NOTE

Oxygen consumption and temperature change in the shrimp *Palaemon elegans*

J. Dalla Via

Institut für Zoologie, Abteilung Zoophysiologie, Peter-Mayr-Straße 1a, A-6020 Innsbruck, Austria

ABSTRACT: Oxygen consumption responses to short-term temperature changes were measured in a Mediterranean population of the shrimp *Palaemon elegans* (Rathke). At all temperatures between 5 and 25°C small shrimp with a body weight of 150 mg showed higher rates of oxygen consumption than larger shrimp. Handling affects metabolic rate; the latter stabilizes only after more than 10 h, especially in small shrimp. $Q_{10}$-values decrease with decreasing shrimp weight and with rising temperature. Compared to a cold-acclimated population of the same species (Alcaraz 1974) metabolic rates at 15 and 20°C are lower in the warm-acclimated Mediterranean population used in this investigation.

INTRODUCTION

The crustacean *Palaemon elegans* inhabits rock pools in the intertidal zone where it is frequently exposed to high temperatures (Höglund 1943, Forster 1951, Morris & Taylor 1983). It also populates shallow sand bottoms and brown algae belts. In the latter this shrimp normally competes with *Palaemon serratus* (Berglund 1980, 1982, 1984, Berglund & Bengtsson 1981). In the Mediterranean, *P. elegans* is found along rocky coasts (Manning & Števčič 1982) but it also migrates into the shallow water of lagoons (Pellizzato et al. 1981, Crivelli 1982, Manning and Froglini 1982, Türkay 1982, Dalla Via 1983a). There the shrimp are exposed to marked diurnal and seasonal temperature changes. In the Lagoon of Lesina, *P. elegans* is exposed to yearly temperature fluctuations between 5 and 31°C (Marolla 1980). Daily fluctuations from 24 to 30°C or from 16 to 23°C within the same month are not infrequent (June; Lumare 1984). The aim of this study is to consider the effects of short-term changes in environmental temperature on the rate of oxygen consumption of this species.

MATERIALS AND METHODS

Animals. Shrimp were obtained from the Lagoon of Lesina (southern Italy) where they occur near the openings to the Adriatic Sea in salinities ranging from 25 to 40 %. The Lagoon of Lesina is a brackish-water lagoon; its dynamics and physico-chemical parameters have been described by De Angelis (1953, 1963), Marolla (1980), Dalla Via (1983a). During the period of investigation the environmental temperature fluctuated between 18 and 22°C. The shrimp were caught in the Lagoon and transported to the laboratory in original sea water. They were maintained at a constant temperature of 20°C in an acclimation chamber for 2 d before being used for determination of oxygen consumption. Experiments were carried out at the Laboratory for the Biological Exploitation of the Lagoons, Lesina, Italy.

Respirometry. Oxygen consumption measurements were made with an automated multiple-chamber intermittent-flow respirometer (Forstner 1983a, b, Dalla Via 1985b). Since crowding affects the rate of oxygen consumption in other palaemonids (Dalla Via 1985a, b), the 8 shrimp per experimental chamber were separated from each other by a stainless-steel net cage. Bacterial respiration was taken into account by subtraction, as described by Dalla Via (1983b). Four experiments were carried out with the following weight classes: 150 ± 38 mg, 275 ± 72 mg, 481 ± 133 mg, 998 ± 40 mg.

RESULTS AND DISCUSSION

Effects of acute change in experimental temperature on the metabolic rate of shrimp acclimated to an environmental temperature of 20°C are shown in Fig. 1. At all temperatures small shrimp with a body weight of 150 mg exhibited higher rates of oxygen consumption than larger ones (Fig. 2). Between 5 and 15°C the $Q_{10}$-values lie between 3 and 4; they decrease with a rise in temperature (Table 1). Similar $Q_{10}$-values have been reported for 20°C acclimated *Palaemonetes antennarius* (Dalla Via 1985b), whereas *P. vulgaris* has lower values (McFarland & Pickens 1965). Table 1 also
Fig. 1. *Palaemon elegans*. Time course of oxygen consumption at different temperature levels, indicated by shaded bars at the bottom of the figure. Mean shrimp weight in mg: Curve 1, 150 ± 38; 2, 275 ± 72; 3, 481 ± 133; 4, 998 ± 40

Fig. 2. *Palaemon elegans*. Effect of temperature on weight-specific oxygen consumption. Fresh body weights indicated (mean ± SD)

indicates that large shrimp with a body weight of 1 g generally exhibit higher $Q_{10}$-values than small shrimp. In a cold-acclimated population of *Palaemon elegans* a constant $Q_{10}$-value (15 to 20°C) of 2.2 was found in individuals of all sizes tested (Alcaraz 1974). When comparing the rates of the cold-acclimated with those of the warm-acclimated populations (Table 2) the effect of handling must be taken into account. From Fig. 1 it is evident that at 20°C *P. elegans* exhibits an initially increased level of oxygen consumption which stabilizes only after more than 10 h. This is especially true for small shrimp. Dalley & Bailey (1981) also found increased locomotory activity in *P. elegans* for up to 8 h

Table 1. *Palaemon elegans*. Size dependence of the $Q_{10}$-values at 3 different temperature intervals

<table>
<thead>
<tr>
<th>Temperature interval</th>
<th>150</th>
<th>275</th>
<th>481</th>
<th>998</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 15°C</td>
<td>3.19</td>
<td>3.22</td>
<td>3.14</td>
<td>3.78</td>
</tr>
<tr>
<td>10 - 20°C</td>
<td>2.22</td>
<td>2.75</td>
<td>2.75</td>
<td>2.30</td>
</tr>
<tr>
<td>15 - 25°C</td>
<td>2.11</td>
<td>2.44</td>
<td>2.68</td>
<td>2.67</td>
</tr>
</tbody>
</table>
Table 2. *Palaemon elegans*. Rates of oxygen consumption of a warm-acclimated and a cold-acclimated population. Values from literature converted to µmol O_2 g^{-1} h^{-1}; n-values for VO_2 in this study represent n hourly measurements of a pool of 8 shrimp

<table>
<thead>
<tr>
<th>Time after handling:</th>
<th>Alcaraz (1974)</th>
<th>This study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2 h</td>
<td>12 °C</td>
<td>20 °C</td>
</tr>
<tr>
<td>Acclimation temperature:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small shrimp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight range in mg:</td>
<td>80 – 260 (6)</td>
<td>150 ± 38 (8)</td>
</tr>
<tr>
<td>VO_2 in µmol O_2 g^{-1} h^{-1} at 15 °C</td>
<td>15.4 ± 2.7 (3)</td>
<td>8.6 ± 0.4 (12)</td>
</tr>
<tr>
<td>VO_2 in µmol O_2 g^{-1} h^{-1} at 20 °C</td>
<td>23.8 ± 6.4 (3)</td>
<td>11.6 ± 0.8 (9)</td>
</tr>
<tr>
<td>Large shrimp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight range in mg:</td>
<td>1090 – 1140 (2)</td>
<td>998 ± 40 (8)</td>
</tr>
<tr>
<td>VO_2 in µmol O_2 g^{-1} h^{-1} at 15 °C</td>
<td>10.3 (1)</td>
<td>5.9 ± 1.0 (12)</td>
</tr>
<tr>
<td>VO_2 in µmol O_2 g^{-1} h^{-1} at 20 °C</td>
<td>10.1 (1)</td>
<td>9.9 ± 1.4 (9)</td>
</tr>
</tbody>
</table>

after placing them in the actograph, and in connection with light on/light off signals. We believe the oxygen consumption levels determined by Alcaraz (1974) must include a high activity component because his measurements were carried out within the first or second hour after handling.

Acknowledgements. I am grateful to Professor W. Wieser for critical reading of the manuscript and to Professor F. Lumare for his kind hospitality at the Laboratory for the Biological Exploitation of the Lagoons, National Research Council, Lesina, Italy. The study was supported by project no. 3307 of the ‘Fonds zur Förderung der wissenschaftlichen Forschung in Österreich’.

LITERATURE CITED


Accepted for printing on July 14, 1985