RESPIRATORY METABOLISM IN *Martesia fragilis* IN RELATION TO BODY SIZE AND NITROGEN

BY V. V. SRINIVASAN

(*Marine Organisms Scheme, Zoology Research Laboratory, University of Madras*)

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The rate of oxygen consumption as a parameter of metabolic activity is of great importance and generally it is size dependent. Zeuthen (1947) in his classical survey of respiration of marine planktonic veliger larvae and adults of *Mytilus edulis*, *Mya arenaria* and *Littorina littorea* correlated the O₂ uptake both to body weight and body nitrogen. Rao (1953) and Jørgensen (1960) however, related the O₂ consumption of *Mytilus californianus* to the rate of water propulsion. Similar studies on wood-boring lamellibranchs are meagre except for accounts on *Teredo* by Lane and Tierney (1951) and Lane *et al.* (1954) who have investigated the respiratory metabolism of adults and larvae both *in situ* and when removed from wood. However, these aspects of study in pholads like *Martesia* which are wood-borers have not received due attention. *Martesia*, like *Teredo*, spends the major part of its life inside timber. But unlike *Teredo* it is an active borer during the early part of its life besides being predominantly a ciliary filter feeder. In the present paper a study of O₂ consumption in relation to these activities is presented.

**MATERIAL AND METHODS**

The oxygen consumption was determined by the Warburg method as described by Umbricht *et al.* (1949). 5 c.c. of filtered sea-water formed the medium while 0·4 c.c. of 20% KOH in the central well of the flask served as an absorbent of carbon dioxide. Each animal was gently transferred into the flask with the shell intact. The experiments were generally run for 2 hours and 30 minutes after an initial equilibration period of 20 minutes. The continuous shaking of the manometers was not resorted to as it would disturb the animals, resulting in the closure of their shell valves and hence was limited to a few seconds prior to a reading. After the experiments, the specimens were carefully removed from their shell, ‘dried’ on a filter-paper
to remove the adherent moisture and weighed in a torsion balance. The results are expressed as $\mu l. O_2/mg.$ wet weight/hr. A few preliminary studies were conducted to determine the $O_2$ uptake of the gill tissue. The dry weights of the tissue was determined in the torsion balance after drying the slices of tissue for 3 to 4 hours at 80°C. The results are expressed as $QO_2/hr$.

The disadvantages mentioned in using Warburg manometers for determining the oxygen uptake by Teredo (Lane and Tierney, 1951) do not seem to apply in the case of Martesia since the animals used were of considerably small size than Teredo (weighing upto 80 mg. wet weight or 16 mg. dry weight) with the result the volume of 5 c.c. of sea-water was sufficient for the oxygen measurements of Martesia. The results obtained with manometric method were checked using Winkler's method. In Teredo (Lane and Tierney, 1951) the removal of the animals from wood results in the mantle being exposed and unsupported by the calcareous lining of the burrow and hence unable to maintain the positive pressure outside the wood. The volume of respiratory flow thus decreases and the mantle develops herniations which are quoted to cause lower respiratory rates in the laboratory experiments. In Martesia as the entire soft body of the animal is within the shell, removal of these animals from wood neither causes injury, upsets the respiratory current of water, nor the positive pressure.

RESULTS

The total oxygen uptake varied from 1.3050 to 28.881 $\mu l/hr.$ in animals weighing 1.3 to 43.9 mg. There was a wide scatter in the results especially in the 9 mg. wet weight group which may be attributed to individual variations. With increase in size increasing oxygen uptake was observed but beyond about 30 mg. wet weight the oxygen consumption indicated a fall.

When the results were plotted in a double logarithmic grid (Fig. 1) the total oxygen consumption did not appear to follow a linear relationship for the entire size range. Therefore, the values of $b$ upto 30 mg. wet weight and beyond it were calculated separately. For the weight range from 1.3 to 27.2 mg. the exponential value of $b$ was $0.55346 \log Y = 0.4369 + 0.5534 \log X$ and from 31.0 to 43.9 mg. group it was $0.30950 \log Y = 0.8462 + 0.3095 \log X$. The fall in the rate of oxygen uptake is indicated since the $b$ value changes from 0.5534 to 0.3095 at 30 mg. size group.
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The results are significant at the 5% level as indicated by t-test. The rate of oxygen uptake shows that between 1.3–27.2 mg. (wet) weight there is a fall in the rate of respiration from 2.444 μl./mg./hr. to 0.508 μl./mg./hr. In larger animals (43.9 mg.) there is a further decrease to 0.3514 μl./mg./hr.

![Figure 1](image)

**FIG. 1.** Oxygen consumption of Martesia fragilis in relation to body weight.

If we consider the young, actively boring, immature animals alone (with foot) the total oxygen uptake is found to vary from 0.16 μl./hr. to 13.82 μl./hr. ranging in weight from 12–27.2 mg. Expressed in terms of unit body weight it is 0.76 μl./mg./hr. to 0.5 μl./mg./hr.

The body nitrogen of Martesia fragilis is about 2.56% of wet weight. When the oxygen uptake is related to unit body nitrogen, the relationship becomes obvious. The total oxygen consumed varied from 3.178 μl./hr. to 21.928 μl./hr. with an increase of body nitrogen. Figure 2 shows the rate of oxygen uptake of Martesia in relation to size (body nitrogen of the
animal). Although the rate of oxygen uptake decreased with increasing body weight, the shape of the curve is different from that found in other species of lamellibranchs. Similarly, the state of maturity also affects the respiratory rates. If two animals, one a boring young form about 13 mg. (body nitrogen) and an adult of 14 mg. (body nitrogen) are compared, the young form consumes more oxygen than the adult (40.9 μl. in young as against 26.3 μl. in the older).

![Graph](image)

**Fig. 2.** Decrease in the rate of oxygen uptake with increase in body nitrogen.

Previous workers have reported a fall in the respiratory rates with time. In a typical experiment the rate of fall from an initial rate of 5.27 μl O₂/hr. to 2.63 μl O₂/hr. at the end of 2½ hours. The fall in the oxygen tension in the flasks in these experiments may have an influence on the respiratory rates.

The rate of oxygen uptake of isolated gills alone varied from 9.947 μl./mg./hr. to 3.687 μl./mg./hr. (Table I). In an animal weighing 45 mg. the gill tissue alone accounts for 30% of the body weight and it would account 60% of the total oxygen uptake. This is not surprising since the gill contains a high nitrogen content indicating higher activity.
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TABLE I
The oxygen uptake of the gill tissues of Martesia fragilis

<table>
<thead>
<tr>
<th>No.</th>
<th>Dry weight mg.</th>
<th>Oxygen uptake µl./hr.</th>
<th>Rate of oxygen uptake µl./mg. dry wt./hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>9.9470</td>
<td>9.947</td>
</tr>
<tr>
<td>2</td>
<td>1.75</td>
<td>12.9820</td>
<td>7.418</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>10.1412</td>
<td>4.056</td>
</tr>
<tr>
<td>4</td>
<td>3.0</td>
<td>16.0416</td>
<td>5.347</td>
</tr>
<tr>
<td>5</td>
<td>3.0</td>
<td>11.0632</td>
<td>3.687</td>
</tr>
<tr>
<td>6</td>
<td>3.0</td>
<td>17.5639</td>
<td>5.854</td>
</tr>
<tr>
<td>7</td>
<td>5.5</td>
<td>28.2550</td>
<td>5.137</td>
</tr>
<tr>
<td>8</td>
<td>6.25</td>
<td>53.9330</td>
<td>8.229</td>
</tr>
</tbody>
</table>

REMARKS

It will be evident from the data presented here, in the species studied, the rate of O₃ uptake decreases with increasing weight. The unit O₃ consumption of Martesia per mg. wet weight declined from 2.44 µlO₂/mg. to 0.3514 µlO₂/mg. in animals increasing in weight from 1.3-43.9 mg. Nagabushanam (1962) observed that M. striata, an allied species, consumes about 0.67 c.c./hr. However, no data has been provided as to the size ranges on which these observations were made. The average oxygen consumption of mature M. fragilis is about 0.56 c.c./gm./hr.

The curve for µlO₂/N is closely comparable to that obtained for the gastropod Littorina (Zeuthen, 1947). The rate of O₂ uptake of Martesia per unit of body nitrogen when compared to forms like Mytilus and Crustacea (Fig. 45; Zeuthen, 1953) is very high and is an indication of higher activity in this animal. Zeuthen (1953) noted that in animals which contained more than 1 mg. N the metabolism grows to a smaller power of the body weight than that found for these which contained less than 1 mg. N. Martesia has less than 1 mg. N and it would appear that up to about 30 mg. (about 0.9 mg. N.) the O₂ consumption increases beyond which there appears to be a fall.
This would support the view that with an increase in body nitrogen after this stage (about 0·9 mg. N) the metabolism grows to a smaller fraction of the body weight (Zeuthen, 1953). Lane and Tierney (1951) found in Teredines that as in Martesia the metabolic rate (as indicated by oxygen consumption) decreases with increase of weight. However, in Martesia this decrease is only upto the level of the mature adult. Thereafter, there is no change either in size or in metabolic rate.

The metabolic rates of Martesia could not be compared to teredines (Lane and Tierney, 1951), since the smallest of teredines studied (27·6 mg. dry wt.) was larger than the Martesia (8·8 mg.). However, for this weight the rate of O₂ uptake for Martesia fragilis is about 2·75 μl./mg., while for 27·7 mg. Teredo it is 272·5 μlO₂/gm. Hence the metabolic rates of Teredines are higher than Martesia. The rate of O₂ uptake of Martesia fragilis is higher when compared to lamellibranchs like Crassostrea virginica, Pecten grandis and Mytilus edulis (15·5 c.c./kg., 70 c.c./kg., 22 c.c./kg.) and Lasaea rubra.

The rate of O₂ uptake of the gill showed that the gills are sites of active metabolism. Gill tissues calculated on a weight basis consumed more of O₂. The gills, mantle and siphons were observed to be responsible for about 60% of total O₂ consumed by the animal.

**SUMMARY**

The rate of oxygen consumption in relation to body size and nitrogen is estimated and presented as index of metabolic rate. The total oxygen uptake in Martesia was found to increase with increase in body weight. This is only upto the level of maturing adult.

The rate of oxygen consumption decreases from 2·444 μl./mg./hr. to 0·280 μl./mg./hr. with increase in body size (wet weight) and 116·70 to 14·63 μl./mg. N with increase in body nitrogen. Over 2½ hours of experimental period, there is a fall in respiratory activity with time.

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REFERENCES


