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On the oxygen consumption of Mesidothea entomon (L.) (Crustacea, Isopoda)

P. Kangas and A. Lappalainen

Department of Zoology and Bothnian Bay Research Station
University of Oulu, Oulu, Finland

Abstract

The level of oxygen consumption of a Baltic population of *Mesidothea entomon* was determined in salinities of 1, 6.5 and 15‰ and at temperatures of 5 °C and 15 °C using males, ovigerous females and non-ovigerous females. No significant dependence was found between respiration and salinity. The mean oxygen consumption is of the same order of magnitude as for Baltic marine isopods in general. It decreases towards the autumn. The oxygen consumption remains at the same level independent of the oxygen concentration in the water until this falls below 2 mg per litre.

Zusammenfassung

Über den Sauerstoffverbrauch von Mesidothea entomon (L.) (Crustacea, Isopoda)

Die Höhe des Sauerstoffverbrauchs einer baltischen *Mesidothea entomon*-Population wurde bei einem Salzgehalt von 1‰, 6,5‰ und 15‰ und bei 5 °C und 15 °C bestimmt. Untersucht wurden männliche, eier- und nichteiertragende Weibchen. Zwischen Respiration und Salzgehalt besteht keine signifikante Abhängigkeit. Der mittlere Sauerstoffverbrauch liegt in der gleichen Größenordnung wie sonst bei marinen Isopoden in der Ostsee. Er nimmt zum Herbst hin ab. Erst unterhalb von 2 mg O_2/l erweist sich der Sauerstoffverbrauch als abhängig vom Sauerstoffgehalt des Wassers.

Introduction

Mesidothea entomon occurs over the whole area of the Baltic Sea, often forming an important constituent of the benthic biomass, especially in the northern part of this area (see SEGERSTRÅLE, 1957). This glacial relict, originating from the Arctic Sea, is euryhaline and also populates fresh water. Its osmoregulation has been studied by BOGUCKI (1932), LOCKWOOD and CROGHAN (1957), BOBOVICH (1968, 1970), CROGHAN and LOCKWOOD (1968) and VINOGRADOV (1973). The species is an osmo-conformer in polyhaline waters and a hyperosmotic regulator in more dilute media. The Baltic and fresh-water forms have equal ion concentrations in the blood at high salinities, but the Baltic form cannot adapt to fresh water, since the two are different physiological races.

The present study was made to provide further information on the eco-physiology of *M. entomon* by determining oxygen consumption at different salinities and temperatures corresponding to the extremes encountered in the distribution area of this species in the Baltic Sea.

Material and methods

The animals were obtained by trawling at Tvärminne Storfjärd, southern Finland, within a depth of 25–30 metres. The hydrographical features on the bottom during the three collection periods were:

	Temperature °C	Salinity ‰
June 20	+ 3.4	6.82
August 1	+ 6.8	6.36
September 13	+ 6.2	6.83

The laboratory experiments were performed in two batches, in July and September. The material was grouped as follows: 1) immature males (mean length 42.4 mm) in their period of rapid growth, 2) mature ovigerous females (41.3 mm) with eggs in the marsupium and 3) mature females (40.9 mm) with empty marsupium. These females had manca-stage larvae in the marsupium at the time of trawling, but all but six released their offspring during the acclimation stage. According to HAAHTELA (1977) females of this size are 1–2 years older than males of the corresponding length.

The animals underwent an acclimation period of 3 to 6 weeks in dark, aerated tanks with a layer of washed sand on the bottom. Salinities of 1, 6.5 and 15‰ were used at temperatures of 5° and 15°C. Sea water of 34.5‰ salinity was prepared from chemicals according to SCHLIEPER (1971) and diluted to the level needed with deionized water. The water volume of 25 l in the acclimation tanks was changed once a week after feeding the animals with fish. A rather low mortality rate prevailed during acclimation. Only specimens at the intermoult stages were taken for the experiments.

The oxygen consumption of single animals was measured using a Delta Scientific polarographic oxygen electrode in a closed 395 ml respirometer (Fig. 1) built on the principle of SNOW and WILLIAMS (1971). The oxygen concentration was standardized at the beginning of the experiment to within a range 8 to 10 mg/l. The measurements were made in day-time, except for some long-term experiments which were run overnight. The running time for one experiment was three hours, the first 45 minutes of the recording being excluded from the calculations, as it was observed that a majority of the animals had significantly lower or higher rates of oxygen uptake initially on enclosure in the chamber. The oxygen uptake normally became linear after this habituation time.

The oxygen consumption determined in this study corresponds to routine metabolism, defined as average oxygen consumption of a moderately active animal undergoing continuous oxygen recording during free activity in a closed system. The locomotory activity of the animals was not recorded.

All weights mentioned in this study are dry weights, obtained after drying overnight at 102°C. The weight of the eggs is not taken into account in calculating the respiration rates. A total of 169 measurements were made, at least 8 for each group. The lenght (L) – dry weight (W) relationship in *Mesidothea entomon* can be described as $\log W = 2{,}50 \log L - 0{,}66$. The standard deviation (S_b) of the regression coefficient amounts to 0,17. The dry weight of the experimental animals amounts on average to 21,7 ± 0,3% of the fresh weight.

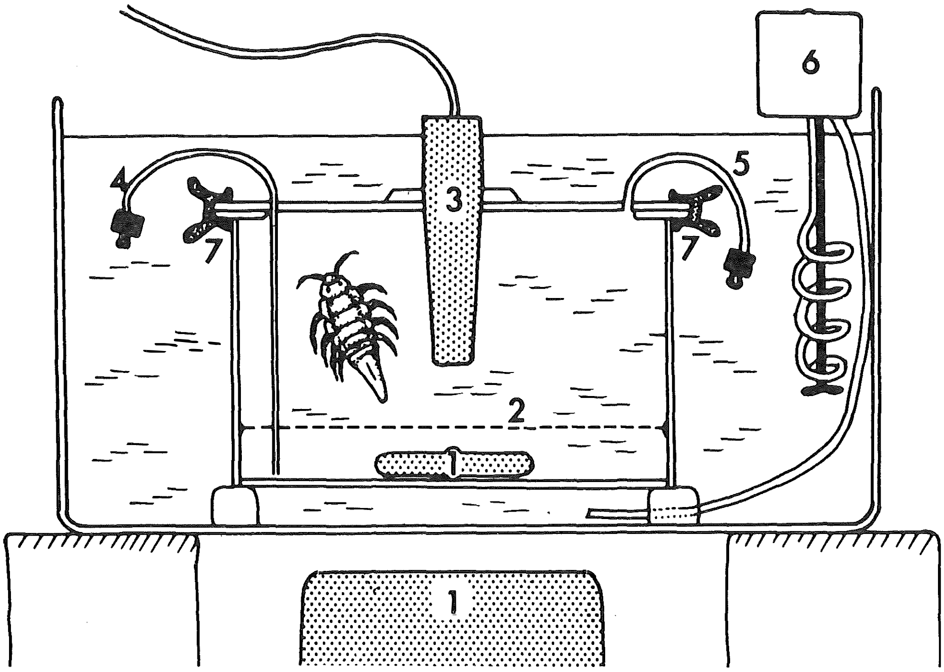

Figure 1

Experimental arrangement for measuring the oxygen uptake of *Mesidothea entomon*. The closed chamber lies in a water bath. The magnetic stirrer (1) rotates below the plastic net (2). The polarographic oxygen electrode (3) is connected to a meter and a recorder. 4 and 5 are the hoses for filling and emptying the chamber, 6 the thermostat, and 7 clamps for the lock

The method involving an acclimation for 3–6 weeks and the use of artifical sea water seemed to have no significant effect on respiration: the oxygen uptake of the males, measured immediately after capture in their own habitat water and temperature, was about the same as that of the males with corresponding acclimation conditions. It was also noted that the metabolism of *M. entomon* was not clearly affected by time of the day, duration of acclimation or fasting.

Results and discussion

Metabolic rate

The mean oxygen consumption for all experiments with *M. entomon* (the length of the animals varied from 32–50 mm) was 0,45 ± 0,02 mg/h · g at 5°C and 0,95 ± 0,03 at 15°C. Although *M. entomon* tolerates temperatures as high as 20°C (APSTEIN, 1909), the upper temperature used here might be considered too high to be normally encountered by this species. Except in their younger stages, *Mesidothea* usually avoids such warm water (I. HAAHTELA, pers. comm.).

Mean Q_{10} was 2,15, the values being relatively constant in the different experimental groups. *M. entomon* is classified as a stenothermic cold water species (DEMEL and MULICKI, 1958), for which the measured Q_{10} values are of a normal order of magnitude and agree with Krogh's curve.

The seemingly wide range of respiration values between single individuals is well comparable with literature data for various species, a two-fold variation being quite common (*c.f.* ZEUTHEN, 1953; SUOMALAINEN, 1958; WALLACE, 1972) and even a ten-fold one being recorded as normal for *Littorina*-species (NEWELL and PYE, 1971). Differences in locomotory activity have been shown to constitute the primary reason for this variation (McLUSKY, 1969; WALLACE, 1972). The moulting cycle might also affect the results since only individuals quite close to ecdysis could be discarded. In *Crangon vulgaris*, for instance, respiration increases 2 or 3-fold during ecdysis (HAGERMAN, 1976), while the duration of ecdysis in *Cambarus immunis* may extend to several days (McWHINNIE and KIRCHENBERG, 1962). The duration of ecdysis in *M. entomon* is not known.

The respiration rate of *M. entomon* appears to be somewhat lower than that of other crustaceans of marine origin. Among the isopods, the oxygen consumption in *M. entomon* is of the same order of magnitude as that in the marine genera *Sphaeroma* and *Idotea*, but much lower than in *Asellus aquaticus* in fresh water, as shown below (values converted to $mgO_2/h \cdot g$ dry weight):

Idotea sp.	(medium?)	16°	2.11	ZEUTHEN, 1947
I. neglecta	(in sea water)	10°	0.84	FOX & SIMMONDS, 1933
I. balthica		5°	~0.4	BULNHEIM, 1974
I. balthica	(in 10‰ S)	15°	~1.0	BULNHEIM, 1974
I. chelipes		5°	~1.9	VLASBLOM et al., 1977
I. chelipes		15°	~2.3	VLASBLOM et al., 1977
Asellus aquaticus		10°	3.73	FOX & SIMMONDS, 1933
A. aquaticus	(in fresh water)	10°	4.61	FOX & BALDES, 1935
Sphaeroma hookeri		5°	0.65	FRIER, 1976
S. rugicauda	(in 10‰ S)	5°	0.65	FRIER, 1976
S. hookeri		15°	1.29	FRIER, 1976
S. rugicauda		15°	1.29	FRIER, 1976
Mesidothea entomon	(in 1–15‰ S)	5°	0.45	this study
M. entomon		15°	0.95	this study

The animals measured in September had a lower respiration rate at 5 °C (0.39 ± 0.02 $mgO_2/h \cdot g$) than those obtained in July (0.52 ± 0.02). This difference is significant ($p < 0.001$). The decrease in respiration was larger for the females, 28.3%, than for the males, 23.5%. A seasonal variation in metabolism has been found in many crustaceans (see LOCKWOOD, 1968). The respiration rate of *Calanus finmarchicus* for example, is highest in early summer, due to reproduction activity (MARSHALL and ORR, 1958). In *Mesidothea entomon* a probable explanation for the lower metabolic activity in September is that the animals have already passed the most active growth and reproduction period.

Body weights without eggs were used for the calculation of respiration rates (cf. p. 303). Most non-ovigerous females had an empty marsupium. Yet, at 5°C six females still had the larvae in their brood pouches when the respiration measurements were made. The mean sum respiration of these females and their larvae was 0.73 ± 0.11 $mg/h \cdot g$, which was 78% higher ($p < 0.01$) than the oxygen consumption of the non-ovigerous females without young.

Effect of salinity on oxygen consumption

When all the population categories are pooled, a weak trend for the effect of salinity variations on respiration can be seen at 5°C (right-hand values in Fig. 2). Oxygen consumption seems to increase with decreasing salinity, although the trend is not significant. No similar tendency can be seen at 15°C.

Looking at the different population categories separately differences in oxygen consumption connected with variations in salinity can be detected, although only few are significant. For instance, the oxygen consumption of the ovigerous females decreased with declining salinity, especially at 15°C, whereas that of the females which had by this time released their young increased.

If the two female groups are pooled, no significant difference in oxygen consumption is found between the males and females. Equivalent results have been obtained in the genus *Sphaeroma* (FRIER, 1976) and in *Asellus aquaticus* (PRUS, 1976). It is not common for experiments to be carried out on ovigerous females, because it is thought that the brood pouch affects the results (e.g. CROGHAN and LOCKWOOD, 1968). This finds support in our results.

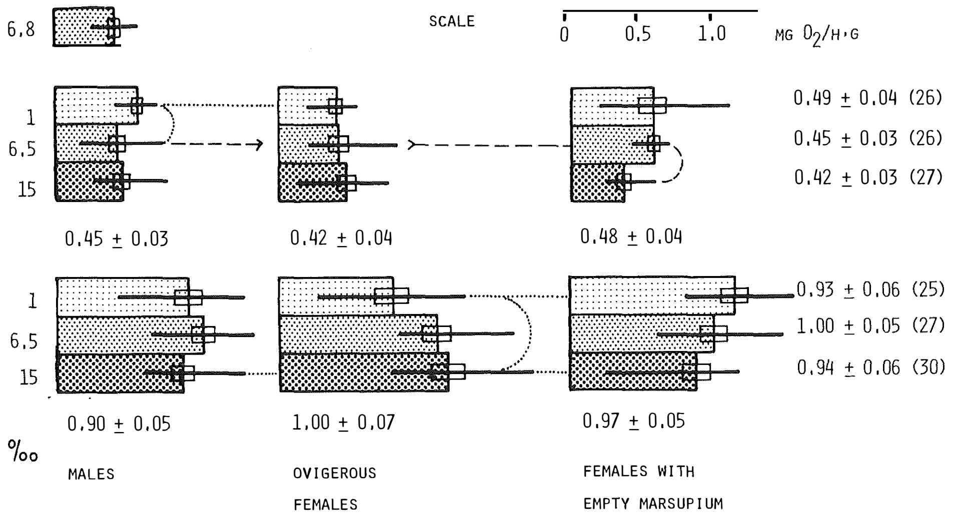

Figure 2

Oxygen consumption in males and two groups of females at 5°C (upper) and 15°C (lower) and at different salinities. The uppermost graph gives the oxygen uptake of males measured immediately after their capture (p.304). The small rectangles indicate the standard error of the mean, the bars the range of variation and the figures in parentheses the number of measurements. The numerical values show pooled consumptions for various groups. The significance of the differences is marked with lines: broken $p < 0.01$, dashed $p < 0.05$

The extensive literature on the effect of salinity on oxygen consumption is apparent from the review of KINNE (1971). In some osmoregulating species of marine origin respiration may increase with diminishing salinity (SCHLIEPER, 1971). This effect was observed in this study with the *Mesidothea* females with empty marsupium. A similar marked increase in respiration rate was noted in *Sphaeroma rugicauda* and *S. hookeri* as the salinity of the medium declined from 30‰ to 5‰ (FRIER, 1976). For *Idotea balthica* (BULNHEIM, 1974) and *I. chelipes* (VLASBLOM et al., 1977) this increase was slight. On the other hand, respiration in brackish-water species, especially in forms with hypo- and hyperosmotic regulation, usually reaches its minimum in water which is isotonic to the blood (FOX and SIMMONDS, 1933; LÖWENSTEIN, 1935; GROSS, 1957; SUOMALAINEN, 1958; RAO, 1969; WALLACE, 1972).

M. entomon is a hyperosmotic regulator at salinities below about 20‰, retaining its blood concentration at the level which corresponds to a salinity of 13 to c. 20‰ (LOCKWOOD and CROGHAN, 1957; own observations). Thus, having hyperosmotic blood at the salinities used in our experiments, *M. entomon* could have been expected to show symptoms of osmotic stress in its oxygen consumption, the stress being the more obvious the lower the salinity of the medium. Yet, altogether, no significant indication of such effect was found when the values of oxygen consumption for different population categories after long term adaptation to salinity were pooled.

Effect of oxygen decline

The oxygen consumption of *Mesidothea entomon* (at 15°C) remains practically unchanged as the oxygen tension in the surrounding water decreases until a level of about 2 mg/l. A steep decrease then occurs at concentrations of 1 mg/l or less (Fig. 3). The linearity in oxygen consumption and the low value for the critical oxygen content show *M. entomon* to be an oxygen regulator well adapted to conditions in which temporary oxygen depletion may occur (LOCKWOOD, 1968). The experiment of longest duration shows that *Mesidothea entomon* can survive for hours under conditions involving an oxygen concentration of less than 0.5 mg/l.

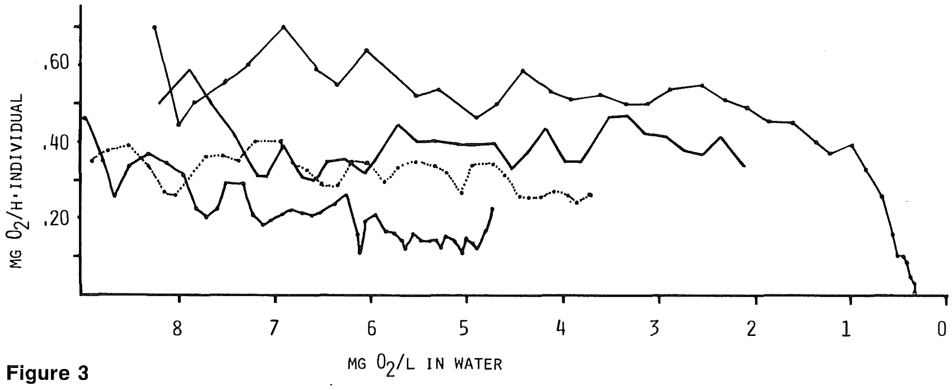

Figure 3

Dependence of oxygen consumption on oxygen content of the water in four long-term experiments with different animals (15°C, 15‰). The recorder curve was read every 15 minutes (dots) and the oxygen consumption calculated from overlapping periods of 30 minutes

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