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Transpiration rates and acclimation to water and temperature of the tropical woodlice, *Porcellionides pruinosus* Brandt and *Porcellio laevis* Latreille

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Abstract. The transpiration rates and acclimation to water and temperature of *Porcellionides pruinosus* Brandt and *Porcellio laevis* Latreille, the common terrestrial isopods occurring in and around Trivandrum, India, were studied. Transpiration rates in different temperatures (24 to 50°C) were higher in both the species during the first 15 minutes' exposure when compared to 1-hour duration. Previous acclimation to different humidity and temperature conditions affected the transpiration rates in both the species and lower rates of transpiration occurred in isopods acclimated to dry conditions and higher temperatures. Survival rates improved at lethal temperatures in specimens acclimated to 34°C.

Keywords. Transpiration; temperature; acclimation; isopods; *Porcellionides pruinosus*; *Porcellio laevis*.

1. Introduction

Although terrestrial isopods are widespread in the tropical south-west coast of India, very little is known concerning their physiological adaptations. In the present study, *Porcellionides pruinosus* Brandt and *Porcellio laevis* Latreille, commonly found in and around Trivandrum, were selected and their rates of transpiration under different temperatures and the nature of temperature and humidity relations have been examined.

Attempts were made to study the physiological adaptations of terrestrial isopods to varying temperature and humidity conditions, the notable contributors of such studies among others being those of Bursell (1955), Paris (1963), Warburg (1965), Edney (1968), Cloudsley-Thompson (1969), Sutton (1969) and Dubinsky and Steinberger (1979).

2. Materials and methods

2.1 *Topography*

Trivandrum lies at 8°20'N lat. and 76°55'E long. in Kerala State, S.W. India. The state is bounded on the west by the Arabian Sea and on the east by the Western Ghats. The area has a tropical climate and the year may be divided into the hot dry pre-monsoon (February to May), the rainy season (June to November) and the comparatively cool

post-monsoon (December and January) periods. The relative humidity is generally above 70% and the maximum goes upto 90% during the monsoon. The atmospheric temperature also varies from a mean maximum of 27·5°C during August to 33·5°C in April and a mean minimum of 21·6°C during January to 25·5°C in April. Rainfall varies from month to month with the maximum during July–November and the minimum during February–April. The region is covered with green bushes, coconut palms and trees and the heavy litter covering the ground provide ideal conditions for the life and propagation of isopods.

2.2 *Material*

Porcellionides pruinosus Brandt and *Porcellio laevis* Latreille, are common terrestrial isopods found in and around Trivandrum. The former is smaller than the latter and the mean weights of specimens used in the experiments were 4·0 mg and 14·7 mg respectively. For transpiration studies, the largest specimens available, mostly adult females, were selected.

2.3 *Sites of collection and methods*

The isopods were collected from 2 localities, one from the Aquarium campus near the seashore, in sandy soils under bricks and stones in humid and shady places, and the other from the city proper about 12 km away from the Aquarium, in loamy soil with rich humus content and also from beneath bricks and stones in cool and shady places. A marked difference was noticeable in the distribution of these isopods in these localities. Over 95% of woodlice collected from the Aquarium area were *P. pruinosus* while an even higher proportion of those taken from the city proper was *P. laevis*. Overlapping of these two populations was not observed in both the localities. Soil pH in the two localities was measured with an analytical pH meter. It averaged 6·8 at the Aquarium campus while in the city it averaged 7·4.

The isopods were maintained in large petri dishes containing damp filter paper with rotting leaves lying on it at room temperature (average about 31 ± 4°C) in natural day light and darkness.

To study the transpiration rates, the effect of acclimation in different temperature and humidity conditions on the rates of transpiration and the effect of acclimation in different temperatures on the lethal temperature, the methods described by Edney (1951, 1954) and Cloudsley-Thompson (1969) were adopted. For transpiration studies the specimens (10 each in number) which were weighed individually were exposed separately for 15 minutes and 1 hour over phosphorous pentoxide at 24, 29, 34, 39, 45 and 50°C before the water-loss through evaporation was estimated by reweighing. The relative humidity was kept constant at 22% in all the temperatures tested. To calculate the surface area of the animal, a value of $K = 12$ was adopted as used by Cloudsley–Thompson (1956, 1969) for many African woodlice and it is the mean of the figures calculated by Edney (1951) for various British woodlice.

3. Results

3.1 *Transpiration*

Water-loss by transpiration is one of the most important physiological factors affecting the distribution of woodlice (Edney 1954, 1968; Cloudsley–Thompson 1969). The results on the transpiration for exposures of *P. pruinosus* and *P. laevis* for 15 minutes and 1 hour in various temperatures are given in table 1. The transpiration rate was higher during the first 15 minutes' exposure for both the species than for 1 hour duration. Thus the mean water-loss for 15 minutes' exposure for *P. pruinosus* at 24°C was 3·80 mg/cm^2/hr which increased to 8·76 mg/cm^2/hr at 34°C and 18·89 mg/cm^2/hr at 50°C whereas the same for 1 hour exposure at 24°C was 1·94 mg/cm^2/hr which further increased to 3·99 mg/cm^2/hr at 34°C and 9·45 mg/cm^2/hr at 50°C. In the case of *P. laevis* the water-loss was lower for both 15 minutes and 1 hour exposures at different temperatures when compared to that of *P. pruinosus*. Thus the mean water-loss for this species for 15 minutes' exposure at 24°C was 2·01 mg/cm^2/hr which gradually increased to 3·68 mg/cm^2/hr at 34°C and 8·21 mg/cm^2/hr at 50°C whereas the values for 1 hour exposure of these animals for the same temperatures were 1·00 mg/cm^2/hr, 1·06 mg/cm^2/hr and 4·26 mg/cm^2/hr respectively (table 1).

3.2 *Effect of acclimation to humidity and temperature on transpiration*

The mean rates of transpiration from both the species previously acclimated in moist and dry conditions and also at two different temperatures of 24°C and 34°C are given in table 2. The transpiration is lower in those acclimated to dry conditions (relative humidity 48%) as compared to those acclimated to moist conditions (relative humidity 68%) and the difference in rates of transpiration between these two conditions is quite significant (at 5% level) in the case of *P. pruinosus*. Such a significant difference, however, was not evident in the case of *P. laevis* (table 2).

Studies on the effect of acclimation to temperature (24 and 34°C) on transpiration rates for both the species show that the transpiration rates are higher in both the species

Table 1. Rate of transpiration in *P. pruinosus* and in *P. laevis*.

Temperature (°C)	Water loss (mg/cm^2/hr)			
	15 min exposure		1 hr exposure	
	P. pruinosus	*P. laevis*	*P. pruinosus*	*P. laevis*
24	3·80 ± 0·07	2·01 ± 0·04	1·94 ± 0·03	1·00 ± 0·02
29	4·15 ± 0·04	2·94 ± 0·06	2·91 ± 0·03	1·04 ± 0·03
34	8·76 ± 0·05	3·68 ± 0·05	3·99 ± 0·05	1·06 ± 0·03
39	10·20 ± 0·05	4·34 ± 0·02	5·82 ± 0·07	2·44 ± 0·04
45	14·78 ± 0·05	6·48 ± 0·03	7·87 ± 0·04	3·57 ± 0·05
50	18·89 ± 0·17	8·21 ± 0·02	9·45 ± 0·05	4·26 ± 0·03

The relative humidity was kept constant at 22%.

Table 2. Mean water loss (mg/cm²/hr) in < 10% relative humidity at room temperatures (34 ± 1°C) for exposure of 1 hr, in woodlice previously conditioned in various ways ($N = 16$).

Species	Conditioning		t	Inference
	moist	*dry*		
P. pruinosus	1·76 ± 0·06	1·43 ± 0·09	2·81	Significant at 5% level $P < 0·05$
P. laevis	1·36 ± 0·19	1·15 ± 0·09	0·87	N.S.
	24°C	34°C		
P. pruinosus	1·65 ± 0·20	3·45 ± 0·51	2·98	Significant at 5% level $P < 0·05$
P. laevis	0·96 ± 0·18	1·31 ± 0·02	1·71	N.S.

N.S.—not significant.

acclimated at 34°C when compared to those acclimated to 24°C. Here also a significant difference (at the 5% level) between the transpiration rates at 24°C and 34°C is discernible in the case of *P. pruinosus* whereas such a difference was not noticed in the case of *P. laevis*.

3.3 *Effect of acclimation on the lethal temperatures*

In preliminary tests conducted at room temperature, most individuals of *P. pruinosus* survived at 41·5°C for 30 min but very few survived at 42·5°C. The lethal temperature of *P. pruinosus* for an exposure of 30 minutes was, therefore, assumed to be around 42°C. In the case of *P. laevis*, however, the lethal temperature was around 44°C although a slight variation occurred on account of the dampness of the filter paper. Studies on the survival rates in their respective lethal temperatures for 2 hr for both the species which were previously acclimatized at two different temperatures of 24°C and 34°C showed that survival was better for both the species acclimated at 34°C as compared to 24°C. The results are presented in table 3. From the data it is apparent that during the initial 30 min exposure, no mortality of *P. pruinosus* and *P. laevis* acclimated at 34°C occurred whereas a gradual reduction in the percentage survival took place in both the species acclimated at 24°C. After 90 min of exposure, however, a sudden increase in the mortality rates for both the species acclimated at 34°C was evident and after 120 min, the percentage of animals survived equalled, irrespective of the temperatures in which they were acclimated (table 3).

4. Discussion

A higher rate of water-loss from the body surfaces of *P. pruinosus* and *P. laevis* during the first 15 min of exposure to different temperatures was noted as compared to 1 hr exposure. The cuticle of land isopods does not possess the water-proofing mechanism,

Table 3. Percentage survival of *P. pruinosus* and *P. laevis* (previously acclimated at 24°C and 34°C) in their lethal temperatures of 42°C and 44°C respectively.

Time of exposure (min)	Percentage survival			
	P. pruinosus Acclimated at		*P. laevis* Acclimated at	
	24°C	34°C	24°C	34°C
0	100·00	100·00	100·00	100·00
15	90·91	100·00	91·67	100·00
30	72·73	100·00	83·33	100·00
45	72·73	90·91	41·67	100·00
60	63·64	90·91	33·33	83·33
75	45·45	81·83	16·67	66·67
90	36·36	81·83	16·67	41·67
105	36·36	45·45	8·33	8·33
120	36·36	36·36	8·33	8·33

an oriental layer of lipid molecules in the epicuticle so characteristic of insects and arachnids (Lees 1947; Baement 1961). Thus the higher initial rate may be due mainly to loss of water from layers of the cuticle external to lipid barrier, which is later followed by shrinkage of the cuticle thus leading to a closer packing of the lipid molecules and, therefore, to decreased permeability (Bursell 1955). This is clearly advantageous to the animal since it acts as a regulating mechanism that reduces the rate of water-loss at a time when conservation is most needed (Cloudsley-Thompson 1969).

Observations on the transpiration rates of *P. pruinosus* and *P. laevis* previously acclimated to moist and dry conditions and also at two different temperatures of 24°C and 34°C, show a significant difference in their transpiration rates in different acclimated conditions and that the transpiration rates are higher in those conditioned under moist conditions and at a higher temperature of 34°C. Higher cuticular permeability at higher temperatures is a typical character of cryptozoic animals (Lawrence 1953). The ability to loose water rapidly by transpiration certainly enables the woodlice to withstand high temperatures for brief periods (Edney 1954). Edney (1951) also found significantly different rates of evaporation from specimens of *Armadillidium vulgare* obtained from different localities of England and concluded that the same species showed considerable difference in their rates of evaporation resulting from selection over a long period or an effect of acclimation within the lifetime of the individual, or both. This seems to be true in the present study also where these animals showed marked differences in transpiration in varying temperature and humidity conditions.

Regarding lethal temperatures, the highest ambient temperature that land isopods tolerate is a reflection of their genetic constitution, the period of exposure, the rate of rise, the ambient humidity and the temperature history (acclimation) (Edney 1968). Thus factors such as size, duration of exposure, permeability of the cuticle and humidity, seem to play significant roles in determining the effects of high ambient temperatures. Studies on the survival rates of *P. pruinosus* and *P. laevis* in their respective lethal temperatures showed that the survival was better for both the species acclimated at higher temperature. Edney (1964) also made similar observations on

Armadillidium vulgare and *Porcellio laevis* in California and he found that neither size nor mortality affected the lethal temperature but that acclimation for some days in different temperatures had a marked effect. This is true in the case of African woodlice also (Cloudsley–Thompson 1969).

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