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RESEARCH ARTICLE.........

Response of post larvae of *Penaeus monodon* (Fabricius, 1798) to varying temperatures

PREETAM B. NAIK, GIRISH N. KULKARNI, ANKITA S. TEKADE AND RAHUL K. SADAWARTE

ABSTRACT...... Temperature is a key environmental variable mainly influencing the survival and biological responses of the organisms. In order to understand the influence of temperature on survival and growth of post- larvae (PL 50) of tiger shrimp, *Penaeus monodon*, static bioassays as per standard methodology were undertaken. The 96 h LT_{50} value was found to be 32.2 ^{0}C. Rates of oxygen consumption were affected by temperature with direct relationship. The oxygen consumption rate of post-larva was the lowest (0.31 mg lit^{-1}) at 28^{0}C, while the highest was at 31^{0}C (0.84 mg lit^{-1}). One-way ANOVA test showed a significant temperature impact on average oxygen consumption rate of the post-larvae. The highest and lowest length and weight gains were observed at 29.5 and 31^{0}C, respectively with a medium growth at 28^{0}C. From the above, it may be concluded that the lethal/critical (maxima) temperature in shrimp thus, depend on acclimatizing temperatures, species, developmental stage and also other environmental variables.

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KEY WORDS...... Growth, Oxygen consumption, *Penaeus monodon*, Post larvae, Temperature

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INTRODUCTION...

The giant tiger shrimp, *Penaeus monodon* (Fabricius) belongs to the family Penaeidae and is the major species cultured worldwide. It has the fastest growth rate among the penaeid species reared in captivity (Foster and Beard, 1974) and is the largest species of shrimp with commercial important. It is markedly euryhaline, matures and breeds only in tropical marine habitats but spend their larval, juvenile, adolescent and sub-adult stages in coastal estuaries, lagoons or mangrove areas.

Amongst the several environmental variables, temperature is an important one for growth and survival of shrimps (Wyban *et al.,* 1995). The degree to which the biological processes are affected is dependent on several factors, including the range of temperatures to which an organism is exposed, developmental stage and interaction of temperature with other environmental parameters that have profound effect on biological processes (Goss, 1980).

In the recent years, the global temperature rise has become the key issue with regard to likely ecosystem impacts. Besides, in order to meet the ever-increasing demand for the power supply several power plants are known to be grooming up over the coastal areas releasing effluents into the river and sea affecting the water quality. Along the Konkan coast of Maharashtra state, a few power plants are already in operation and few more are expected to come up. Several investigations were made earlier in experimental study to evaluate the temperature impact namely on copepod species (Santhanam *et al.*, 2013), flounder species (Byung *et al.,* 2015) and Indian major carps (Das *et al.,* 2004), but scanty literature is available on the response of shrimps/prawns. The precise technical knowledge with regard to effect of increasing temperature on shrimp growth and distribution is very much limited (Tian *et al.,* 2004 and Gonzalez *et al.,* 2010). Thus, it becomes pertinent to investigate the effect of water temperature on the biological processes of the shrimps.

The shrimp being an important commodity along the coastal region of Konkan, the studies on the optimum conditions during the early stages of development will help to determine adequate conditions for sustainable production. Hence, the present study was undertaken to examine the survival and development of the post-larval stages of *Penaeus monodon* in response to varying temperatures under laboratory conditions.

RESEARCH METHODS....................................

Collection and acclimatisation :

The *Penaeus monodon* post-larvae, used in this study were obtained from Skyline Hatchery, Kumta (Dist. Karwar, Karnataka). The post- larvae were acclimatized using filtered sea water procured from Mirya Bay, Ratnagiri, in plastic pools of 500 l capacity for a period of one week prior to their transfer to the experimental tanks. During this period, the post- larvae were fed with *Artemia* nauplii daily and continuous aeration was provided.

Determination of lethal (acute) temperature (LT_{50}):

The static bioassay was conducted by using glass aquaria in order to determine 96 h LT_{50} for post-larvae by temperature controlling devices (APHA, 2012). The healthy post- larvae were stocked at a density of 10 no's tank^{-1} with different temperatures, *i.e.* 28 (T_1), 30 (T_2), 32 (T_3) and 34 ^{0}C (T_4), to find out the temperature, lethal to 50 per cent of post-larvae (LT_{50}). Based on LT_{50} values, three levels of test temperature were selected to determine the effect of temperature on oxygen consumption and growth of post-larvae. Lower level of temperature was fixed as per the average temperature maintained during the acclimatization of newly brought post–larvae to laboratory condition (control) and the upper level being one degree less than the $LT_{50.}$ The third level was being exactly between the upper and lower level.

Effect of temperature on oxygen consumption rate:

At the time of starting this experiment, precaution was taken not to allow the diffusion of atmospheric oxygen into water, contained in the test container by layering liquid paraffin on the surface of water and the water sample was drawn for estimating oxygen by suctioning into BOD bottle. The dissolved oxygen was estimated by using Winkler's method (APHA, 2012) and the actual oxygen consumption rate for post- larvae was calculated at different temperatures as per Strickland and Parsons (1968) method.

Effect of temperature on length/ weight gain :

The length and weight of post-larvae at the start and end of each experiment were recorded for a period of 30 days. Sampling was carried out at an interval of 15 days to observe the growth of larvae. At the time of sampling, larvae from each experimental tub were randomly collected with the help of beaker for recording length and weight of shrimp larvae. The growth parameters namely, length-gain and weight-gain were calculated as per Hari and Kurup (2003).

Analysis :

LT_{50} was determined by the SPSS software version 16.0 and oxygen consumption rate and growth were tested by ANOVA by employing Newman-Keul's multiple comparison test (Snedecor and Cocharan, 1967 and Zar, 2005). Experimental design was planned according to methodology given by Hoang *et al*. (2003).

RESEARCH FINDINGS AND ANALYSIS..........

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Determination of lethal (acute) temperature (LT_{50}):

The average mortality of post- larvae exposed at four different temperatures, 28 (T_1), 30 (T_2), 32 (T_3) and 34 ^{0}C (T_4) is shown in (Fig. 1). In this experiment, no mortality of post- larvae was observed upto 24 h. At the end of exposure period of 48 h, the first total average mortality of post-larvae of 43.33 per cent was observed only at 34 ^{0}C whereas for the exposure period of the 72 h, the total average post larval mortality of 3, 16.67 and 63.33 per cent was observed at temperatures of 30^{0}C, 32^{0}C and 34^{0}C, respectively with no mortalities in the control.

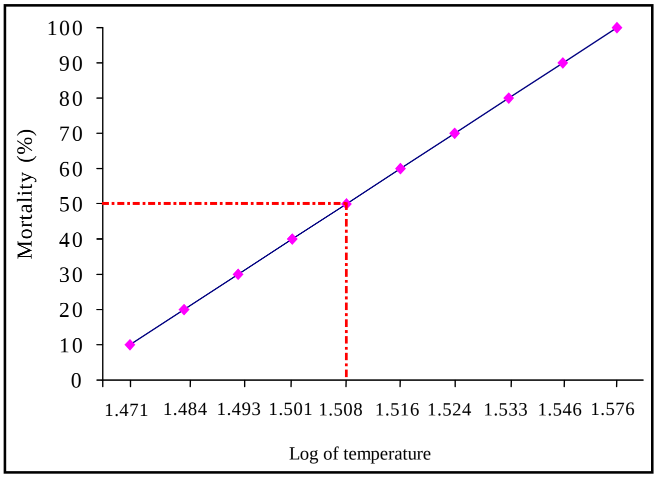

Fig. 1 : Cumulative average mortality (%) of post larvae exposed to the different temperatures for 96 h

At the end of 96 h exposure, the total average mortality of 0, 20, 40 and 80 per cent was observed at 28, 30, 32 and 34 ^{0}C, respectively. The 50 per cent mortality of post- larvae (LT_{50}) as obtained by probit analysis was observed at temperature 32.2^{0}C for 96h. (Fig. 1). Further the present results were compared with that of the results obtained by Hoang *et al.* (2003) who observed that cold tolerance of the sub-adults of *P. mergueinsis* of size 1.6-7.4 g had the highest CTM in of the tested prawns ranging from 4.1 to 10.4 ^{0}C. At cooling rates of 1 and 3^{0}C h^{-1}, the prawns in 24 ^{0}C group had the highest CTM in followed by the 21^{0}C and 18^{0}C groups while prawns acclimated at 15 ^{0}C had the lowest CTM in. Effect of high water temperature on the *P. japonicus* of size 15.6 ± 0.2 g was studied by Hewitt and Duncan (2001) and it was noted that the shrimp maintained at 34^{0}C showed 100 per cent cumulative mortality by day 24, which was different from 28-32^{0}C grouping and from the 36 ^{0}C groups which depicted 100 per cent mortality by day 12.

From the above, it may be concluded that the lethal/ critical (maxima) temperature in shrimp thus, depend on acclimatizing temperatures, species, developmental stage and also other environmental variable.

Effect of temperature on oxygen consumption rate (mg lit^{-1}) :

The average oxygen consumption rate (mg lit^{-1}) of post-larvae, exposed to different temperatures 28 ^{0}C (T_1), 29.5 ^{0}C (T_2) and 31^{0}C (T_3) over a period of seven days are presented in the (Fig. 2). A gradual increase in the oxygen consumption rate of post- larvae was observed from 28 to 31^{0}C. The maximum oxygen consumption rate of post-larvae was observed at 31^{0}C (0.90 mg lit^{-1}) contrary to minimum at 28 ^{0}C (0.27 mg lit^{-1}).

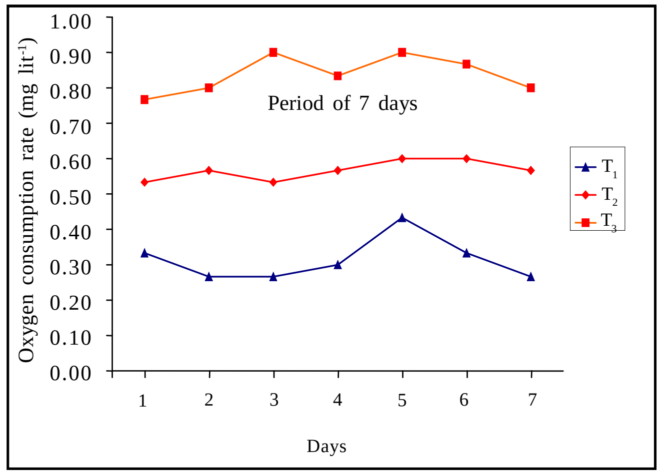

Fig. 2 : Average oxygen consumption rate (mg lit^{-1}) of post larvae exposed at different temperatures during a period of 7 days

One-way ANOVA analysis showed a significant temperature impact on average oxygen consumption rate of post-larvae. Student-Newman Keul multiple range test (SNK) indicated that average oxygen consumption rate of post-larvae at 31^{0}C (T_3) was significantly higher ($P \geq 0.05$) than that of 28 and 29.5 ^{0}C.

Oxygen consumption rate in juvenile (<20mm) *Crangoncrangon* was studied by Donk and De Wilde (1981) with directly proportional increase when maximum temperature of 30 ^{0}C was reached. At higher temperatures, mean O_2 consumption decreased except in the case of the standard metabolism values. In the present study also, the oxygen consumption rate increased at 31 ^{0}C with the least oxygen consumption rate at 28 ^{0}C. The observations are in close agreement considering the size specific tolerance of both the shrimp species. The influence of water temperature on oxygen consumption in shrimp has been demonstrated by Diaz *et al.* (2004); Tian *et al.* (2004) and Gonzalez *et al.* (2010) with the possible role of metabolic compensation and osmoregulatory ability.

Effects of water temperatures on length- and weight- gain (Growth parameters) :

Length gain (%) :

The average length gain of post-larvae, exposed to different temperatures, 28^0 C (T_1), 29.5^0 C (T_2) and 31^0 C (T_3) over a period of 30 daysare presented in Fig. 3. The maximum average length gain of 102.40 per cent was observed at 29.5 ^{0}C, whereas at 31^0 C the minimum average length gain of 67.27 per cent was noted.

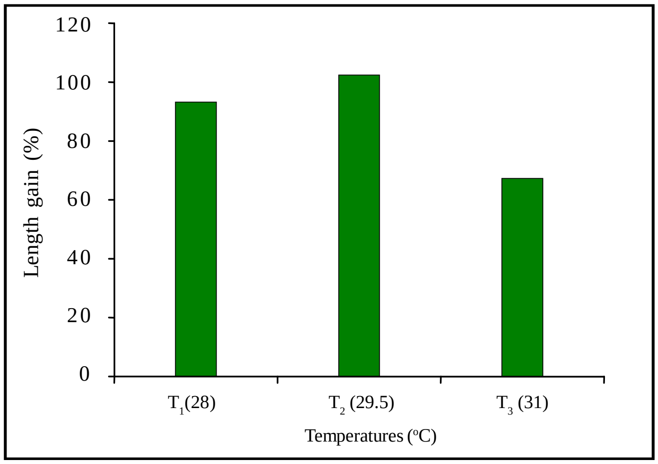

Fig. 3 : Average length gain (%) of post larvae exposed at different temperatures for a period of 30 days

One-way ANOVA showed significant difference ($P \geq 0.05$) in the average length gain (%) of the post-larvae exposed to different temperatures. Student-Newman Keul multiple range test (SNK) indicated that average length gain at 31^0C was significantly higher ($P \geq 0.05$) than that of 28 and 31^0C.

Weight gain (%) :

The average weight gain of post- larvae exposed to different temperatures, 28^0 C (T_1), 29.5^0 C (T_2) and 31^0 C (T_3) over a period of 30 days is depicted in Fig. 4. The maximum average weight gain of 162 per cent was observed in 29.5^0 C and the minimum weight gain of 124 per cent in 31^0 C.

One-way ANOVA showed significant difference ($P \geq 0.05$) in the average weight gain (%) also for the experimental post-larvae. Student-Newman keul multiple range tests revealed that average weight gain (%) in 29.5^0

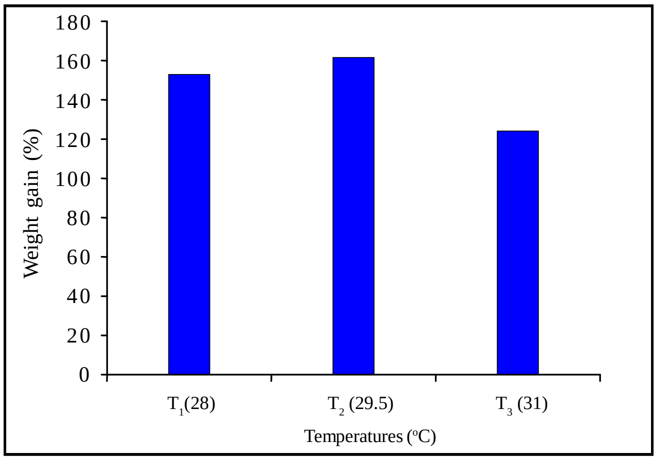

Fig. 4 : Average weight gain (%) of post larvae exposed at different temperatures for a period of 30 days

C was significantly higher ($P \geq 0.05$) than 28 and 31^0 C.

In a study by Jackson and Burford (2003), the slowest growth from late nauplius to first mysis stage in *P. semisulcatus* for 5 to 6 days was found at 20^0 C and the growth index increased significantly at each higher temperatures. However, growth at 32^0 C was marginally greater than at 29^0 C. In the present study the lowest growth rate was observed at 31^0 C and significant increase was observed at 29.5^0 C over a period of 30 days. The differences probably reflect the size dependent growth resistance to the ambient temperature. Zein-Eldin and Griffith (1969) noted that the post larval growth rate of *P. aztecus* increased rapidly between 15 and 20^0 C and continued to increase at slower rate between 20 and at 25^0 C while at 35^0 C, the growth rate decreased. In the present study also, the growth rate was observed to initially increase and then decrease at 31^0 C indicating similar growth pattern in relation to temperature.

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