PHYSIOLOGICAL RESPONSES OF BROWN MUSSEL (*PERNA INDICA*) TOWARDS ALTERNATIONS IN MARINE TEMPERATURE

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KEYWORDS

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ABSTRACT

The brown mussel, *Perna indica* is an important marine bivalve resource due to their dietary and medicinal properties. The increasing atmospheric CO₂, ocean warming and consequent acidic changes of the ocean waters adversely affected these sedentary organisms by directly influencing the physiological activities and their energy levels. Experiments were conducted in the present study to infer the influence of temperature on the physiological responses of *Perna indica* collected off Kadiapattanam coast, Tamil Nadu, India. The mussels were acclimatized at three different temperatures viz., 25.0, 30.0 and 35.0°C and the oxygen consumption levels were examined. The results indicated that the smaller size group *P. indica* (viz., 30 mm shell length) was more active at 35.0°C compared to the larger size groups. The oxygen consumption of *P. indica* acclimated at 35.0°C was higher with 0.61±0.01mL/g/h than those acclimated at 30.0 and 25.0°C. It was also observed that at 25.0 and 30.0°C, the mussels started secreting new byssal threads and the numbers of threads formed were at the rate of 5±0.05 and 6±0.05 respectively per hour. However, byssal threads were not produced by those specimens reared at the elevated temperature of 35.0°C. The observations point out to the fact that temperature increase due to global warming could adversely affect physiological responses of the brown mussel in its natural marine conditions.

INTRODUCTION

Mussels are commercially valuable species and amenable for large scale cultivation along with coastal areas. They are very important for marine ecology and for human diet, since they are an important source of nutrients. Consumption of these bivalve molluscs provide an inexpensive source of protein with a high biological value, essential minerals and vitamins (Astorga-Espana et al., 2007). Mussels are rich in omega-3, fatty acid which help to prevent the cardiovascular and heart disease. Zinc content of mussel promotes mental alertness and aids in proper brain function. In numerous studies the influence of the different environmental and nutritional conditions on the composition of mussels has been proven (Astorga-Espana et al., 2007; Khan et al., 2006). On the other hand, temperature over 20ºC (Incze et al., 1980) and variation in salinity (Bohle, 1972) can decrease growth. Widespread mussel spat settlement occurs in the intertidal and subtidal areas during the post monsoon period. Substantial spat also perish due to adverse ecological conditions (Appukuttan et al., 2001). Temperature is the most important environmental parameter for aquatic life. Rising temperature up to certain limit favors aquaculture by reducing the time required to produce marketable sized animal and produces more generation per year. On the contrary, temperature adversely affects the health of aquatic animal by increasing metabolic rates and subsequent oxygen demand and assisting proliferation, invasiveness and virulence of bacteria and other pathogens that cause a variety of pathophysiological disturbances in the host (Wedemeyer et al., 1999). Currently the importance of temperature investigation was carried out to infer the effect of different marine temperatures (25, 30, 35ºC) on the physiological responses in various shell sizes (30, 40, 50 and 60 mm) of brown mussels *Perna indica*, including O₂ consumption, Ammonia excretion, CO₂ content in mussels acclimatized water, as well as byssal thread formation.

MATERIALS AND METHODS

Mussels

Mussels with shell lengths ranging from 30 to 60 mm were collected from the Kadiyapatanam coast, Kanyakumari district (8º07’ 57” NL and 77º19’ 27” EL) and transported quickly to the laboratory in wet and aerated conditions. The mussels were detached carefully from their clumps by cutting their byssus threads with scissors, to avoid damaging the pedal apparatus which would impair their re-secretion. They were maintained in large wide mouth conical flasks (1L capacity) in sea water with adequate air supply. The temperature of sea water was maintained at 25, 30 and 35°C in the holding flasks of different size groups such as 30, 40, 50 and 60 mm.

Estimation of oxygen consumption, ammonia excretion and CO₂

The rate of Oxygen consumption was measured using respirometer fabricated indigenously by the modified Winklers method (APHA, 1998). The amount of
The mussels were placed for acclimation for 1 h in a conical flask containing 1000 mL aerated, unfiltered seawater for a minimum 1 h. Temperature of 25, 30 and 35ºC were maintained in each respective group of conical flask. The different size group of mussels were introduced into the conical flask at the given temperature, without damaging the thread and the length was measured using a 0.05mm precision caliper. The experiment was repeated 5 times in each temperature with each shell size group.

Statistical analysis
All the results were given with standardized mean (±SD) values and were graphically represented. One-way ANOVA was used to detect the significant differences of the effect of temperature.

RESULTS
At 25 to 26ºC (normal temperature) the O₂ level was 4.52 ± 0.10mm/L. The O₂ level was 18 ± 0.14mg/L and ammonia level was 4.32 ± 10µg/L. The 30 mm length group of mussels produced was noted an average 2 ± 0.107 of threads; while 40mm of mussels produced 2 ± 0.014 threads. No thread formation attained in 50mm and 60mm of mussels acclimatized in 1 h, at the normal temperature of 25 to 26ºC. The results of the experiments on oxygen consumption of brown mussel Perna indica under different temperature conditions (25, 30 and 35ºC) are given in Fig.1. In general, the rate of O₂ consumption enhanced with the increasing temperature among the lowest shell size (30mm) group of mussels tested. At 25ºC, the O₂ consumption rate was higher with 0.181ml/lt/g/h among the 30mm size group of mussels and low with 0.152 ± 0.05 mL/g/h along 60mm of mussels. At 30ºC, the highest rate of 0.48 ± 0.01 mL/g/h, among 30mm of mussels was noted, which decreased to 0.163 ± 0.01ml/g/h among 60mm of mussels. At 35ºC, the highest rate was 0.61 ± 0.01 mL/g/h among 30mm of lowest of 0.37 ± 0.01 mL/ g/h in 60 mm of mussels. In all three acclimation groups (25, 30 and 35ºC), the higher rate of O₂ consumption of P. indica was attained at the higher tested temperature of 35ºC among smaller size (30 mm) of mussels was 0.61 ± 0.01 mL/g/h. But the rate of O₂ was very low 0.152 ± 0.05 mL/g/hr in 60mm of mussels acclimatized at 25ºC water. One-way ANOVA analysis showed a significant effect of temperature on oxygen consumption rate (F = 9.984 p≤0.005) could be noted for Fig.1. The results of experiment on CO₂ content in 1 h, after the various sizes (30, 40, 50, 60 mm) of mussels acclimatized with various temperature (25, 30 and 35ºC) are presented in Fig. 2. The CO₂ content increased at higher temperature among the smaller shell size group of mussels. The CO₂ level was highest with 23.4 ± 0.1mg/L at 35ºC in 30mm size. But at the rate of CO₂ level was very low (18.3 ± 0.1mg/L) among 60mm sizes of mussels acclimatized at 25ºC. The CO₂ content of brown mussel acclimatized water increased significantly (F = 27.896 p≤0.00139) as the temperature increased from 25 to 35ºC with 30mm to 60mm shell sizes. The results of ammonia excretion of the brown mussel P. indica under different temperature conditions (25, 30 and 35ºC) are presented in Fig. 3. The ammonia excretion increased with increasing temperature among the smaller size groups. The ammonia excretion at 25ºC for the 60mm shell size group was very low (4.05 ± 0.1µg/L). But the highest level at 35ºC (6.92 ± 0.011µg/L) among lower sizes 30mm was noted. The rate of ammonia excretion of brown mussel P. indica increased significantly (F = 25.9890, p≤0.00182) as the acclimation temperature increased from 25 to 35ºC with 30mm to 60mm sizes of mussels (Fig. 3). Byssus thread formation gradually increased with the increase in ambient temperature in lowest shell sizes. Maximum number was 6 ± 0.05 at 30ºC among the 30mm size group. The lowest thread formation was also at 30ºC but highest shell size (50mm). Interestingly no thread formation occurred at 35ºC among all the group of shell sizes (Fig. 4). One-way ANOVA analysis showed a significant effect (F = 2.293, p≤0.001) of temperature (25 to 35ºC) with in different sizes 30 to 60 mm in the formation of threads. The highest length size of 12.5 ± 0.1mm of thread find out in 50mm of shell size at 30ºC. But the lowest thread length was measured at 25ºC in 40mm shell size as Fig. 5. One-way ANOVA analysis showed a significant effect (F = 4.4712, p≤0.001) of temperature (25 to 35ºC) with various sizes (30 to 60 mm) on formation of new thread length.

DISCUSSION
The information on relationship between water temperature with shell size and oxygen consumption is not only useful for comparative physiological aspects, but also essential for aquaculture, transporting of stocks, harvests as well as, mussel fishing management options along the coastal areas. The present study revealed that the lower size group of P. indica average 30mm length showed higher rate of O₂ consumption at the tested elevated temperature of 35ºC. This aspect relates their sensitivity to temperature. Similar reports were revealed by a few researchers indicating the relationship between metabolic rates of bivalve molluscs and temperature. Metabolic rates of bivalve molluscs usually increase directly with the ambient temperature, up to an optimum limit beyond which they rapidly decrease (Shumway, 1982; Yang et al., 1998; Yukihira et al., 2000; Wang et al., 2002). This peak and decline in metabolic rates could be related to the balance between two opposite effects at temperature increases: to speed up chemical reactions versus greater denaturation of the enzymes that catalyze them as suggested by Yukihira (2000). Effect of seasonal temperature on O₂ consumption in relation to body size of fresh-water fish, the flying barb, Esomus dandicus (Ham.) was documented by Bhattacharya and Subha (2006). Ammonia excretion is known to be affected by factors such as species, body weight, water temperature, feeding and ration size (Yager and Summerfelt, 1993). Results of this study are in agreement with earlier reports on the weight specific rate of excretion. Ammonia induces detrimental changes in tissue structure, cell function, blood chemistry, osmoregulation, disease resistance, growth and reproductive capacity (Jenny et al., 1992).
The results indicated that the ammonia excretion also increased with the increase in temperature suggesting degradation of protein for energy was more at elevated temperature. Ammonia excretion decrease with increasing body weight and increase with increasing water temperature were reported in fasting organisms. Thus it could be inferred that the degradation of protein was more at elevated temperature as evidenced from higher ammonia excretion in Brown mussel *P. indica*. Coastal zones are ecologically and economically important and are among those areas that will be strongly affected by global climate change. It is commonly accepted that increases in anthropogenic emissions of carbon dioxide (CO\(_2\)) in the atmosphere are mainly responsible for Global Climatic Changes. Increasing atmospheric CO\(_2\) concentrations is expected to increase mean temperatures and a higher frequency of thermal extremes as well as to ocean acidification. Anthropogenic climate change poses a serious threat to biodiversity. In marine environments, the important abiatic changes are likely to be increased water temperature and elevated carbon dioxide concentration (Harley et al., 2006). In marine environments, multiple climate variables, including temperature and CO\(_2\) concentration are changing simultaneously. Although temperature has well-documented ecological effects, and many heavily calcified marine organisms experience reduced growth with increased CO\(_2\), little is known about the combined effects of temperature and CO\(_2\) as indicated by Rebecca et al. (2009). Global climate changes...
changes are predicted to occur in the next hundred years through increases in temperature, water acidification and changes in sea water salinity (IPCC, 2007). This study also indicated that, experimental shells of lower size group of mussel when acclimatized to higher water temperature excreted more carbon dioxide content (23 ± 0.01mg/L) while comparison with increased shell size mussel. It also revealed that lower water temperature indicated lower carbon dioxide content. According to Saha et al. (2011), the mussels Geukensia demissa, Mytella charruana, had lowered their byssal thread production capabilities at the colder tested temperature of 10ºC and 13ºC than at the control temperature of 23ºC. However, based on the results from our current study, temperature would act as a barrier to where in P. indica could not establish, and itself due to non production of byssal thread, at elevated water temperature of 35ºC during the extended period of experimental duration. These observations point out to the fact that the rise in temperature as a consequence of global warming could adversely affect physiological responses of the brown mussel P. indica in its natural marine conditions.

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Plate 1: New thread formation with in 1h among 30mm shell sizes of P. indica at 25°C

Plate 2: New thread formation in P. indica with in 1 h among 30mm shell size at 30°C

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