

## **Aquatic and aerial respiration of an intertidal tropical gastropod *Morula granulata* (Duclos) in relation to temperature**

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**Abstract.** The rates of aquatic and aerial oxygen consumption of an intertidal tropical gastropod *Morula granulata* increases with increasing temperature. The temperature at which the breakdown occurred in their oxygen consumption was observed to be different, 45°C for aquatic and 42°C for aerial respiration. However, the aquatic rates of oxygen consumption were higher than the aerial rates at all temperatures studied. The aquatic and aerial  $Q_{10}$  values showed almost the same trend, higher at lower temperatures and *vice versa*. The results were discussed in relation to the habitat of the animal.

**Keywords.** Aerial respiration; aquatic respiration; tropical gastropod; *Morula granulata*.

### **1. Introduction**

It is well established that many intertidal molluscs are capable of utilising atmospheric oxygen and the ability has generally been considered to be predominantly high in high tide level molluscs (Newell 1979). Comparison of a number of species of molluscs indicates that the ability to utilise atmospheric oxygen is very much related to their position in the intertidal zone (Micallef 1967). In general, high level bivalves (Widdows *et al* 1979; Griffiths and Buffenstein 1981) and a variety of gastropods (Sandison 1966; McMahon and Russell-Hunter 1977; Prabhakara Rao and Prasada Rao 1983) are able to meet much of their metabolic energy demands by aerial oxygen consumption during intertidal exposure.

A perusal of the literature shows that most of the work has been carried out only on temperate species except the works of Houlihan (1979) on three mangrove snails and Prabhakara Rao and Prasada Rao (1983) on two tropical gastropods *Cerithidea cingulata* and *Cerithium coralium*. The purpose of the present investigation is to study the temperature related aquatic and aerial oxygen consumption of an intertidal tropical gastropod *Morula granulata* inhabiting mid tide level. As such these animals are exposed to air during low tide. Since exposure may be a convenient means of reducing metabolism, the effect of temperature change on the aerial and aquatic oxygen consumption was studied.

### **2. Materials and methods**

Animals of about the same size (wet weight of the animal without shell ranges from 85–109 mg) collected from Palm beach of Visakhapatnam, were kept in the laboratory at  $25 \pm 0.5^\circ\text{C}$  in aerated running sea water (Whatman 42 filtered (32‰)) for 24 hr.

Preliminary experiments showed that oxygen consumption was fairly steady up to 24 hr, therefore, all the experiments were planned within this period.

The aquatic oxygen consumption was determined as described earlier (Prabhakara Rao and Prasada Rao 1983). The aerial oxygen consumption was estimated by using Warburg's Respirometer (Prabhakara Rao and Prasada Rao 1983). Both the aquatic and aerial oxygen consumptions were measured at 15, 20, 25, 30, 35 and 40°C but the highest temperatures *i.e.*, 45°C for aquatic and 42°C for aerial were fixed depending on the breakdown in each medium. At each temperature, 40 different animals were used and they were allowed to acclimatize for 30 min. Thus the effect is acute. After the experiment, the soft parts of the animal were removed from the shell and the wet weight was considered for calculations. The average body weight and the average hourly oxygen consumption were presented in the data. The M-T curves were presented using semilog graphs.  $Q_{10}$  values were calculated using the formula  $Q_{10} = k_1/k_2^{(10/t_1 - t_2)}$  (Prosser and Brown 1965).

### 3. Results

A semilog graph of the average rates of aquatic and aerial oxygen uptake of *Morula granulata* is shown in figure 1. It is clear from the M-T curves that there was a peak in its

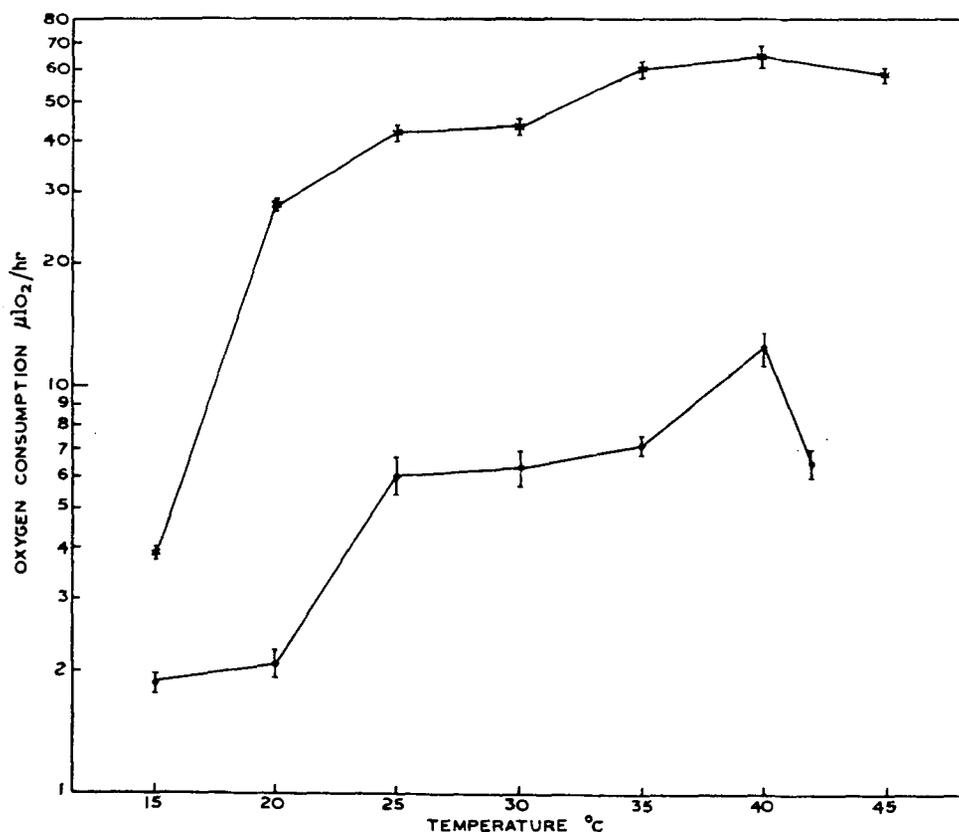


Figure 1. Semilog plot showing the comparison of aquatic (x) and aerial (●) oxygen consumption of *M. granulata* at different temperatures (vertical bars represent standard deviation).

**Table 1.** Aquatic to aerial ratio of oxygen consumption in *Morula granulata* at different temperatures.

Temperature (°C)	Aquatic:Aerial respiration
15	2.08
20	13.25
25	6.86
30	6.81
35	8.36
40	5.14

**Table 2.** Comparison of  $Q_{10}$  values of aerial and aquatic respiration rates in *Morula granulata* at different temperatures.

Range of temperature (°C)	$Q_{10}$ values	
	Aerial	Aquatic
15-25	3.26	10.69
20-30	3.03	1.55
25-35	1.18	1.44
30-40	1.97	1.49
15-20	1.25	7.10
20-25	8.46	1.50
25-30	1.08	1.03
30-35	1.29	1.40
35-40	3.02	1.07

aquatic and aerial rates of oxygen consumption at 40°C beyond which there was a metabolic breakdown at 45°C for aquatic and at 42°C for aerial medium. It is also seen that the aquatic and aerial rates were found to be low below the ambient temperatures *i.e.*, at 15 and 20°C. In *M. granulata* aquatic rates of oxygen consumption are significantly higher ( $P < 0.001$ ) than aerial rates at all temperatures studied.

The aerial:aquatic oxygen consumption ratios of *M. granulata* at different temperatures are given in table 1. It is clear from the table that at all temperatures the aquatic consumption was approximately 2-14 times higher than the aerial rates.

Table 2 represents the temperature coefficient values ( $Q_{10}$  values) of aerial and aquatic respiration of *M. granulata*. It is evident from the table that the aerial and aquatic  $Q_{10}$  values show more or less the same trend, higher at lower ranges of temperatures and *vice versa*.

#### 4. Discussion

It is evident from the results that both aquatic and aerial oxygen consumption of *M. granulata* are temperature-dependent. But 'critical temperature limits' are different for both the consumptions which may be due to relative preference of *M. granulata*

towards aquatic conditions. In the habitat, *M. granulata* experiences more aquatic conditions than aerial. Similar differences were observed by McMahon and Russell-Hunter (1977) for *Acmaea testudinalis* and *Littorina saxatilis* which have critical temperatures of 25°C in air and 30°C in water.

Though *M. granulata* exhibited an increase in the aerial and aquatic respiration with increase of temperature up to 40°C, the rate of increase is not the same throughout the range of temperatures (figure 1). However, there is a thermal range (25–40°C) over which the effect of temperature is very little indicating some of the 'homeostatic mechanisms' probably in operation as has been suggested by Bullock (1960) in most of the poikilothermic animals. A comparison of the M-T curves (figure 1) shows that this 'homeostatic range' is the same for both aquatic and aerial respiration.

It is clear from the comparison of the M-T curves (figure 1) that the displacement is similar towards higher temperatures in both aerial and aquatic respiration showing its tropical habitat (Scholander *et al* 1953). However, the displacement of the curve is slightly towards the higher temperatures in aquatic than in aerial respiration indicating its less adaptation to aerial temperatures because of mid tide distribution in the intertidal zone.

Houlihan and Innes (1982) made a generalisation that mid and high shore gastropods (50–90% aerial exposure) have aquatic to aerial ratios of  $\approx 1$ . But according to Branch (1979), this generalisation is not always valid. *M. granulata* of the present study, though a mid shore animal occurs in rock crevices and percentage aerial exposure is very low (35%) (Fretter and Graham 1962). This might be one of the reasons for its low aquatic to aerial ratios. Similar trends of low aerial rates were demonstrated by Sandison (1966) for mid and high shore gastropods and McMahon and Russell-Hunter (1977) for high shore species. This elucidates that *M. granulata* is mostly adapted to aquatic environment.

$Q_{10}$  values of *M. granulata* for aerial respiration are higher than for aquatic respiration except at the low temperature range 15–25°C (table 2). This might be due to adaptation of *M. granulata* more to the aquatic habitat which is possible by this mid level distribution in the intertidal zone. However, similar high  $Q_{10}$  values for aerial oxygen consumption have been reported in the mangrove snails *Nerita articulata*, *Cerithidea obtusa*, *Cassidula auresfelis* (Houlihan 1979) and in *Cerithidea cingulata* and *Cerithium coralium* (Prabhakara Rao and Prasada Rao 1983). Low  $Q_{10}$  values observed at 25–35°C, represent the habitat range of temperature and this is of adaptive value to the animal as has been stated by Scholander *et al* (1953).

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