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NOTE

A study on the metabolism in green mussel *Perna viridis*

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Abstract

Measurements of oxygen consumption and ammonia excretion were made from different size groups of green mussel, *Perna viridis* collected from Ratnagiri coast in Maharashtra. Oxygen: Nitrogen ratios were calculated by atomic equivalents and ranged between 57.5 and 96.5 for small, 80 and 86 for medium and 80 and 85 for large mussels on day 1, but after day 3, 116.2-120.5, 101.1 – 105.5 and 77.7 – 84.4 for the above respective groups. Decline in excretion rate during starvation, has been proposed as an index of stress. The study supports interaction of oxygen consumption and nitrogen excretion, which help in understanding oxidative and nitrogen metabolism of the animal.

Proteins ingested through food are hydrolyzed in the digestive system to their constitutive amino acids by proteolytic enzymes. These amino acids are then accumulated for carbon and nitrogen catabolism. Hammen (1968) reported 4 nitrogenous compounds (ammonia, urea, amino acid and uric acid) excreted by *Crassostrea virginica* and *Mercenaria mercenaria*. A number of investigators have studied nitrogen excretion of molluscs. It is clear from their study that the size (Johannes, 1964), physiological state (Widdows and Bayne 1971) or environment of the organism (Feng *et al.*, 1970) can affect nitrogen excretion.

It is evident that the energy content of excreta comprises a significant component of total energy loss. The nitrogenous excreta, a major component in excretory loss, could be more readily estimated. The composition of this component varies between species as a result of environmental conditions. But in most marine molluscs, ammonia is assumed to be the dominant end product of protein catabolism. Among a variety of bivalves, ammonia comprises 60% to 90% of total measured nitrogen excretion in certain circumstances (Bayne, 1976), however, primary amines may also comprise a significant component (Bayne and Scullard, 1977). Review of literature reveals paucity of information on O: N ratio of marine molluscs from India. Howkins *et al.* (1986) reported O: N ratio of *Perna viridis* and *P. indica* from Cochin waters where impact of eutrophication is pronounced.

Mathew and Menon (1993) reported heavy metal stress induced variation in

O: N ratio in *P. indica* and *Donax incarnatus*. Recently, Nagwanshi (1996) reported O: N ratio of freshwater mussels *Lamallidens corrianus*, while Yennawar (1997) determined this ratio in oyster *Saccostrea cucullata* from Maharashtra coast. Patare (1998) reported it in the clam *Meretrix meretrix* in estuaries in Raigarh and Ratnagiri districts of Maharashtra. In view of the paucity of information on O: N ratio in *P. viridis* from this area, a study was undertaken on different size groups of this species from Bhatye Creek in Ratnagiri coast of Maharashtra. An attempt was also made to understand the size dependent variation and effect of starvation.

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Material and methods

Just before the commencement of monsoon, i.e. first week of June 1994, thirty mussels were collected from the Bhatye Creek in Ratnagiri coast and brought to the laboratory. The shells were cleaned and the mussels were divided into three size groups of shell length, viz., small (66 – 81mm), medium (100 – 112 mm) and large (131 – 135mm). Each group comprised of ten specimens. After measuring length and weight of each individual mussel, they were kept in double filtered seawater with continuous aeration. Ten closed respiratory chambers of one-liter capacity each with an inlet and outlet were used for determination of oxygen consumption of individual mussel. They were kept in a continuous flow of filtered seawater inside the chamber in order to open the valves. Once they opened their valves, the flow of water was stopped and a sample of seawater from it was drawn for determination of initial oxygen content and ammonia. After one hour, 100 ml sample of water from the chamber was drawn to find out the oxygen content. At the same time 50ml water sample from the chamber was also drawn and processed for the analysis of ammonia by Phenol – phinate method (Widdows 1985).

The oxygen consumption, ammonia excretion and O: N ratio (in this ratio by using atomic equivalents) were calculated. The mean values for ten mussels of each group were used for statistical analysis. The estimations of oxygen consumption and ammonia excretion were made again after three days of starvation under nor-

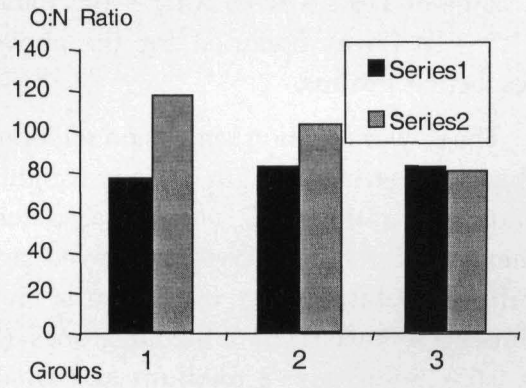

Fig. 1. *The variations in the O: N ratios after day one and after day three of starvation in different size groups of* Perna viridis *from Bhatye creek at Ratnagiri. Group 1 – small sized, Group 2- medium sized and Group 3- large sized. Series 1 - O : N ratio after day one, Series 2 - O : N ratio after day three.*

mal laboratory conditions. Double filtered seawater was changed once in a day and constant aeration was provided.

Results

The rate of oxygen consumption of the small, medium and large specimens, on day one ranged from 0.129 to 0.216, 0.09 to 0.097 and 0.073 to 0.095 ml/g/h respectively. But on day 3, the values were 0.274 to 0.285, 0.102 to 0.108 and 0.079 to 0.085 ml/g/h for the above respective groups. The rate of ammonia excretion of the individuals in the respective size groups after day one ranged from 2.8 to 3.0, 1.5 to 1.6 and 1.2 to 1.4 *u*g/l/g/h. After day 3, it was 2.9,1.3 and 1.3 *u*g/l /g/h. The calculation of O: N ratio after determining the atomic equivalents of oxygen and nitrogen were 57.5 – 96.5 for small, 80 – 86 for medium and 80 –85 for large mussels after day one and after day three a range of 116.2 – 120.5,101.1 – 105.5 and 77.7 – 84.4 was obtained for the above respective groups.

The power function regression relationship between shell length or body weights and O: N ratio for *P. viridis* was determined. The ratio on day one showed significant relationship in medium size mussels ($P < 0.001$) than the large ones ($P < 0.05$). After day, 3 medium and small sized mussels showed significant relationship ($P < 0.0001$ and < 0.05 respectively). When the ratio was calculated against weight, only medium sized mussels showed significant correlation ($P < 0.001$). However, after three days, the medium sized specimens showed highly significant correlation ($P < 0.001$) compared to large mussels ($P > 0.05$).

Discussion

In the present study, experiments on the green mussel from different localities were performed just before monsoon and both oxygen consumption and ammonia excretion rates were higher in small individuals than medium and large ones, which possibly showed reliance of mussels on carbohydrate and protein metabolism. The effect of shell valve activity on oxygen consumption rates has been noted by several authors (Galtsoff,1964; Bidarkar, 1975 and Mane, 1975).

The present study indicated that the O: N ratio increased after three-day starvation. Oxygen uptake was mainly dependent on reproductive condition in summer, but ammonia excretion was maximum during spring. The energy utilized in oxygen uptake and ammonia excretion was significantly different depending on the season and temperature, but the season being an important factor could affect the overall fitness of the animal (Navarro and Torrijos, 1994). The effect of starvation interact with the seasonal changes; small individuals with a relatively small glycogen reserve increase considerably their protein catabolism during starvation, where as larger ones to a greater extent on their relatively large glycogen stores (Bayne, 1973a). The present study also recorded changes in the O: N ratio resulting from starvation and exposure to

increased temperature. Changes in the ratio correlated reasonably with gross biochemical changes in the tissue (Gabbot and Bayne, 1973; Bayne, 1973 b). Changes in the O: N ratio due to starvation was further documented in *M. edulis* by Bayne (1973 b). Since the metabolic rate is strongly dependent on body size, it is necessary to introduce a weight correlation comparison between animals of different sizes. It is well known that weight specific metabolic rate (ml $O_2 g^{-1} h^{-1}$) is lower in large organisms than in small ones. This generalization applies in both interspecific comparisons between molluscs of different sizes and between individuals of any one species. In the present study, in *P. viridis* the weight specific oxygen consumption followed a general trend of acceptance, i.e. higher values for small sized animals than large sized mussels. Mane (1975) and Bayne (1976) stated that body size in bivalve has important implication. Populations that are dominated by large or old individuals have a lowest value than those composed of small individuals. It also shows that the energy flow through small individuals or species may be much greater than larger ones.

The ratio of atomic equivalent of oxygen consumption to nitrogen excretion can provide indices of the balance in animal tissues between the rates of catabolism of proteins, carbohydrate and lipid substrates. Changes in the rates of nitrogen excretion are best understood in the context of physiological energetics and nitrogen balance when related to overall metabolic rate by means of the oxygen: nitrogen ratio. This ratio, when calculated by atomic equivalents, may be used to indicate the proportion of protein catabolised relative to carbohydrate and lipid. A low value of O: N (~10) signifies considerable protein metabolism.

In both *Prolinices* spp. (Mace and Ansell, 1982) and *Thais lapillus* (Strickle and Bayne, 1982), the O: N ratio did not alter with size that is the exponents for rates of oxygen consumption and ammonia excretion against body weight. With *Mytilus,* however, the ratio varied considerably with size and the complex interaction with seasons, temperature and ratio (Bayne and Scullard, 1977). Bayne (1976) stated that if the amino acids which result from protein catabolism are deaminated and the resulting ammonia excreted, while the carbon skeletons of the amino acids are completely oxidized, the theoretical minimum for the O:N ratio is about 7, signifying unequal protein catabolism. Higher values for O: N ratio indicate increased catabolism of carbohydrate or lipid. The O: N ratio increase in mussels of various sizes after starvation stress and its difference noticed between individual size group at the significant level (statistical) could be due to the state of gonadal development and level of metabolic activity. Further study is needed to evaluate the seasonal variation in the O: N ratio amongst mussels of different sizes.

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