Notes and records

Cuticular transpiration in woodlice (Isopoda, Oniscidea) inhabiting Benghazi, Libya

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Introduction

Three woodlice species, *Armadillo officinalis* (Dumeril, 1816), *Hemilepistus reaumuri* (Audouin & Savigny, 1826) and *Porcellio scaber* (Latreille, 1804) (Isopoda, Oniscidea) are common in the woodlands, semiarid regions and farmlands, respectively, in Benghazi, Libya. However, only moderate information is available (Nair, Fadiel & Mohamed, 1989; Al-Jetlawi & Nair, 1994; Nair & Bhuyan, 1996; Nair & Fathi, 1997; Nair, 1998; Nair, Mohamed & Bhuyan, 2001) concerning their adaptations to the local environmental conditions. These woodlice play important roles in the trophic dynamics by hastening the decomposition of vegetation. In the present study, the effects of temperature on the transpiration rates of these woodlice were measured. Data analysis included tabulation of the least square fits and their constants from the experimental values. It is hoped that results of the present study may be useful as a reference for any future studies on the transpiration rates of these animals undertaken along the coastal Mediterranean regions of North Africa.

Materials and methods

Adult *A. officinalis* (body length 7–10 cm), *H. reaumuri* (body length 14–18 cm) and *P. scaber* (body length 11–14 cm) were selected for the study. The adult woodlice used were from populations recovered during soil sampling.

The methods described by Cloudsley-Thompson (1969), Nair & Nair (1985) and Nair, Mohamed & Bhuyan (2001) to measure the transpiration rates of various terrestrial isopods were adopted in the present study. Twenty adult animals (10 males and 10 non-gravid females) from each species were acclimatized in the laboratory for 2 days and were later weighed individually to 0.05 mg, and then exposed separately for 1 h over phosphorus pentoxide (P_2O_5) at 10, 15, 20, 25, 30, 35, 40 and 45 °C, before reweighing. The changes in the body weight of woodlice through transpiration are more pronounced when exposed over P_2O_5 as compared with another desiccant such as calcium chloride (Cloudsley-Thompson, 1969). The duration of the 1-h exposure in the present study was based on initial trial experiments where these isopods could withstand this exposure period over P_2O_5 even at high temperatures without showing symptoms of stress or high mortality (5–10% mortality was observed in *P. scaber* exposed at 40 and 45 °C). The results of the transpiration are expressed as mg cm^{-2} h^{-1}, the surface area of the animals being calculated from the formula $S = kW^{2/3}$, where 'S' is the surface area, 'W' is the initial weight of the animal and 'k' is a constant. A value of $k = 12$ was adopted as used by Cloudsley-Thompson (1969), Nair *et al.* (1989, 2001) for African woodlice and Nair & Nair (1985) for Indian species. This value is also the mean calculated by Edney (1951) for the British species. The experiment was repeated and there were not many variations between the values of the replication tests, and thus the data were pooled and the mean values were taken.

The least square technique described by Brice, Luther & James (1969) was used to determine the values of constants in the least square fits.

Results and discussion

Results from soil sampling showed that *A. officinalis*, *H. reaumuri* and *P. scaber* were found in sand (56.4%)–clay

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Table 1 Transpiration rates (X ± SE) of woodlice exposed to different temperatures ($n = 20$: 10 male and 10 non-gravid females) from each species

Temperature (°C)	Water loss (mg cm^{-2} h^{-1})				
	A. officinalis	*H. reaumuri*	*P. scaber*	*F*	*P*
10	0.56 ± 0.05	0.30 ± 0.07	1.99 ± 0.11	646.95	<0.01
15	0.60 ± 0.07*	0.50 ± 0.07*	1.99 ± 0.10*	527.13	<0.01
20	0.69 ± 0.13*	0.80 ± 0.08*	2.32 ± 0.33*	96.79	<0.01
25	1.49 ± 0.17*	1.10 ± 0.22*	3.30 ± 0.18	191.99	<0.01
30	2.59 ± 0.19	3.00 ± 0.28	3.45 ± 0.14*	66.99	<0.01
35	3.06 ± 0.21*	3.30 ± 0.19*	4.55 ± 0.20*	80.75	<0.01
40	3.47 ± 0.17	6.50 ± 0.44	6.76 ± 0.25*	175.61	<0.01
45	6.91 ± 0.24*	8.30 ± 0.15*	8.82 ± 0.15*	144.16	<0.01

*The values are plotted in Fig. 1.

(30.0%) mixture soil with moderate-to-rich humus content (6.0–11.6%) and beneath litter and stones in semi-dry-to-moist shady places. *A. officinalis* and *P. scaber* were mostly active at night and early hours of the morning before sunrise, like most other species of woodlice (Cloudsley-Thompson, 1977), whereas *H. reaumuri* were active during the daytime, wandering in search of food, and retreating back into their shelters before dark.

The transpiration rates of these woodlice over 1 h at various temperatures from 10 to 45 °C are shown in Table 1. There was an increase in the transpiration rates in all the three species in relation to the rise in temperatures, and comparatively lower rates of transpiration in different temperatures were recorded in *A. officinalis* and the higher ones were recorded in *P. scaber*. ANOVA analysis showed significant differences ($P < 0.01$) in transpiration between these three species in different temperatures tested. Computing the '*t*' values of transpiration rates at different temperatures (Table 2) between any two species revealed that there did not exist any significant difference in transpiration rates between *A. officinalis* and *H. reaumuri* exposed at temperatures between 10 and 35 °C ($P > 0.05$), after which significant differences in transpiration rates were discernible at 40 and 45 °C ($P < 0.01$). In the case of *A. officinalis* and *P. scaber*, there were significant differences ($P < 0.01$) in transpiration rates in all the temperatures tested, whereas a comparison of transpiration rates between *H. reaumuri* and *P. scaber* showed significant differences ($P < 0.01$) of the same from 10 to 25 °C and in 35 °C, whereas the differences in transpiration rates were insignificant at 30, 40 and 45 °C.

The observed values of transpiration rate (Y) were plotted against the temperature (T) for each species (Fig. 1). A common trend in transpiration rate was observed for all the three species. After filtering out some of the outer data points, a smooth curve was drawn through the remaining points for all the three species. The large deviations might be attributed to possible errors in the experimental observations. The points that are considered in Fig. 1 are indicated with '*' marks in Table 1. The curves were observed to be closer to parabolic shapes. Hence, it was decided to fit a second-degree polynomial, which may be expressed as:

$$Y = aT^2 + bT + c$$

where Y = transpiration rate, T = temperature and a, b and c are the constants to be determined. A least square technique (Brice *et al.*, 1969) was used to determine the values of these constants. The values of these constants are shown in Table 3, and the curves obtained by using the above equation are shown in Fig. 1.

Table 2 *T*-values of transpiration between two species of woodlice and their levels of significance at different temperatures

Temperature (°C)	*T*-values of transpiration between		
	A. officinalis and *H. reaumuri*	*A.officinalis* and *P. scaber*	*H. reaumuri* and *P. scaber*
10	0.07	7.49*	8.96*
15	0.59	7.58*	8.06*
20	0.54	5.42*	5.33*
25	1.41	6.83*	7.80*
30	1.33	3.33*	1.55
35	0.85	5.22*	4.50*
40	8.68*	11.34*	0.70
45	5.01*	6.85*	2.11

*Significant at 5% level.

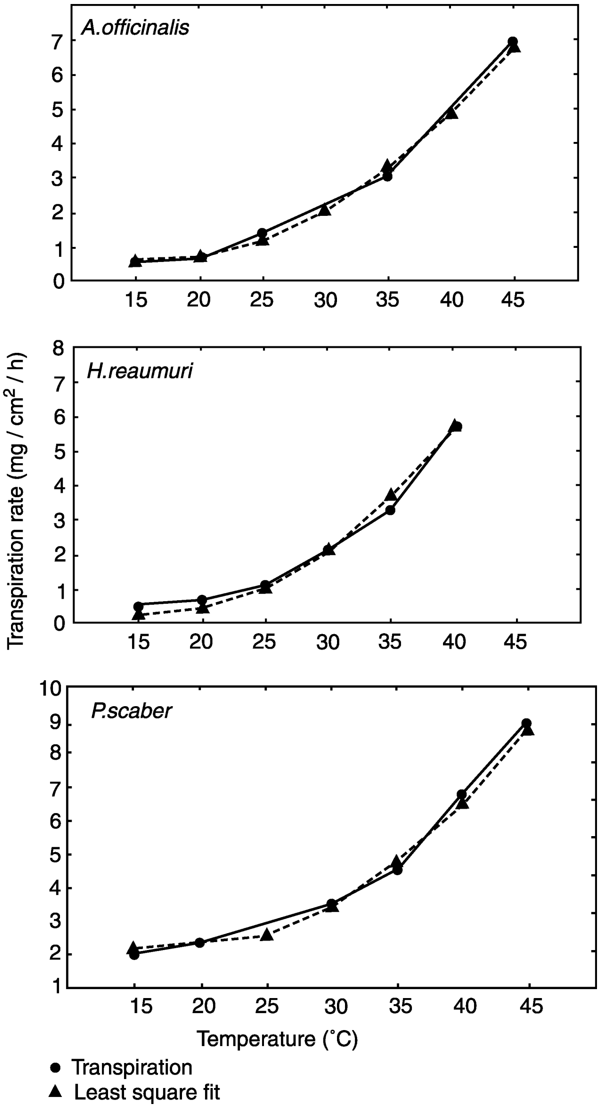

Fig 1 Transpiration rates and their least square fits in woodlice exposed to different temperatures.

Water loss by transpiration is one of the most important physiological factors affecting the survival and distribution of woodlice (Edney, 1968; Cloudsley-Thompson, 1969). Most terrestrial isopods are quite sensitive to desiccation and have to seek out sufficiently moist shelter to survive (Wieser, 1984). The cuticle of land isopod is more permeable than that of insect (Wallwork, 1970), and it was previously believed that a water-proofing mechanism, an orientated layer of lipid molecule, is lacking in isopods (Beament, 1961). Later, however, evidence suggested that some type of water-proofing mechanism may be present in some species (Edney, 1968; Hadley & Quinlan, 1984). Measurements of transpiration rates of several species of woodlice at various temperatures have demonstrated a sharp increase in higher temperatures (Warburg, 1965; Edney, 1968; Cloudsley-Thompson, 1969, 1977; Nair & Nair, 1985; Nair *et al.*, 1989, 2001; Nair & Bhuyan, 1996). This suggests that the water-proofing barrier ability is reduced at higher temperatures. This might be the reason why sharp increases in transpiration rates at 40 and 45 °C in *H. reaumuri* and *P. scaber*, and at 45 °C in *A. officinalis* were observed in this study when compared with the same for lower temperatures (10–35 °C), where the increase was gradual.

Table 3 Values of constants tabulated in the least square fit

Species	*a*	*b*	*c*
A. officinalis	0.007376	−0.237872	2.587956
H. reaumuri	0.008960	−0.277200	2.440010
P. scaber	0.009055	−0.322545	4.931829

The ability to limit the amount of water loss by transpiration through the cuticle varies with species, and is better developed in isopods such as *Venezillo arizonicus* and *Armadillidium vulgare*, which inhabit arid zones, than those of *Porcellio laevis* and *Porcellionides pruinosus* (Wallwork, 1970; Cloudsley-Thompson, 1977). The results of the present study suggest that *A. officinalis* could be included in the first category and *P. scaber* in the second one.

In conclusion, the woodlice inhabiting Benghazi, Libya, are well acclimatized to the temperature range prevailing in the region. For example, large numbers of these animals in the field were found actively feeding on leaf litter in shady places when the surface temperature ranged between 15 and 28 °C. Except for short periods during July/August, the temperature range of the habitat of these woodlice was well within their tolerance limits. Coupled with an abundant supply of foliage throughout the year, this may explain why these woodlice have colonized in large numbers the coastal city of Benghazi, Libya.

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