Brief Note: The Oxygen Requirements of the Crayfish, Orconectes Rusticus

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BRIEF NOTE

THE OXYGEN REQUIREMENTS OF THE CRAYFISH,
ORCONETES RUSTICUS

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Although much has been published on the respiration of crayfish (Armitage et al. 1972, Helff 1928, Hiestand 1931, Larimer and Gold 1961, Moshiri and Goldman 1969, Moshiri et al. 1970, Moshiri et al. 1971, Rice and Armitage 1974a, 1974b; Wiens and Armitage 1961), there are no previously published accounts of the oxygen requirements of *Orconectes rusticus*. This crayfish is very common in central Ohio, and its distribution includes most of Ohio and part of Kentucky (Turner 1926, Langlois 1935, Prins 1968). The authors believe that this ecologically important species of crayfish deserved further study, particularly regarding its oxygen requirements.

*Orconectes rusticus* seineed from Alum Creek, about 1 km south of Broad Street, Columbus, Ohio, were taken to the laboratory. They were maintained for at least 48 hr at the temperature at which the subsequent experiment would be carried out with a photoperiod of 16 hr of light and 8 hr of darkness. We constructed metabolic chambers from wide mouth glass quart (0.946-l) jars. Each jar was fitted with a thermometer and a glass shelf glued into place approximately 4 cm from the bottom with silicone rubber aquarium sealer (Dow Corning Corp.). An aluminum wire screen was placed on the shelf and a stirring bar under the shelf so that during the experiment, the magnetic stirrer could keep the water in the chamber well mixed.

For each test, 700 ml of aerated tap water at the experimental temperature was added to the chamber. After activation of the stirring bar, an aluminum screen with one crayfish was placed on the shelf. A 1 cm layer of mineral oil was placed on the water to exclude atmospheric oxygen. The crayfish were maintained on a diet of Ralston Purina Cat Chow and had access to food until the experiment started. Starved cray-
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OXYGEN REQUIREMENTS OF CRAYFISH

TABLE 1

Data from which the oxygen consumption of Orconectes rusticus may be calculated. The slope times the g fresh weight of the living crayfish gives a prediction of the oxygen consumed by the crayfish in mg of oxygen per hr.

<table>
<thead>
<tr>
<th>Temp. °C</th>
<th>Feeding status</th>
<th>Sex*</th>
<th>Slope**</th>
<th>Sample size</th>
<th>Grams fresh weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5</td>
<td>fed</td>
<td>MF</td>
<td>0.07749</td>
<td>22</td>
<td>2.7-6.5</td>
</tr>
<tr>
<td>16.0</td>
<td>fed</td>
<td>MF</td>
<td>0.13656</td>
<td>19</td>
<td>2.7-6.3</td>
</tr>
<tr>
<td>20.5</td>
<td>fed</td>
<td>MF</td>
<td>0.16059</td>
<td>26</td>
<td>1.0-6.0</td>
</tr>
<tr>
<td>24.8</td>
<td>fed</td>
<td>MF</td>
<td>0.21919</td>
<td>26</td>
<td>2.6-6.5</td>
</tr>
<tr>
<td>20.5</td>
<td>fed</td>
<td>F</td>
<td>0.15293</td>
<td>10</td>
<td>0.4-6.0</td>
</tr>
<tr>
<td>20.5</td>
<td>fed</td>
<td>M</td>
<td>0.10393</td>
<td>17</td>
<td>1.0-4.7</td>
</tr>
</tbody>
</table>

*MF = Both sexes combined.  
**Test for significant differences in slope at different temperatures.  
10.5 °C vs 16 °C = P<0.01; 10.5 °C vs 20.5 or 24.8 °C = P<0.001;  
16 °C vs 20.5 °C = NS, 16 °C vs 24.8 °C = P<0.01, and 20.5 °C vs 24.8 °C = P<0.01. Starved vs fed and male vs female were NS.

Fish were kept in water with no food added for 48 hr before the experiment. In each experimental test, a crayfish in the metabolic chamber was allowed to acclimate for 10 min. Then mineral oil was added and another 5 min was allowed before the first water sample was drawn for oxygen content measurement (method of Burke 1962). One or 2 hr later, a final water sample was taken and its oxygen content determined. Controls without crayfish were run at the identical temperature and the results were corrected for any variation they showed. Fed male and female crayfish were tested at 10.5, 16.0, 20.5, and 24.8 °C, and starved males were tested at 20.5 °C. Each crayfish was weighed while alive, the carapace measured, and then placed in a drying oven at 80 °C for 48 hr for dry weight determination. Linear regressions were calculated using the Ohio State University computer program BMD 02 R, and comparison of regression lines followed the method of Snedecor and Cochran (1967).

Tables 1 and 2 were used to predict the oxygen consumption of crayfish when the environmental temperature and the weight of the living crayfish were known. In all but one case, when two regression lines for the temperature effect were compared, a significant difference existed but when starved crayfish were compared to fed or males were compared to females, no significant difference occurred.

TABLE 2

Data from which the oxygen consumption of Orconectes rusticus may be calculated. The slope times the temperature in °C gives a prediction of the oxygen consumed by the crayfish in mg of oxygen per hr.*

<table>
<thead>
<tr>
<th>Fresh weight (g)</th>
<th>Slope</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.02</td>
<td>0.01573</td>
<td>19</td>
</tr>
<tr>
<td>3.53</td>
<td>0.02830</td>
<td>30</td>
</tr>
<tr>
<td>4.42</td>
<td>0.04175</td>
<td>30</td>
</tr>
</tbody>
</table>

*The data were plotted by linear regression through the origin. All crayfish were fed, and both males and females were used. P = <0.001 in all cases.

The data for table 3 were generated by plotting a regression line of the temperature against the calculated slopes of the regression lines calculated at the four environmental temperatures shown in table 1. The result was a regression line: Y intercept = -0.021499 and slope = 0.0044683, which had an F-ratio of 91.0 (P<0.005). This regression line allows one to generate a predicted slope for any environmental temperature from 10 °C to 25 °C and to use that slope to predict the oxygen consumption of a crayfish from 2.0 g to 7.0 g fresh weight. The slopes generated were used to create table 3, which
can be used to estimate the temperature coefficient for *Orconectes rusticus*.

### Table 3

Data which may be used to predict the oxygen consumption of *Orconectes rusticus*. The slope times the g fresh weight of the crayfish gives the oxygen consumption in mg of oxygen per hr. These data were generated by regression analysis of the temperature data in table 1.

<table>
<thead>
<tr>
<th>Temp. °C</th>
<th>Slope</th>
<th>mg O₂/hr for 5 g crayfish</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>0.07318</td>
<td>0.3659</td>
</tr>
<tr>
<td>15.0</td>
<td>0.12052</td>
<td>0.6026</td>
</tr>
<tr>
<td>20.0</td>
<td>0.16786</td>
<td>0.8393</td>
</tr>
<tr>
<td>25.0</td>
<td>0.21520</td>
<td>1.0760</td>
</tr>
</tbody>
</table>

Fed *Orconectes rusticus* apparently used more oxygen than *Orconectes nais* and *Orconectes immunis*, as reported by Wiens and Armitage (1961). Several differences between our experiments and those of Wiens and Armitage may explain the variations shown. They tested their crayfish in the dark, with a flow-through system, and it was not clear whether their animals were fed or starved. *Orconectes rusticus* was tested in the light, in a closed system, and we used the data from fed animals for comparison. If Wiens and Armitage starved their animals before tests, their results might agree more closely with ours. The data in table 3 make it easy to compare our results with those of other species. By generating a slope for any temperature in the range of 10 °C to 25 °C and using the weight of the crayfish, one can make a rather precise comparison with another species.

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**LITERATURE CITED**


