EFFECT OF TEMPERATURE ON FRESHWATER

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ABSTRACT
This study has proposed to determine the effects of water temperature in between 28 and 34 ºC on the growth of cultivable fish Common carp, Cyprinuscarpiofor freshwater aquaculture. Four similar (50 l capacity) dimension aquariums (T1; 28 ºC, T2; 30 ºC, T3; 32 ºC and T4; 34 ºC, respectively) were taken for this 21 days experiment. They were fitted with mechanical and bio-filter, high-performance air compressor aerator, automatic heater with thermostat and alcohol thermometer. Recirculation set up was arranged in all aquariums to maintain identical parameters except the temperature alone. Standard management procedures were adopted such as pre-stocking, stocking and post stocking management. Fishes were slowly acclimatized in their appropriate aquarium temperature before the initial morphometric measurements. Feed percentage was 5% of their total body mass of ten fishes in eachaquarium. The growth parameters such as Totallength, Standard length, BodydepthandBodymassweremeasuredfromtheinitialdaytotheendoftheexperiment period at weekly intervals. Particularly, the body mass growth was governed by morphometric measurement from an initial, T1; 1.8 ± 0.16, T2;2.08±0.20,T3;2.31±0.17andT4;2.69±0.14gtotheendoftheexperiment,T1;2.92±0.79,T2;3.34±0.72,T3;3.33±0.37andT4;3.43±0.21g, respectively. The growth parameters such as Growth rate, Condition factor and Body ratio were calculated. The survival rate was 100%.Based on thegrowth rate statistical analysis (ANOVA), there is no significant (P>0.05) change on their growth rate of body mass. But their body mass growth rate was gradually increased in all aquariums. Based on the observations and results in this study, it is clearly indicated that the temperature in between 28 and 34 ºC did not affect the growth and also this is the optimum range of temperature of Common carp Cyprinuscarpio for fresh water aquaculture.

Keywords: Cultivable fish; Cyprinus carpio; Temperature; Growth rate; Optimum range; Freshwater aquaculture.

1. Introduction

Temperature is an important environmental factor. It plays major role in the growth and metabolism of fish. It affects all forms of life. Further, it influences the various stages of life activities, such as growth, metabolism, reproduction, movement, distribution, behavior, death etc. Each and every organism survives well at a particular range of temperature which is called as optimum temperature. The physiological activities are high at the optimum temperature and hence the organism survives well. The minimum effective temperature is the lowest temperature at which organism can live indefinitely in an active state. The maximum effective temperature is the highest temperature at which an organism can live indefinitely in an active state. The minimum survival temperature is the lowest temperature at which survival is possible. The maximum survival temperature is the highest temperature at which survival is possible (Arumugam, 2010).

Temperatures fluctuate widely in natural environments (Yamanaka et al., 2010). Temperature has

an intensive influence on biological activity. Oxygen consumption will be two times higher at 30 °C than at 20 °C. The temperature in between 33-35 °C was the lethal for several species. While fishare able to tolerate gradual temperature changes without ill-effect, but they are unable to withstand sudden changes. Optimum growth of fish in cyprinids occurs between 20 and 30 °C. Common carp have wide geographical range of distribution due to their advantageous cultivable characteristic features for aquaculture (Billard, 1995).

The body temperature of cold-blooded fish rise as water warms and simultaneously their metabolism increases to maintain the temperature. Warm water causes them to need more food and oxygen to survive. The increased temperatures cause a decrease in the amount of oxygen that is available to fish. Thus the fish may not get enough oxygen to support their needs and ultimately leads to death (Sunil et al., 2013).

Certain limit of increase in temperature favors aquaculture by increasing growth rate. On the contrary, temperature beyond optimum limits of a particular species adversely affects the health, increasing metabolic rates and subsequent oxygen demand (Wedemeyer et al., 1999).

Carps contribute a major share in freshwater aquaculture. Cyprinus carpio culture is well suited in temperate as well as tropical countries of the globe (Chatterjee et al., 2004). Water temperature has a significant effect on growth, metabolic and immune function in teleosts (Person-Le Ruyet et al., 2004). The increase of temperature related to climate change has gradually altered the ecosystem function (Winder et al., 2011; Val et al., 2016).

Common carp is one of the most important freshwater composite aquaculture species. Here, the question is whether there is any significant changein their growth at different temperature ranges from 28 °C to 34 °C of common carp, Cyprinus carpio is yet to be answered. Hence to fulfill this requirement the present study is undertaken with the following objectives: 1. To determine the optimum temperature for better growth of Common Carp, Cyprinus carpio for freshwater aquaculture. 2. To recommend the optimum temperature for the growth of Common Carp, Cyprinus carpio culture to aquaculture farmers.

2. Materials and methods

2.1. Experimental animal

The fingerlings of common carp, Cyprinus carpio were obtained from a local fish farm, Kolathur, Chennai.

2.2. Period and duration of study

The period of this study was carried out from March 2022 to April 2022. The duration of the experiment was 21 days.

2.3. Geographical location

The experiment was conducted in the Department of Zoology, University of Madras, Guindy Campus, Chennai, Tamil Nadu, India. The geographical location of this experiment is 13º0'36" **N** 80º14'20" E. This experiment was conducted inside the laboratory.

2.4. Experimental setup

Four aquariums with similar dimension were taken for this experiment (Fig. 1 and 2). The dimension of an aquarium was 59 cm length × 29 cm width × 30 cm height. The aquariums were linked with Cooler

tub, mechanical and biofilter. The bottom of the aquarium contains a thermocol to protect the bottom of the glass. 7cm space was maintained in between the aquariums. Each aquarium was labeled to differentiate the temperature as T1, T2, T3 and T4 for 28 ºC, 30 ºC, 32 ºC and 34 ºC, respectively. The water carrying capacity was 50 liters.

Mechanical filter was selected for this experiment. The Mechanical filter was fully made up of plastics and one sand-air stone present at the bottom of this filter. The bottom of this filter was heavy compared with the upper part. So this filter was submerged in aquarium water. The outer side of the filter was covered with a sponge. So this was also called as sponge filter. The main role of sponge filter was to absorb the dust particles in the water and also increase the dissolved oxygen in aquarium water. Further it acts as a bio-filter.

The automatic heater with thermostat was immersion type, and they have attached to the inner surface of the aquariums. It was a 100W power- consuming heater with thermostat. The number of the heater installation differs in each aquarium. T1, 28 ºC and T2, 30 ºC fish tanks contained one heater with thermostat. T3, 32 ºC and T4, 34 ºC fish tanks contained two heaters with thermostats for proper and quick maintenance of the particular water temperature and harmless to fish. The heater with thermostat was automatic, so aquarium water was maintained at a particular temperature.

Alcohol thermometer was fixed inside the aquariums. They were used to regularly confirm the particular water temperature and also to confirm the heater with thermostat was properly maintain their water temperature in aquariums.

A high-performance electromagnetic air compressor aerator was used in this experiment. This aerator contains one inlet and one outlet. The air fromthe atmosphere was consumed by the inlet and the dust-free air was released in outlet through air pipe. A sponge was present inside the aerator, which is used to filter the air. A plastic air divider was used to divide the air to supply four fish tanks. Small air tubes from the aerator were connected to each mechanical sponge filter. Air regulators were attached to their air tubes. The standby aerators were fixed in fish tanks.

The Cooler tank was circular in dimension. The dimension of the Cooler tank was 60 cm diameter x 25 cm height and filled with a maximum quantity of water. This cooler tank was connected with one inlet and one outlet. Inlet water was hot in condition. It was coming from T4, 34 ºC aquarium through pipeline connection. The cooler tank has fountain that cool the water coming from T4, 34 ºC and the cool water was supplied to the T1, 28 ºC aquarium through airlift system.

Bio filter was attached to this experiment. It was placed inside the cooler tank. The size of the biofilter tank was 17 cm height × 35 cm length × 16 cmwidth. The two-thirds volume of the tank was filled with fine

gravel which will act as a substratum for beneficial microorganisms.

The four aquariums were inter-connected with polyvinyl chloride pipeline to circulate the water in all aquariums. The flow of water circulation was T1 to T2, T2 to T3, T3 to T4, T4 to Bio-filter and Bio-filter to Cooler Tank. Further, the water was circulated from the Cooler Tank to T1 with the help of an airlift system. This arrangement has maintained all the hydrobiological parameters in all the aquariums were identical except for the difference in temperature alone. Water flow in this setup was 520 ml/min. This recirculation was operated for 3 hours per day.

2.5. Management

During pre-stocking management, all the tanks were washed thoroughly and disinfected. Tanks were filled with 50 l of clean tap water. Mechanicalwith bio-filter was installed in all the aquariums with an aerator connection. An immersion heater with thermostat and thermometer was installed in all the aquariums as per the experimental setup. Water circulation arrangements were operated as per the experimental arrangement. In this manner, mechanical filter with aeration, heater with thermostat and thermometer, recirculation of water were fixed during this stage.

Fingerlings of Common carp, Cyprinus carpio were acclimated 10 days in the four tanks at room temperature. Thereafter the temperature was gradually raised. After ten days of room temperature acclimatization, the T1, T2, T3 and T4 aquarium heaters were regulated at 28 ºC, after two days the T2, T3 and T4 aquarium heaters were raised at 30 ºC. Thereafter two days, the T3 and T4 heaters were raised at 32 ºC. Furthermore, after two days the T4 aquarium alone raised the level of temperature at 34 ºC. These fishes were slowly acclimatized in relation with their appropriate temperature in this manner.T1 for 28 ºC, T2 for 30 ºC, T3 for 32 ºC and T4 for 34 ºC, respectively. After the particular temperature acclimatization, the fingerlings were transferred in a small plastic tub and the initial morphometric characters such as total length, standard length, body depth and body mass were measured. Measured values were recorded. Morphometrically measured fish were restocked in their appropriate aquariums. Stocking density was ten in an aquarium.

After stocking, the following post-stocking management procedures were adopted throughout the experimental period viz., water exchange with the removal of the excreta, standard feeding rate (5% of their body weight/day) and weekly sampling for morphometric measurements. The excreta were removed daily in the morning with the help of siphon and 1/4 of the water in an aquarium was exchanged.

Commercial feed was taken for this experiment. Feed has been scientifically formulated to provide 100% complete and balanced nutrition for aquaculture. Feed composition were crude protein 35%, fat 5%, moisture less than 12% and fiber 4% with fat and water soluble vitamins and also macro and micro minerals.

Feed percentage was 5% of their total body weight of fishes in each aquarium throughout the experimental period. Feeding frequency was two times per day. 5% of feed has divided into two times viz., morning 10 am, and evening 5 pm throughout the experimental period. Morphometric measurements were measured weekly once.

2.6. Measurement of fish

The growth of the fish was governed by morphometric measurement from an initial ('0' day) to the end of this experimental period ('21st' day) at weekly intervals. Fishes were collected with the help of a hand net. Collected fish were kept in a small-sized plastic tub for morphometric measurement. Tub size was 30 cm in diameter and 15 cm in height. Fishes were handled by hand during measurement. All the fishes were measured.

Before the morphometric measurement, fishes were transferred in a small size bowl containing the cold water. Bowl water was cooled with the help of ice pieces. The temperature was maintained from approximately 15 ºC to 10 ºC. This physical sedation method benefits for reducing the injury in fishesand easy handling (Jhingran and Pullin, 1988) during the measurement.

Graph sheet mounted measuring board, divider, centimeter-scale, electronic weighing machine were used for this measurement.

Morphometric measurements such as total length, standard length, body depth and body mass were measured in all the physically sedated fishes.

Total Length: Total length is the maximum elongation of the body from one end to the other end, the distance between starting of the snout to end of thecaudal fin in fishes. A measuring board was used to measure the total length of this experiment.

Standard Length: Standard length is an actual length of the fishes, the distance between starting of the snout to the base of the caudal fin where themedian fin meets the hypural plate in fishes. A measuring board was used to measure the standard length in this experiment.

Body Depth: Body depth is the distance between dorsal surfaces to the ventral surface of the deepest part of the body of fishes. Divider and centimeter-scale were used to measure the body depth in this experiment.

Body Mass: Electronic weighing machine was used to measure the body mass in this experiment. One small bowl with water was placed on the electronicweighing machine and was tared to set the zero, then the sedated fish body mass was measured.

All the measured values are recorded. After the measurement, fish were transferred to a small tub for few minutes to reduce the handling stress offishes and they were restocked in their respective aquariums.

2.7. Calculations

All the measured morphometric values were calculated for growth studies. The following growth parameters were calculated.

Growth Rate (GR): The growth rate of fishes has calculated in the given formula (Weatherly, 1972).

$$GR = \frac{\text{Average final value}}{\text{Average initial value}\,\text{Duration in days (time)}}$$

Values represent mass in gram and length, breadth in cm. The growth rate has a weekly growth rate.

Condition Factor (K): The values of weight (g) and total length (cm) were substituted in this formula (Frost and Brown, 1967).

$$K \quad \frac{\text{Weight in gram} \times 100}{(\text{Length in cm})^3}$$

Survival (S): Survival of fishes was calculated as this formula (Islam et al., 2019).

$$S\,(\%) = \frac{\text{Final number}}{\text{Initial number}} \times 100$$

1.1. Statistical Analysis

Basic statistics were applied viz., arithmetic mean and standard deviation was calculated for all the fishes and are given as mean $\pm$ S.D. Statistical analysis was performed through excel 2010. One-way analysis of variance (ANOVA) was performed. Hypothesis testing $p<0.05$ was considered for this experiment.

Results

The growth of Common Carp, Cyprinus carpio was observed during the experimental period. The Table 1 shows the morphometric values from the '0' day (initial) to the '21st' day (end of the study period). Weekly growth rate, Condition factor and Body ratio were calculated and recorded.

The total length, standard length, body depth and body mass values are gradually increased at all the temperatures from the beginning to the end of the experiment (Fig. 3).

The growth rate of Common Carp, Cyprinus carpio was observed weekly once from the beginning to the end of the experimental period (Table 1). The Fig. 4 shows the growth rate values of total length, standard length, body depth and body mass under different water temperatures i.e., 28, 30, 32 and 34 °C.

The Fig. 5 depicts the values of condition factor and body ratio of Common carp, Cyprinus carpio. The values were properly maintained at all the temperatures from the beginning to the end of the 21 days of the experimental period. These show the wellbeing of the fishes during this experiment under different temperatures.

All the growth rate parameters were statistically (ANOVA) not significant ($P>0.05$).Since it is confirmed that there is no effect of water temperature in between 28 and 34 °C on the growth of Common Carp, Cyprinus carpio.

Discussion

The cumulative growth and growth rate of Common Carp was measured and calculated in this experiment. The cumulative growth and growth rate were steadily maintained on all the growth parameters such as Total Length, Standard Length, Body Depth and Body Mass from the beginning to the end of the experiment at 28, 30, 32 and 34 °C, respectively during 21 days. It is confirmed that there is no growth rate differences between the temperatures 28, 30, 32 and 34 °C. The increasing of the steady growth rate indicates the better growth performance. Therefore, the temperature didn't affect the growth of Common Carp fish in between the temperature 28 to 34 °C.

The previous reports informed that the optimum temperature for growth of different size Common carp, Cyprinus carpio under different water temperature. Chatterjee et al., (2004) estimated that the 30 and 35 °C were the optimum temperature for early fingerlings. Korwin- Kossakowski (2008) determined that the 26 to 28 °C was optimum temperature for larvae. Singh and Desai, (2009) stated that the 28 °C was optimum temperature for fry. According to Oyugi et al., (2012) the growth rate was maximum between 24 and 28 °C. Pitt et al., (2015) suggested that 32 °C was the optimum temperature for fish. Pang et al., (2016) reported that 25 °C was optimum temperature for juvenile. In contrast, Zeng et al., (2017) reported that 28 °C was the optimum temperature for juvenile.

Oyugi et al., 2012 reported that the growth was enhanced in equatorial regions. Based on the temperature the production of natural food also played their role on growth. Due to temperature influence in nature in their natural environment, natural food production will also increase the growth. Here not only the temperature but also the primary food might enhance the growth of Common carp. In this experiment, the experimental design clearly shows the temperature alone played their role. Based on the observation and result made in this study the growth and growth rate was steadily increased from beginning to the end at all the temperatures 28, 30, 32 and 34 oC. In this statistical analysis, we observed that there is no growth retardation in between the temperatures 28 to 34 oC. We concluded that growth and growth rate was enhanced in Common carp in between 28 and 34 oC. Furthermore, the coefficient of condition and body ratio values were steadily maintained from the beginning to the end of the experiment which indicate the wellbeing of the common carp. The earlier studies showed that up to 35 ºC there is no retarding effect. Similarly, in relation with the previous information the growth and growth rate was not affected and also steadily maintained in between the temperatures 28 to 34 ºC. In river and reservoir not only the temperature and also the natural food should support the growth of carp. In our experiment temperature alone played the growth of common carp, Cyprinus carpio.

Based on the observations and results in this study, it is clearly indicated that the temperature in between 28 and 34 °C did not affect the growth of common carp, Cyprinus carpio. Further it is confirmed that the temperature in between 28 and 34 °C is optimum range of temperature on common carp, Cyprinus carpio.

Conclusion

The present study showed that the growth of common carp Cyprinus carpio has enhanced in between the temperature 28 and 34 °C. Further this study highlighted the temperature alone played their role as per the experimental design. The condition factor and body ratio values show the wellbeing of common carp during the experiment. We recommended that the temperature in between 28 and 34 ºC didn't affect the growth of common carp fish. Hence the temperature in between 28 and 34 ºC was the optimum temperature for common carp, Cyprinus carpio. Farmers can culture the common carp upto 34 ºC which is the optimum temperature level of common carp. Further studies should be directed at higher temperature above 34 ºC.

Author contribution statement

AVM Conceptualization. AVM & MD Data curation. AVM & MD Formal analysis. AVM Funding acquisition.
AVM & MD Investigation. AVM Methodology.
AVM & MD Project administration. AVM Resources.

AVM Supervision. AVM & MD Validation.

AVM & MD Visualization.

AVM & MD Writing – original draft. AVM & MD Writing – review & editing.

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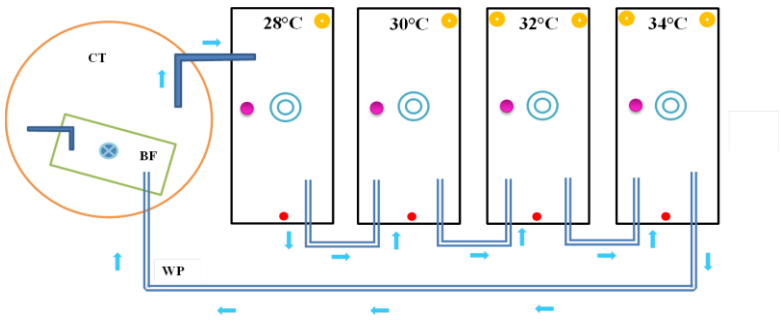
Highlights

- Influence of water temperature on growth and growth rate were tested on common carp, Cyprinus carpio in between 28 and 34 °C.
- Temperature in between 28 and 34 °C was the optimum temperature for growth of common carp, Cyprinus carpio.
- The experimental design shows all the parameters are identical except the temperature alone.
- Fish farmers can culture the common carp up to 34 ºC.

Table 1: Measurements of growth parameters of Common carp, Cyprinus carpio reared under different water temperatures during the 21 days of the experimental period. Values are mentioned in Mean ± Standard deviation (No. of fishes =10) with survival 100%.Values in Parenthesesindicate growth rate. Growth rate values are not significant (P>0.05) in ANOVA.

Day	Temperature (ºC)	Total Length (cm)	Standard Length (cm)	Body Depth (cm)	Body Mass (g)	Condition Factor	Body Ratio
Initial	28	5.13±0.28	4.10±0.27	1.40±0.15	1.80±0.16	1.33±0.13	0.34±0.03
Initial	30	5.25±0.14	4.20±0.26	1.55±0.05	2.08±0.20	1.46±0.13	0.36±0.02
Initial	32	5.39±0.16	4.25±0.17	1.59±0.03	2.31±0.17	1.48±0.15	0.36±0.01
Initial	34	5.60±0.18	4.42±0.13	1.67±0.08	2.69±0.14	1.53±0.15	0.37±0.01
7^{th}	28	5.22±0.24(0.05)	4.19±0.17(0.09)	1.50±0.08 (0.10)	2.19±0.30 (0.39)	1.53±0.14	0.36±0.01
7^{th}	30	5.34±0.16(0.12)	4.24±0.18(0.04)	1.58±0.10 (0.03)	2.49±0.34 (0.41)	1.63±0.12	0.37±0.02
7^{th}	32	5.46±0.17(0.07)	4.30±0.18(0.08)	1.65±0.12 (0.06)	2.79±0.20 (0.48)	1.72±0.16	0.38±0.03
7^{th}	34	5.67±0.17(0.07)	4.47±0.14(0.05)	1.72±0.11 (0.05)	3.11±0.20 (0.42)	1.73±0.19	0.38±0.02
14^{th}	28	5.28±0.32 (0.16)	4.28±0.28(0.09)	1.67±0.09 (0.17)	2.48±0.49 (0.29)	1.57±0.07	0.39±0.02
14^{th}	30	5.57±0.23(0.23)	4.38±0.21 (0.14)	1.70±0.09 (0.12)	2.88±0.50 (0.39)	1.66±0.12	0.38±0.02
14^{th}	32	5.31±0.20 (0.15)	4.44±0.16 (0.11)	1.75±0.07 (0.10)	3.05±0.26 (0.26)	1.73±0.17	0.39±0.01
14^{th}	34	5.70±0.15 (0.03)	4.50±0.12(0.03)	1.79±0.03 (0.07)	3.22±0.18 (0.11)	1.74±0.15	0.39±0.01
21^{st}	28	5.61±0.49 (0.23)	4.46±0.40 (0.18)	1.88±0.13 (0.21)	2.92±0.79 (0.44)	1.62±0.09	0.42±0.03
21^{st}	30	5.78±0.28 (0.21)	4.74±0.21(0.36)	1.89±0.13 (0.19)	3.34±0.72 (0.46)	1.71±0.17	0.39±0.02
21^{st}	32	5.67±0.23 (0.06)	4.52±0.18 (0.08)	1.92±0.09 (0.17)	3.33±0.37 (0.28)	1.82±0.18	0.42±0.02
21^{st}	34	5.47±0.19 (0.07)	4.61±0.13(0.11)	1.89±0.05 (0.10)	3.43±0.21 (0.21)	1.79±0.16	0.40±0.01



BF = Bio filter

CT = Cooler Tank

WP = Water Circulation Pipe

= Mechanical filter

= Standby aerator

= Heater

= Thermometer

= Submersible motor

= Water flow

= Airlift system

Fig. 1. Schematic diagram of the design and arrangement of the experimental setu