DETERMINING THE OPTIMUM TEMPERATURE FOR GROWTH, FEED EFFICIENCY AND SURVIVAL OF DOMESTICATED INDONESIAN MAHSEER, *Tor soro* LARVAE

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ABSTRACT

Temperature plays a pivotal role in the success of larvae production. Evaluation of the effects of different temperatures on growth, feed efficiency, and survival of domesticated Indonesian mahseer (*Tor soro*) larvae was carried out to determine an optimum rearing temperature. Five different temperature settings of 22°C, 24°C, 26°C, 28°C, and 30°C were used as the treatments arranged in triplicates, in indoor closed recirculating systems. The larvae were stocked in a rectangular glass tank with a stocking density of 150 larvae per tank and fed with a commercial feed (30% protein content) three times a day, about 10% per body weight over 61 days of observation. Measured parameters included the specific growth rate of total weight (SGR_{TW}) and length (SGR_{TL}), feed efficiency (FE), and survival rate (SR). The result showed that the treatments of different temperatures significantly affected the growth performance and feed efficiency of the larvae. The growth performance and feed efficiency of mahseer larva were much better at rearing temperature from 24°C to 28°C compared with those at 22°C and 30°C. There were no significant differences in SR in different temperatures tested. The SR was found to range from 86.44% to 100% in all treatments. Maintaining temperature ranging from 24°C to 28°C is the best rearing condition to achieve the optimum growth and feed efficiency of mahseer during the larval rearing period. The findings from this research could be set as a standard technique in larval rearing of Indonesian mahseer (*Tor soro*).

KEYWORDS: rearing temperature; mahseer hatchery; Kancra; Dewa; RAS

INTRODUCTION

Mahseer is a highly valued and culturally important cyprinid fish in Southeast Asia (Pinder *et al.*, 2019). In Indonesia, Mahseer *Tor soro*, locally known as "Ikan Kancra" or "Ikan Dewa", can be found in the freshwater ecosystem in Sumatera, Kalimantan, and Java Islands (Kottelat *et al.*, 1993). This species is used as an iconic offering in multiple cultural ceremonies in these regions. However, the supply of fish production mainly depends on inland fisheries, especially in riverine areas (Haryono & Subagja, 2007). Exploitation and habitat degradation of this iconic fish have increased in the last decade, decreasing the fish populations in many regions (Wahyuningsih *et al.*, 2012). In dealing with this issue, the Research Institute for Freshwater Aquaculture and Fisheries Extension (RIFAFE),

Bogor, Indonesia, has successfully domesticated the fish since 2011 and initiated to promote its hatchery technology for seed production for aquaculture and conservation (Gustiano *et al.*, 2013; Kurniawan *et al.*, 2021).

Various studies have been conducted to support the improvement of hatchery technology for *Tor soro* aquaculture, including evaluating its broodstock management (Subagja *et al.*, 2006), hormonal treatment on eggs maturation and spawning larvae (Gustiano & Subagja, 2006; Farastuti *et al.*, 2014), stocking density in larval rearing (Qudus *et al.*, 2012), and incubation temperatures effects on eggs and embryonic development (Arifin *et al.*, 2020). However, the effects of rearing temperature on larval development and survival performances of *Tor soro* have not yet been investigated. Temperature significantly affects the growth, survival, and physiological performance of fish species (Boltana *et al.*, 2017; Prakoso & Kurniawan, 2020; Takata *et al.*, 2014). Temperature ranges have different effects different responses on

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the optimum growth rate, biomass, and survival of different fish species (da Costa *et al.*, 2016; Rønnestad *et al.*, 2013; Pyanuth *et al.*, 2020). Therefore, it is essential to understand thermal influences on cultured fish to improve larval rearing in aquaculture (Prakoso *et al.*, 2019; Singh *et al.*, 2013; Tang *et al.*, 2017).

The range of temperature implemented for optimum larval rearing of mahseer was found different among various mahseer species. The effects of different rearing temperatures on Semah Mahseer *Tor douronensis* larvae showed that the highest growth of larvae was observed at temperature 26°C. In contrast, the highest survival rate of larvae was identified at 24°C (Arifin *et al.*, 2021). On the other hand, the Malaysian mahseer *Tor tambroides* need a higher temperature for their optimum growth of about 30°C (Das *et al.*, 2018). The rearing temperature for the mass production larvae of golden mahseer *Tor putitora* ranges from 20°C to 27°C (Sarma *et al.*, 2010). The preferred temperature for larval rearing of chocolate mahseer *Neolissochilus hexagonolepis* ranges from 23°C to 27°C, and the optimum temperature for growth was predicted about 25°C (Dash *et al.*, 2021).

This research aimed to evaluate the effects of different temperatures on growth, feed efficiency, and survival performances of domesticated Indonesian mahseer (*Tor soro*) larvae reared in a recirculating aquaculture system.

MATERIALS AND METHODS

Fish Larvae

This research was conducted at the Research Institute for Freshwater Aquaculture and Fisheries Extension (RIFAFE), Cijeruk, Bogor, Indonesia, from May to July 2019. Fish larvae were used in this experiment aged 31 days after hatching produced by the artificial reproduction method. The initial length and weight of the larvae were 1.48 ± 0.05 cm and 0.02 ± 0.00 g, respectively. The first generations of sexually mature *Tor soro* broodstocks were selected for artificial reproduction. Commercial hormone Ovaprim™ (0.6 mL/kg body weight) was injected intramuscularly to accelerate gonad maturation. Ovulation of eggs mainly occurred after a 12-hour injection. The eggs dan sperms were released by stripping method and mixed in containers filled with NaCl solution. Freshwater was added to the mixture to allow fertilization. Egg incubation was carried out in rectangular tanks and larvae were commonly hatched after 24 hours. Five days after hatching, the larvae were fed ad libitum with *Artemia* sp. nauplii for up to 14 days. Subsequently, a commercial diet (30% protein content) was given to the larvae at satiation two times a day until a month-rearing period. Then, the larvae (31 days after hatching) were removed from incubation tanks to rectangular tanks for 61 days experiment.

Experimental Design

This study used a completely randomized design using five temperature treatments where each treatment had three replications. Five different temperature settings of 22°C, 24°C, 26°C, 28°C, and 30°C were used as the treatments arranged in triplicates 30-L tanks. These temperature ranges were based on the preliminary study and current practices of mahseer larval rearing in different hatcheries. The fish tanks used in this experiment were glass aquaria sized 40 cm x 30 cm x 30 cm (LxWxH) aerated by a bubbling system. Each fish tank was connected to a recirculating aquaculture system and set to each specified temperature level using an automatic thermostat (Resun-CL450). The stocking density used was 150 fish per tank. Fish larvae were fed with a commercial feed three times a day, about 10% per body weight, during 61 days of observation. Sampling was carried out at the beginning and the end of the study. The lengths of the larvae were measured using laminated paper block (accuracy 0.1 mm) and weight was measured using a digital balance (accuracy 0.01 g).

Water Quality Monitoring

The temperature levels were kept constant and regularly monitored during the 61 days experiment. Water quality measurements were carried out every two weeks following data sampling. The water quality parameters measured were pH (pH-meter digital, Hanna HI98107) and dissolved oxygen (DO meter, Trans Instrument HD3030). In the present study, pH and DO were still within the acceptable range for fish growth (Table 1).

Data Analysis

Growth, feed efficiency, and survival performances of *Tor soro* larvae reared using different temperature settings were calculated using the following equations.

Specific growth rate (SGR):

$$SGR\ (TW) = \frac{\ln Wt - \ln Wi}{t} \times 100$$

Where: Wt = final weight
        Wi = initial weight

$$SGR\ (TL) = \frac{\ln Lt - \ln Li}{t} \times 100$$

Table 1. Water quality conditions measured in fish tanks with different temperature settings during the experiment

Parameters	Values	References
pH	6.90 (6.88-6.92)	6.5-8.0 (Arifin *et al.*, 2019)
DO (mg/L)	5.21 (4.54-5.65)	> 2 (Pratama *et al.*, 2018)

Where: Lt = final length
   Li = initial length
   t = the cultured period in a day
   In = logarithmic natural

Feed efficiency (FE):

$$FE = \frac{1}{PCR} \times 100$$

Feed conversion ratio (FCR)

$$FCR = \frac{Total\,feed\,intake\,(g)}{Total\,weight\,gain\,(g)}$$

Survival rate (SR):

$$SR\,(\%) = \frac{Nf}{Ni} \times 100$$

Where: Nf = final number of live fish
   Ni = the initial number of larvae

The effects of temperature on larval growth and survival were statistically evaluated using analysis of variance (ANOVA) to determine significant differences of the experiment, followed by Duncan's Multiple Range Test (DMRT) to identify the best responses among treatments. The significance level was set to $\alpha = 0.05$. All statistical analyses were performed using SPSS 16.

RESULTS AND DISCUSSION

Growth performance and feed efficiency of *Tor soro* larvae reared using five temperature settings are shown in Table 2. There was a significant difference in the specific growth rate of total weight (SGR_{TW}) and total length (SGR_{TL}) among different temperatures ($P < 0.05$). The results of the DMRT post hoc test revealed that the treatment temperatures of 24°C, 26°C, and 28°C were not significantly different in both SGR_{TW} and SGR_{TL}, while the treatment temperatures of 22°C and 30°C were significantly different in both SGR_{TW} and SGR_{TL} as compared with treatment temperatures of 24°C, 26°C, and 28°C. These conditions were also supported by the feed efficiency of the fish that was significantly impacted by different temperatures ($P < 0.05$). The treatment temperatures of 24°C, 26°C, and 28°C were not significantly different in feed efficiency, while the temperature settings of 22°C and 30°C were significant differences in feed efficiency as compared with 24°C, 26°C, and 28°C. These findings indicated that temperature settings ranging from 24°C to 28°C are the optimum temperature for *Tor soro* growth, while temperatures of 22°C and 30°C are not recommended for *Tor soro* larvae rearing.

The trend of specific growth rate in weight and length and feed efficiency increased from 22°C until they reached maximum points at temperature about 26.0°C and decreased with further temperature increase (Figure 1). This model is in line with the research conducted by Bar & Radde (2009), who reported that the effects of different temperatures on the growth of fish commonly followed bell-shaped curves. This pattern is possibly related to the metabolic rate of most fish species which increases at an optimum temperature and decreases at higher and lower temperatures (Emaliana *et al.*, 2016).

Table 2. Growth performance and feed efficiency of *Tor soro* larvae reared using five temperature settings (22°C, 24°C, 26°C, 28°C, and 30°C) during the 61 days experiment

Temperature treatments (°C)	SGR_{TW} (%/day)	SGR_{TL} (%/day)	Feed efficiency (%)
22	0.121 ± 0.007[a]	1.107 ± 0.035[a]	59.60 ± 3.20[a]
24	0.159 ± 0.008[b]	1.341 ± 0.033[b]	77.16 ± 6.40[b]
26	0.162 ± 0.014[b]	1.355 ± 0.05[b]	78.85 ± 4.81[b]
28	0.151 ± 0.006[b]	1.300 ± 0.033[b]	73.07 ± 1.90[b]
30	0.120 ± 0.01[a]	1.093 ± 0.029[a]	55.37 5.10[a]

Note: Values are means ± SD (n=3). Superscript letters represent significant differences ($P < 0.05$) between different temperatures
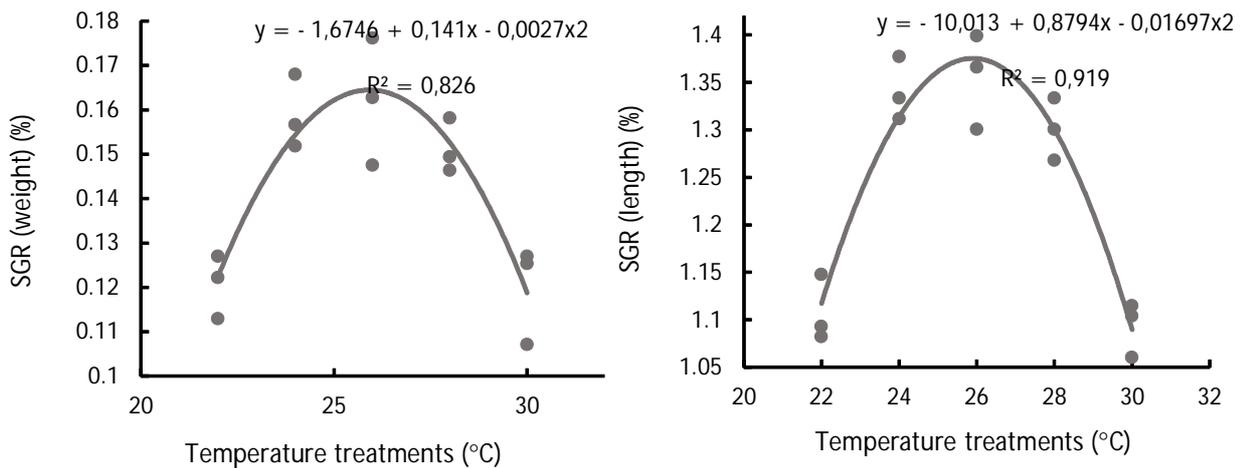
Figure 1.   Polynomial regression models of the specific growth rate of weight and length of *Tor soro* larvae reared at different temperatures.

The excellent growth of fish is influenced by several water quality parameters. Temperature and feed are the most significant factors in successful larval rearing (Kolman *et al.*, 2018; Karimah *et al.*, 2018). Fish larvae are susceptible to changes in environmental conditions, especially temperature. Low temperatures reduce the activity of cells that inhibits fish growth. For instance, a change of 1°C will affect metabolic change reactions in the fish body by 10% (Pratama *et al.*, 2018). The effects of temperature on fish can be observed in some metabolic processes, including growth, feed intake, and survival (Abram *et al.*, 2017; Nytrø, 2013). The optimum temperature accelerates fish metabolism, which positively influences fish growth, while low temperatures decrease metabolic rate, fish appetite, feed intake, and eventually lead to slower fish growth (Islam *et al.*, 2019). Also, the difference in altitude impacts water quality parameters that affect fish growth. In this case, temperature plays a pivotal role in fish's fast or slow growth traits (Subagja *et al.*, 2018).

In this study, the growth of Mahseer *Tor soro* was higher than wild mahseer reared in the pond for the domestication program. The growth of three wild population mahseer *Tor soro* only reached SGR around 0.61%/day (Asih & Setijaningsih, 2011). However, the growth of mahseer was categorized as a slow-growth performance as compared with other cultured fish larvae such as Common carp *Cyprinus carpio* (SGR: 3.82%/day at 28°C) (Desai *et al.*, 2009) and African catfish *Clarias gariepinus* (5.14%/day at 28°C) (Orina *et al.*, 2016). The optimum temperature for the excellent growth of fish in the Cyprinidae family commonly ranged from 25°C to 27°C (Ariyana, 2015; Ridwantara *et al.*, 2019). Fish need specific temperatures for their optimum growth rate, feeding efficiency, and nutrient utilization (Bogevik *et al.*, 2010). Feed intake by

fish was influenced by different temperatures, which affect enzyme activity (Kamarudin *et al.*, 2011). The increase of enzyme activity relates to the increasing efforts of fish in digesting nutritional content, especially protein, for its optimal growth (Gheisvandi *et al.*, 2014). Thus, it can be explained that the higher the feed efficiency value, the better fish response to feeding, leading to growth acceleration.

Effects of different temperatures on the survival rate (SR) of larvae were not significantly different (P>0.05) (Figure 2). These results indicate that the temperature range from 22°C to 30°C in this experiment is still within the acceptable level for mahseer rearing. Still, it provides a different performance in their growth. Survival rate can be influenced by biotic and abiotic factors, abiotic factors including food availability and quality of cultured media (Istiqomah *et al.*, 2018). Temperature is an environmental parameter that affects the survival and development of fish larvae and plays a major role in accelerating the metabolism of the fish (Rønnestad *et al.*, 2013).

The effects of temperature on the survival rate (SR) of the other mahseer species are also present in different performance characteristics. Semah mahseer *Tor douronensis* larvae have a wide range of temperature regimes. This species can be reared at the temperature of 24°C to 32°C, and the optimum temperature was 24°C indicated by the highest SR (83.50%) (Arifin *et al.*, 2021). Similarly, Malaysian mahseer *T. tambroides* also has excellent survival in wider temperature settings ranging from 22°C to 30°C (Das *et al.*, 2018). However, compared to other Cyprinids, mahseer is likely more tolerance to wider range of rearing temperature. The effective rearing temperature of the Rohu carp *Labeo rohita* ranges from 24°C to 26°C (Kausar & Salim, 2006). The common carp *Cyprinus carpio* fry can be optimally reared at 28°C to
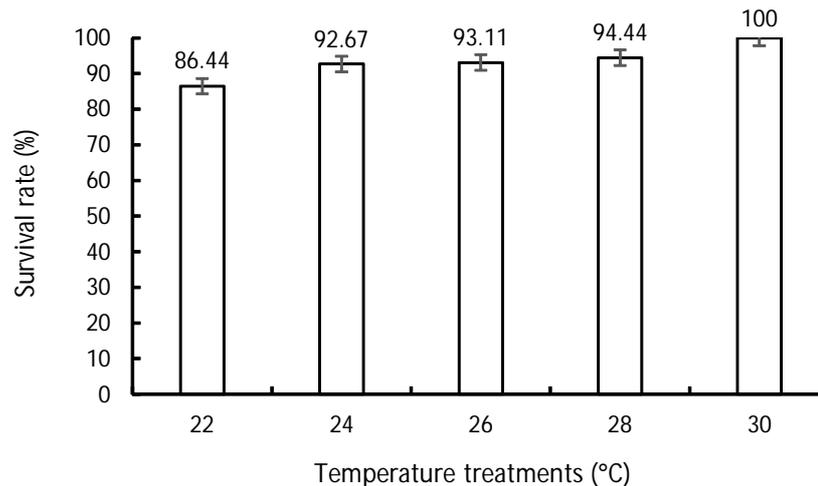
Figure 2. Survival rate of domesticated mahseer larvae reared in five temperature conditions.

30°C (Laila, 2018). The temperature range for Goldfish (*Carasius auratus*) larval rearing was determined to be from 27°C to 30°C, and the optimum temperature was observed at 29°C (Sihombing, 2018).

CONCLUSION

The ambient water temperatures ranging from 22.0°C to 30.0°C are still within the acceptable level for survival of mahseer *Tor soro* larvae. This study suggests that 24°C to 28°C is the optimum temperature range to achieve better growth and feed efficiency of mahseer *Tor soro* during the larval rearing period. The result of this study could be incorporated into the technical development standard of mahseer *Tor soro* larval rearing in hatcheries.

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