific growth rate and feed conservation of *L.rohita* in relation to temperatures

Growth of *labeo rohita* raised at different culture temperatures is presented in (SGR) specific growth rate ( $1.65 \pm 0.03$  g) water temperature of 33°C. This was followed by ( $1.47 \pm 0.02$ ) and ( $1.36 \pm 0.04$ ) SGR water temperature of 30°C and 36°C, respectively (Table.3) The fish reared in 33°C water temperature showed the superlative (FCR) feed conversion ratio ( $1.25 \pm 0.01$ ), followed by those maintained at 30°C ( $1.30 \pm 0.06$ ), 36°C ( $1.47 \pm 0.07$ ), respectively (Table 3). Survival at 30°C ( $90.00 \pm 00$ ) and 33°C ( $90.00 \pm 00$ ) was similar but was significantly lowered 36°C ( $70.00 \pm 00$ ) temperatures and was not lethal to the fishes at the experimental acclimation temperatures.

### Specific growth rate and feed conservation of *Oreochromis niloticus* in relation to temperatures

Growth of *Oreochromis niloticus* increased at different culture temperatures were presented in (Table 4) (SGR) specific growth rate ( $2.35 \pm 0.007$  g) water temperature of

33°C. This was followed by (2.25±0.005) and (2.17±0.02g) SGR water temperature of 30°C and 36°C, respectively (Table.4). The fish reared in 33°C water temperature showed the superlative (FCR) feed conversion ratio (1.39±0.01), followed by those maintained at 30°C (1.41±0.01), 36°C (1.73±0.03), respectively (Table 4). Survival rate at 30°C (90.00±00), 33°C (90.00±00) and 36°C (80.00±00) temperatures and was not lethal to the fishes at the experimental acclimation temperatures.

## Discussion

The optimum temperature for development and survival varies for each species of fish. It has been shown that fish have physiological and biochemical changes in response to temperature variations, which increase their energy for embryological development. The aquatic environment temperature plays a unital to of determines their development and survival rate. In the present study fingerlings of *Labeo rohita* and *Oreochromis niloticus* were selected and treated with varied temperatures ranging from 30°C to 36°C in which 100% survivality were observed in all temperature regime. In the present study, *Labeo rohita* attained significantly higher growth rate at rearing temperature at 33 °C followed by at 30°C respectively. The lowest growth was observed temperature of 36°C. At temperature of 35°C, no significant difference was observed in the specific growth rate of *Labeo rohita*, as compared to 28°C. Das *et al.*, (2005)<sup>[15]</sup> Reported significant increase growth rate of *L. rohita* when reared at 32 °C to 34°C delayed development growth was observed at 35 °. Moreover then fingerlings of *L.rohita* is restricted under (36 °C) reported by (Shahjahan *et al.*,2018 :Ashaf-Ud-Douhah *et al.*, 2019)<sup>[44,4]</sup>. findings imply that a high acclimation temperature can inhibit this species' capacity for thermal tolerance. Compared to previous findings, this study shows a temperature limit that might be outside of the ideal range because early fry of *L. rohita* showed higher levels of plasma cortisol, a stress indicator, at the higher acclimated temperature (36 °C) (Das *et al.*, 2009) <sup>[16]</sup>. The development of growth stripped catfish was converted (or) delayed responses of growth noticed when the fish exposed with high temperature was reported by (36 °C) in the striped catfish (Islam *et al.*, 2019) <sup>[29]</sup>. In the present study, when the ambient temperature was increased from 24 to 34 °C, it was found that the body temperature of the Nile tilapia in the range from 24 to 34 °C increased every 2 °C and to a maximum at 34 °C. From the results of this study, it was found that *Nile tilapia* body temperature also had the same level as the ambient water temperature. Physiological responses due to stress are important in the maintenance of homeostatic conditions for the well-being of fish. A positive correlation between and skin colour development was observed in Nile tilapia, and Dela Cruz (2020) <sup>[18]</sup> Moreover, environmental stressors, such as water quality issues, handling stress, or competition, can indeed lead to weight loss in fish without negatively impacting survival rates. These stressors can affect fish health and behaviour, potentially causing reduced feeding, increased energy expenditure, or physiological changes that result in weight loss ph. is a measure of the relative amount of free hydrogen and hydroxyl ions in the water; however, in the current study, there were no significant changes in ph or total alkalinity in high temperature among treatment. There are some reasons to believe that ammonium ions can contribute

significantly to ammonia toxicity under certain conditions. Temperature change is also directly correlated with dissolved oxygen concentration (Boyd and Tucker, 1998) <sup>[10]</sup>. The oxygen demand of the fish increases as temperature increases (Ravichandra, 2012). According to (Das *et al.* 2005) <sup>[15]</sup> and (Brahmane *et al.* 2014) <sup>[7]</sup>, dissolved oxygen concentration decreased and pH increased significantly (P<0.05) with increasing water temperatures., while the pH and total alkalinity of the water were almost unchanged (Shahjahan *et al.*, 2018; Islam *et al.*, 2019) <sup>[29,45]</sup>. When compared to treatment 36°C, the *L. rohu* grew noticeably more at 33°C and 30°C. A likely reason for the higher feed efficiency of fish kept at higher temperatures is that the fish's increased feed intake as the water temperature rose led to better growth and a higher feed conversion ratio. It is believed that the ideal temperature for growth and the preferred temperature is the same (Brett, 1971; Kellog and Gift, 1983) <sup>[9,30]</sup>. Higher temperatures cause digestive enzymes to become more active, which could speed up nutrient digestion and improve growth (Shcherbina and Kazlauskene, 1971) <sup>[47]</sup>. 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) <sup>[2]</sup>, 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 33°C.

## Conclusion

The results indicate that the suitable temperature for the growing of *Oreochromis niloticus* and *Labeo rohita* is 33°C and fish showed better growth performance. Taken altogether, this study settled that high temperature is stressful to *Oreochromis niloticus* and *L.rohu*. In this study, both fishes were comparatively reared with uniform density. The main variable differentiates these two fresh water fishes was variation in culture temperature. In these adopted culture systems, the temperature showed much variation and which in turn altered both the growth responses and in the experimental fish. The better feed conservation and growth responses recorded in *L. rohita* culture system may be attributed to the variation in culture temperature.

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