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The effect of rearing temperature on growth and survival of *Labeo rajasthanicus* spawn

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Abstract
To assess the impact of temperature on growth and survival of *Labeo rajasthanicus* spawn, an experiment was conducted under laboratory conditions using FRP tanks ($1m^3$). Four temperature treatments (22, 26, 30 and 34 ^{0}C) were used in triplicate. Total five thousand spawns were stocked in each tank and their growth and survival was monitored for a period of 21 days. The weight gain had positive relationship with temperature treatments. As such the growth gain increased with increasing temperature (22 to 30 ^{0}C). However, a reduced growth rate was noticed with further increase (30 to 34 ^{0}C) in rearing temperatures. SGR was significantly higher at 30 ^{0}C (5.19 ± 0.11) as compared to other treatments except 26 ^{0}C. Whereas, lowest SGR (4.04 ± 0.06) was found in lowest (22 ^{0}C) temperature treatment. In general the spawn reared at 30 ^{0}C and lower temperature performed better than that reared at higher (34 ^{0}C) temperature.

Keywords: Minor carp, *Labeo rajasthanicus*, growth, survival, fish spawn, SGR

Introduction
Fish, being cold-blooded animal are affected by the temperature of the surrounding water which influences the body temperature, survival, growth rate, food consumption, feed conversion and other body functions [1, 2]. Therefore, water temperature is considered as a driving force in the fish life because its effects are more than any other single factor. Growth and survival in fish are optimum within a defined temperature range. Although short-term changes, such as weather conditions, may influence a fish for a day or two, but temperature has more predictable and seasonal effect. Each fish species has an ideal temperature range within which it grows quickly. However, fish move into more favorable areas of a stream to regulate their body temperatures. In warmer environments fish have a longer growing season and faster growth rate but tend to have a shorter life span than in cool water [3]. High water temperatures increase the metabolic rates, resulting in increased food demand. Although, fish can generally function in a wide range of temperatures, but they do have an optimum range, as well as lower and upper lethal temperatures, for various activities [4]. Freshwater fish have an optimum growing temperature in the range of 25-30 ^{0}C at which they grow quickly [5]
Labeo rajasthanicus usually known as sarsi is one of the important minor carp native to South Rajasthan. This species has potential for inclusion in composite culture [6, 7]. However, there is a lack of adequate knowledge about the optimum rearing condition, especially for temperature requirements of larvae. Therefore, the present study was conducted to investigate the effect of temperatures on growth and survival of *Labeo rajasthanicus* spawn.

Materials and Methods
After three days post hatching, the larvae were stocked in FRP tanks (1x1x0.75m). Water in FRP tanks were assigned to temperature treatments of 22, 26, 30 and 34°C. The larvae were fed initially (3 days) with culture contained live zooplankton collected from natural habitat. Seventh day later of post hatching, the artificial food containing 25-30% protein was supplied twice a day. The experiment was terminated after 21 days. Samples were collected at an interval of 5 days from 5th day onwards for growth performance evaluation. The growth, specific growth rate (SGR) and percentage of survival were estimated at the end of experiment using following formula:
$WG=W_1-W_0$
Where: WG = Average weight gain (g), W_1 = Average final weight (g) & W_0 = Average initial weigh

SGR = (Ln Wt. - Ln W_0) x 100/t
Where: Wt. =Final weight (g), Wo= Initial weight (g) & t= duration of experimental days
Survival rate = Nt x 100/N_0
Where: Nt = final number of fish & $N_{0=}$, Initial number of fishes
Water quality parameters *viz.* temperature, pH, dissolved oxygen, alkalinity, total hardness and nitrate were recorded weekly during the experimental period for all the experimental tanks.

Results

In this experiment the impact of rearing temperature on *Labeo rajasthanicus* spawn was evaluated for a period of 21 days. The application of temperature at different levels (22, 26, 30 & 34 ^{0}C) in FRP tanks (1m^3 in size) has a significant impact on water quality and spawn growth. As such the results pertaining to water quality and spawn growth are presented in Tables 1 & 2 and Figs. 1 to 2.

Table: 1: Weekly variations in selected water quality parameters of spawn rearing systems

Treatment	Days of observation	Parameters					
		Dissolved Oxygen (mg/lit.)	pH	Alkalinity (mg/lit.)	Hardness (mg/lit)	Nitrate (mg/lit.)	Orthophosphate (mg/lit.)
22 ^{0}C	0	6.23	7.6	310	670	0.41	0.07
	7	5.81	8.11	210	600	0.37	0.09
	14	4.74	7.64	240	450	0.32	0.71
	21	4.31	8.14	360	390	0.18	0.63
24 ^{0}C	0	6.6	8.1	350	690	0.48	0.22
	7	5.08	8.57	240	610	0.51	0.09
	14	4.47	7.85	270	470	0.52	0.08
	21	5.5	7.5	290	380	0.32	0.05
30 ^{0}C	0	6.38	7.8	220	700	0.63	0.09
	7	5.06	8.36	230	670	0.43	0.08
	14	5.13	8.15	250	580	0.52	0.07
	21	4.72	7.72	280	370	0.37	0.02
34 ^{0}C	0	6.15	8.24	280	720	0.30	0.08
	7	6.09	8.39	300	660	0.46	0.05
	14	4.55	8.12	320	580	0.51	0.04
	21	4.31	8.14	360	390	0.38	0.06

Table 2: Growth and survival of *Labeo rajasthanicus* spawn reared at different temperatures under laboratory conditions (*Values are expressed as mean ± SE, values with same superscripts in a column are not significantly different -Duncan's multiple range test, p<0.05*)

Treatments	Nos. of stocked spawn	Nos. of survived spawn	Survival Rate (%)	Weight gain (mg)	Specific growth rate (SGR)
22 ^{0}C	5000	2720±19.40^a	54.40±0.93^a	210±0.024^a	4.04±0.06^a
26 ^{0}C	5000	3670±21.05^b	73.40±0.88^b	350±0.008^b	5.00±0.02^b
30 ^{0}C	5000	2440±19.25^{ca}	48.80±0.86^{ca}	380±0.014^{cb}	5.19±0.11^b
34 ^{0}C	5000	2130±18.34^c	42.60±0.92^c	260±0.018^{da}	4.62±0.02^c

Water Quality Parameters

The variation in physico-chemical characteristics of waters were well marked (Tables 1 and Fig. 1) in different treatments. The temperature range recorded during the experiments did not differ significantly from the pre-set temperatures for the different treatments (22, 26, 30 & 34 ^{0}C). pH of experimental water oscillated between 7.5 and 8.57. (Table 1). Both the lowest and highest pH values were recorded in 22 ^{0}C treatment. Further, the respective highest (8.22) and lowest (7.87) average values of pH were observed in 34 ^{0}C and 22 ^{0}C (Fig.1).

The concentration of dissolve oxygen was initially high (i.e. up to7th day) which increased subsequently in all the treatments (Table 1). The lowest value (4.31 mg/l) of the dissolved oxygen was recorded in 34 and 22 ^{0}C treatments on 21 day of experiment, while the highest (6.38 mg /l) was in 30 ^{0}C. However the lowest (4.82mg/l) and highest (5.41 mg/l) mean values of DO were in 30 and 26 ^{0}C treatments respectively (Fig.1).

In experimental waters, the values of total alkalinity ranged from 210 to 360 mg/l. The lowest alkalinity was noticed in 22 ^{0}C on 7st day. Whereas, the highest alkalinity was observed in both 34 and 22 ^{0}C on 21 days (Table 1). Further, the respective highest (315 mg/l) and lowest (245mg/l) mean values of total alkalinity were in 34 ^{0}C and 30 ^{0}C (Fig. 1). The values of water hardness in experimental waters ranged between 380 to 720 mg/l. The lowest concentration was observed in 24 ^{0}C, while highest was in 30 ^{0}C. The lowest (527.5 mg/l) and higher (587.75 mg/l) average value of hardness were recorded in 22 and 34 ^{0}C respectively (Fig 1).

Nitrate-nitrogen concentration ranged between 0.18 to 0.63 mg/l. The lowest value (0.18 mg/l) was noticed on 21st days in 22 ^{0}C. Whereas, the highest value (0.63 mg/l) was noticed in 30 ^{0}C on initial day. The lowest (0.322mg/l) and highest (0.48 mg/l) average values of nitrate-nitrogen were observed in 22 and 30 ^{0}C respectively (Fig 1). Orthophosphate concentration in experimental waters ranged from 0.02 to 0.71 mg/l. The lowest concentration was observed in 30 ^{0}C on 21st day, while the highest was in 22 ^{0}C on 14th day (Table 1).The lowest (0.059 mg/l) and highest (0.10mg/l) average value of orthophosphate were in 26 and 30 ^{0}C respectively (Fig 1).

Growth and Survival of *L. rajasthanicus* Spawn

The data pertaining to survival and growth of *Labeo rajasthanicus* in temperature treatments are presented in Table 2 and Fig.2. The detailed observations on survival per cent and growth are described below:

Survival: At 21st day of the experiment, the mean survival rate of *Labeo rajasthanicus* ranged from 42.60±0.92 to 73.40±0.88 per cent (Table 2). The respective highest and lowest survival rate was observed in 26 and 34 ^{0}C treatments. Average survival rates at different temperatures were generally decreased with increasing temperature (Fig.2). Survival rates of highest temperature treatment (34 ^{0}C) was much lower than that of 26 ^{0}C treatment. There was a significant (p<0.05) difference between 26 ^{0}C treatment and other treatments (22, 30 & 34 ^{0}C). Whereas, no significant difference (P>0.05) was found between 22 & 30 ^{0}C and 30& 34 ^{0}C treatments (Table 2).

Growth: The weight gain was having positive relationship with temperature treatments. The weight gain of *Labeo rajasthanicus* fry at different temperature treatments is presented in Table 2. In experimental waters, the growth gain significantly increased with increasing rearing temperature. However a subsequent decrease from 30 to 34 ^{0}C was noticed. The highest weight gain (380±1.40 mg) at 30 ^{0}C was not significantly differed (p>0.05) from 26 ^{0}C (355±0.80 mg) treatment (Table 2). However, the weight gain in other treatments were significantly different from each other.

Specific growth rate: In this study, the SGR was having inverse relationship with temperature treatments. SGR was significantly higher (P < 0.05) in 30 ^{0}C (5.19 ± 0.11) as compared to other treatments except 26 ^{0}C. Whereas, lowest SGR (4.04 ± 0.06) was found in lowest (22 ^{0}C) temperature treatment In general the spawn reared at 30 ^{0}C and lower temperature performed better than that reared at higher (34 ^{0}C) temperature (Table 2 and Fig 2).

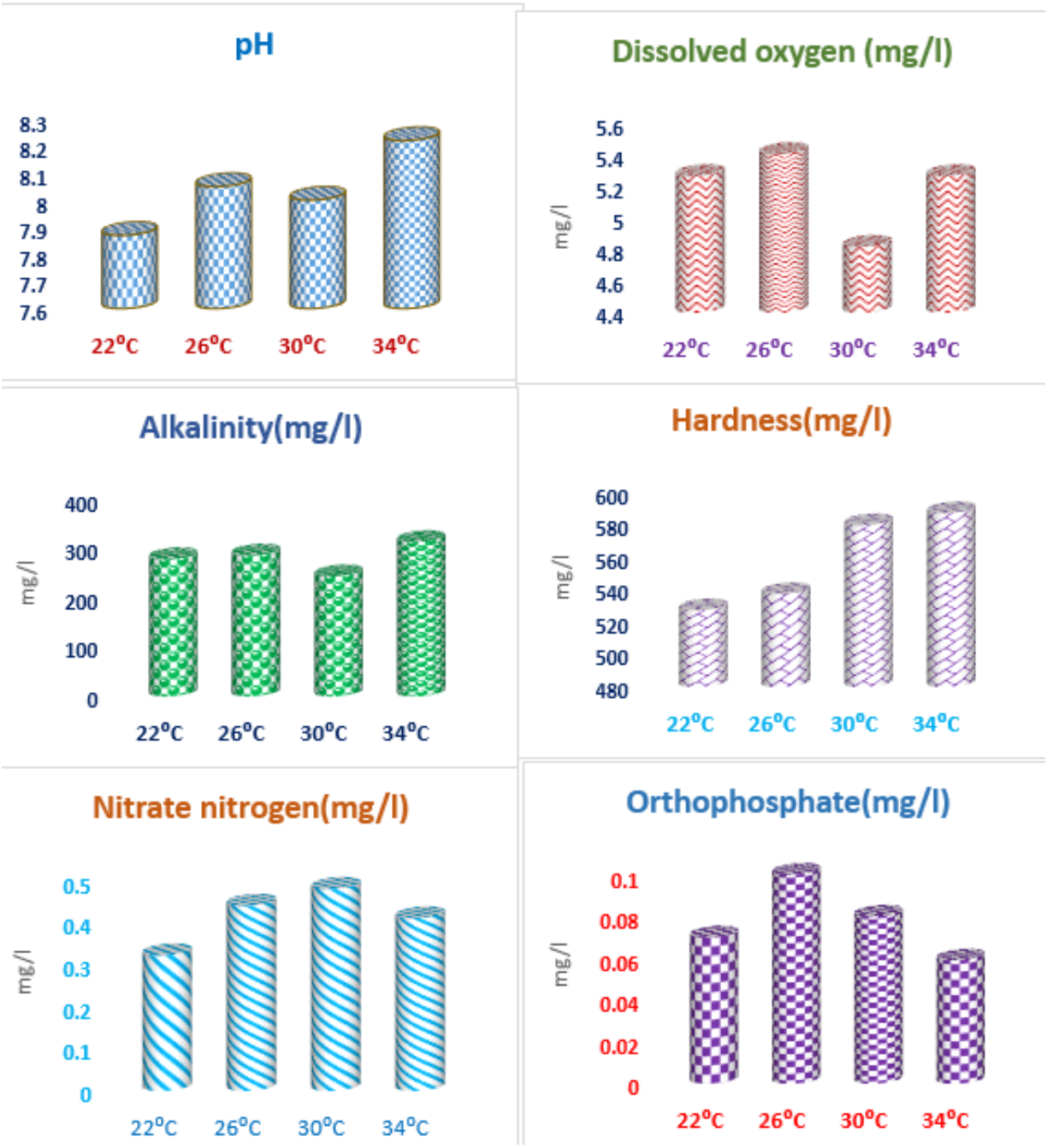

Fig 1: Mean values of selected water quality parameters in *Labeo rajasthanicus* rearing systems

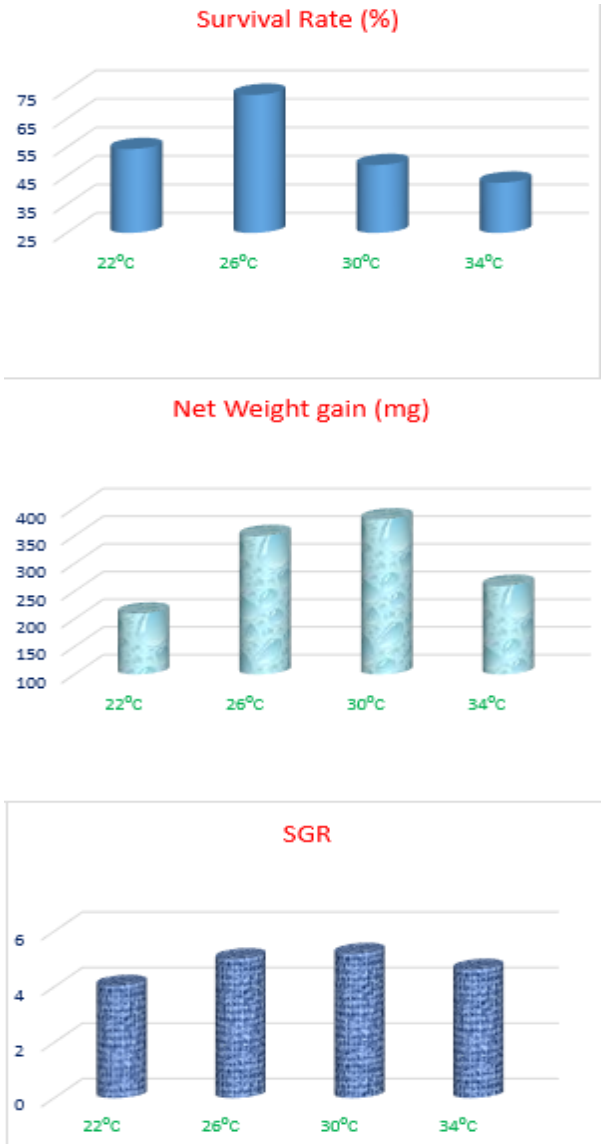

Fig 2: Survival, growth and SGR of *L. rajasthanicus* spawn reared at different temperatures

Discussion

The results of the present investigation (Tables 1 & 2) have revealed the significant impact of temperature on various water quality parameters, survival and growth of *Labeo rajasthanicus* spawn. On comparing the initial and final day values of different water quality parameters, obviously the levels of dissolved oxygen, pH, hardness and nitrate nitrogen were found to have decreased significantly. On the other hand, orthophosphate and alkalinity showed indefinite trends (Table 1).

Studies on several fish species have revealed that in the temperature range tolerated by fish, growth rates increase with increasing temperature and show a parabolic pattern [8]. When experimental temperature reaches the upper extreme of the tolerance range, performance of growth decreases. This depression of growth is due to the higher energy cost for maintenance metabolism and seems to be related mainly to a loss of appetite.

In the present study the growth performance of *Labeo rajasthanicus* was better at higher temperature (30 ^{0}C) than lower temperate (22 ^{0}C). Generally, growth rate increased with increasing water temperature and reached its optimal at 30 ^{0}C, then declined significantly (P<0.05) at 34 ^{0}C. The reduced growth performance at 34 ^{0}C could be attributed to the high rate of gastric evacuation, as reported by Elliot [9], who observed a positive correlation between water temperature and the rate of gastric evacuation in fish. It has been suggested that higher temperature accelerates the rate of passing digesta through the intestinal tract, thus reducing the digestibility and assimilation of nutrients, signifying that at high temperature, physiological processes associated with digestion and nitrogen retention function are less efficient in fish. In the present experiment, maximum growth of *L. icare* at 30 ^{0}C in relation with better SGR as shown in Table 2.

The present study revealed that larval growth rates were high over a wide range of temperature (26-30 ^{0}C) and that survival remained high at temperatures range of 22-26 ^{0}C). These results complement previous observations of Greenwood [10], Donnelly [11], Van der Waal [12] and Babiker [13]. The eurythermality of the larvae may be interpreted as an adaptation facilitating the reproduction of this fish, which spawns under unstable environmental conditions which accompany rain and flood. During this period temperatures may fluctuate widely, however the temperature tolerance of the larvae enables them to efficiently exploit the newly inundated floodplain environment, in which competition and predation are low and food resources probably abundant.

From the results of the present study, it is evident that 30 ^{0}C is the optimal temperature for larval rearing, however temperatures in the range 26-33 ^{0}C are acceptable. The temperature tolerance of *Labeo rajasthanicus* is clearly of benefit to the fish culturist facilitating more flexibility with regard to temperature control in the larval rearing operation. This attribute could possibly preclude the installation of expensive equipment to regulate hatchery temperatures. For example, in the event of a temperature fluctuations, to which flow through systems drawing water at ambient temperatures are susceptible, the growth and survival of larvae would not be seriously impaired. Overall, it is possible to conclude that a temperature near 30 ^{0}C is the optimum for growth of *L. rajasthanicus* fry; lower temperature (22 ^{0}C) results in slow growth. Similar temperature optima have been noted in other species of carp family. For example, *Labeo rohita* [14] has an optimum temperature range of 26 to 31 ^{0}C

The results of the present study revealed that fish, *Labeo rajasthanicus* maintained at low temperature (22 ^{0}C) gained significantly less specific growth rate (SGR) and survival as compared to the other treatments (p<0.05). The SGR and survival increased with increase in water temperature. These results support the earlier findings that growth and survival of fish are optimum within a defined temperature [15]. The highest weight gain was observed in the fish maintained on 30 ^{0}C. Azevedo *et al*. [2] have observed that fish were markedly influenced by the temperature of water in which they lived. In conclusion, water temperature ranging from 26-30 ^{0}C seemed to be the most effective for rearing of *Labeo rajasthanicus*.

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