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Catedral, F. F.

Aquaculture Department, Southeast Asian Fisheries Development Center

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Effect of temperature on the oxygen consumption of *Penaeus monodon* postlarvae

F. F. Catedral and R. Sayson

Introduction

Measurement of oxygen consumption of animals is necessary in the understanding of their metabolism. However, there are a few practical applications, among which are the oxygen levels that have to be maintained during culture or transport. In the culture of tiger prawns *Penaeus monodon* at SEAFDEC, one of the commonly encountered problems is the low oxygen levels in ponds. This occurs especially at night when both plants and animals respire and in some instances when the density of phytoplankton is very high, and the concentration of dissolved oxygen in water goes below the critical level. Another problem concerns fry transport. In some instances, oxygen becomes depleted during transport, causing mass mortality.

The oxygen requirements may be predicted once oxygen consumption is known, and dissolved oxygen levels must be maintained above these values to ensure high survival of the animal. Although other factors may contribute to dissolved oxygen levels in water (*e.g.*, its utilization), basic knowledge of how much oxygen an animal consumes for a given length of time and under specified conditions is necessary in culture. Information gathered may be further utilized in studies on the metabolism of the animal (Clark, 1955; Dehnel, 1960; and Kinne, 1963).

One of the factors that affect oxygen consumption of animals is temperature. It is known that at high temperatures, respiration increases, and likewise, oxygen consumption increases. In as much as temperature varies during culture, knowledge of its effect on the oxygen consumption of the animal is important. Knowledge of temperature effects may also suggest optimal temperatures for transport of fry from the hatchery to fishponds where they will be stocked.

Materials and Methods

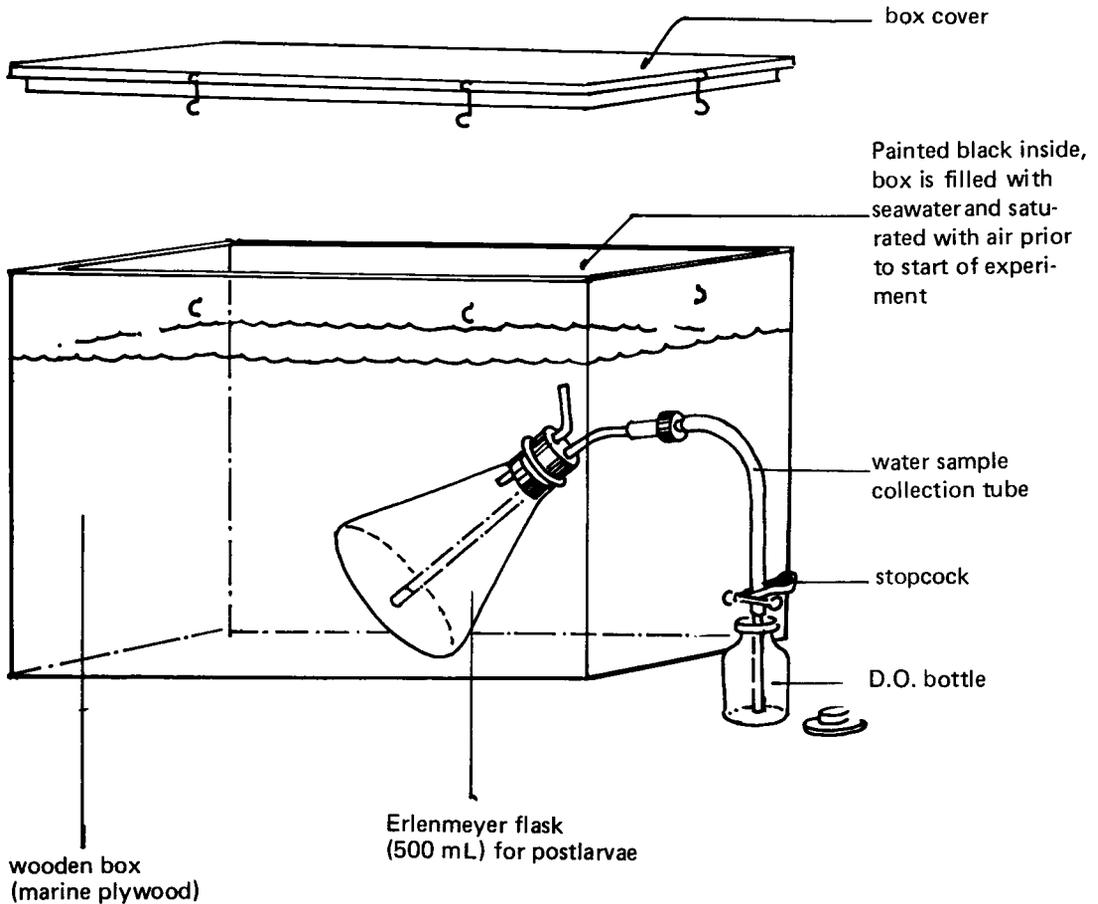
The *Penaeus monodon* postlarvae used in the study were obtained from either the hatchery or the wet laboratory and were reared in retaining aquaria inside the laboratory until used in the experiments. The animals were fed minced mussel or tuna meat daily. The retaining aquaria were maintained at salinities of 30–34 ppt and temperatures between 24 and 28°C.

Fig. 1 shows diagrammatically the setup used for the study patterned after Kutty (4). Five hundred mL Erlenmeyer flasks were used as respiration chambers and placed in the box filled with seawater. The flasks remained submerged in the water during measurement of oxygen consumption. The box was made of marine plywood and the inner walls and lid were painted black. Animals used for the study were fed the day before they were used in the experiment. Feeding was not resumed until after they were placed back in the retaining aquaria.

Oxygen consumption was measured by getting the difference between the dissolved oxygen concentration before and after holding the animals in the respiration chamber. The length of time used varied between 2 and 4 hours, depending upon the number and average weights of the animals. The number of animals used was likewise dependent upon their size, but in all cases, the number of larvae per experimental run ranged from 3 to 30 (0.8 to 80 mg average weight/postlarva, respectively).

To examine oxygen consumption at different temperatures, the seawater in the box was first brought to the desired temperature and the experimental animals acclimated at that temperature for approximately 30 min prior to starting the experiment. Temperatures were measured at the start and end of the experiment.

Fig. 1. Setup for oxygen consumption study.



Dissolved oxygen concentrations were determined using the Winkler method (5) on 100 mL samples drawn from the respiration chamber. Water was allowed to flow through the chamber (about 500 mL) to replace the water inside the chamber with that saturated with air before drawing the sample for initial dissolved oxygen readings. Water was again drawn after allowing the animals to respire for a specified length of time.

The animals were weighed at the end of the experiment and oxygen consumption was expressed as mg O₂ consumed per hr per postlarva.

At least 30 experimental runs were conducted at five different temperature ranges: 20-23°C, 25-27°C, 28-30°C, 30-32°C, and 33-35°C. Correlation between oxygen consumption and weight of postlarva at each temperature was determined, and the equations of the regression lines computed and compared. Data were analyzed using the t-test and analysis of variance.

Results and Discussion

Fig. 2. Shows the oxygen consumption of *P. monodon* postlarvae at five different temperatures plotted against weight of postlarvae. The data show significant correlation at 1% significance level between oxygen consumption and weight (Table 1).

The regression lines were computed using the method of least squares and the following equations were obtained:

$$\begin{aligned}
 20-23^{\circ}\text{C}: Y &= 0.0004422 X + 0.004527 \\
 25-27^{\circ}\text{C}: Y &= 0.0007693 X + 0.004342 \\
 28-30^{\circ}\text{C}: Y &= 0.0009914 X + 0.006882 \\
 30-32^{\circ}\text{C}: Y &= 0.0009641 X + 0.006592 \\
 33-35^{\circ}\text{C}: Y &= 0.0013972 X + 0.004740
 \end{aligned}$$

where Y is mg O₂ consumed/hr/postlarva, and X is weight of postlarva, mg. Analysis of variance shows highly significant dependence of oxygen consumption on the weight of postlarva at 1% significance level (Table 2). The regression coefficient increases with temperature indicating that oxygen consumption is likewise dependent on temperature. This study was limited to temperatures between 20 and 35°C due to problems on survival of the test animals. It was found that high mortality occurred at temperatures below 20°C and above 36°C.

Fig. 3 shows the relationship between oxygen consumption (mg O₂/hr/mg weight of postlarva) and temperature. The midvalues of the temperature ranges were used. (These values are close to the approximate mean temperatures of 21.6, 26.0, 31.4 and 33.9°C.) High correlation between temperature and oxygen consumption was obtained ($r = 0.9562$) and test of significance (5%) showed significant relationship between oxygen consumption and temperature. The regression line, obtained by the method of least squares, was found to give the following equation:

$$Y = 0.00007064 X - 0.001086$$

where Y is mg O₂ consumed per hr per mg weight of postlarva, and X, the temperature in C. Analysis of variance shows significant dependence of oxygen consumption of temperature at 5% significance level.

Results suggest dependence of oxygen consumption on both weight of postlarvae and temperature. The relationships appear linear at the temperature range examined (20-35°C). Postlarvae weighing 0.8-80 mg were used in this study. Those weighing up to 200 mg were also found to follow the same regression lines obtained in this study. Whether or not juveniles and adults will follow the same regression lines will have to be examined.

Table 1. Correlation between oxygen consumption, expressed as mg O₂ consumed per hr per postlarva, and weight of postlarva at five different temperatures.

| Temperature Range, °C | Correlation Coefficient | t(0.01) | |
|-----------------------|-------------------------|----------|-----------|
| | | Computed | Tabulated |
| 20-23 | 0.8988 | 12.47* | 2.70 |
| 25-27 | 0.9532 | 18.92* | 2.72 |
| 28-30 | 0.8783 | 10.06* | 2.75 |
| 30-32 | 0.9797 | 27.21* | 2.75 |
| 33-35 | 0.9304 | 15.65* | 2.72 |

*Highly significant

Table 2. Analysis of variance on the oxygen consumption of *P. monodon* postlarvae at five different temperature ranges.

| Temperature Range, °C | F Value (0.01) | |
|-----------------------|----------------|------|
| | Comp. | Tab. |
| 20-23 | 155.48* | 7.35 |
| 25-27 | 357.43* | 7.37 |
| 28-30 | 101.29* | 7.50 |
| 30-32 | 762.65* | 7.50 |
| 33-35 | 244.81* | 7.33 |

*Highly significant

Table 3. Oxygen consumption of *P. monodon* postlarvae at 5 different temperatures.

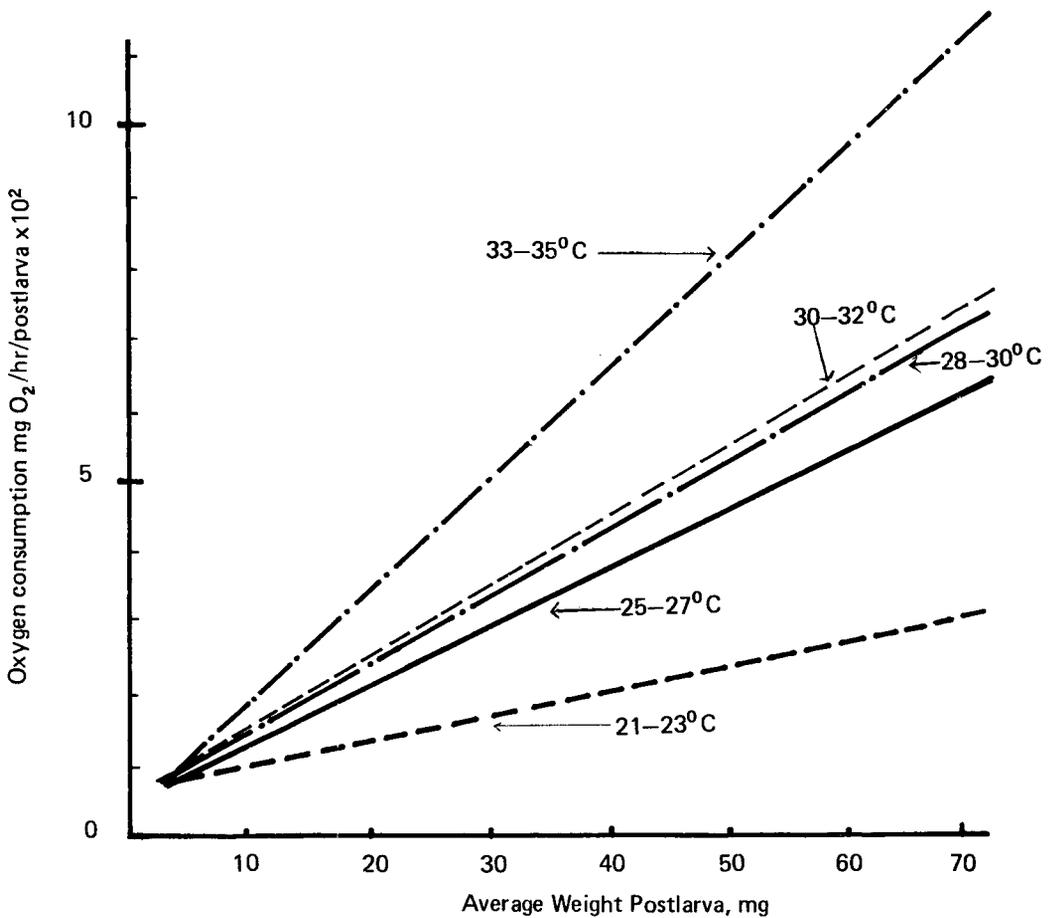
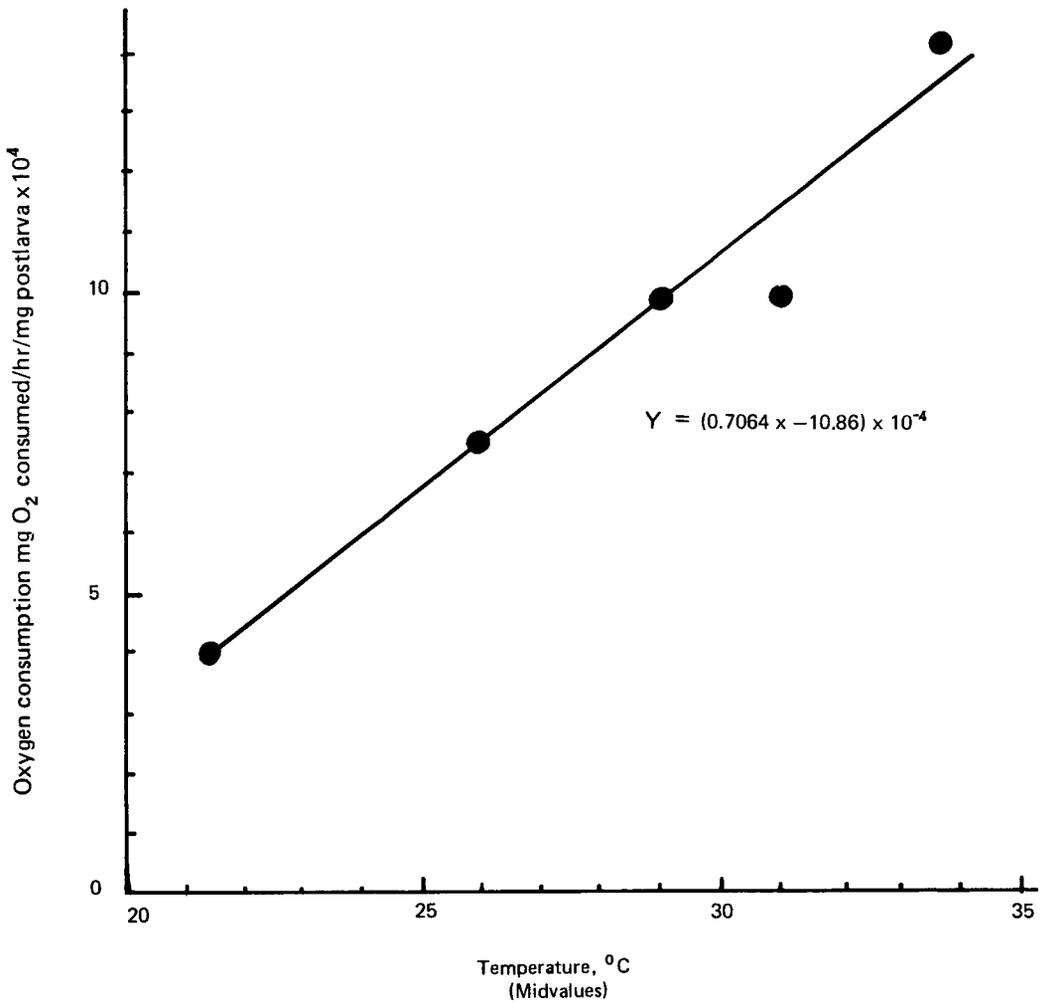


Fig. 3. Effect of temperature on the oxygen consumption of *P. monodon* postlarvae. Regressive coefficient of lines in Fig. 2 are plotted against midvalues of the temperature ranges.



Temperature dependence of oxygen consumption suggests that oxygen requirement (and metabolism) increases with temperature. The study was done only at temperatures which did not subject the test animals to undue stress and may explain why the relationship appears linear. Below 20 and above 35°C, the slope of the line may change.

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