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OSMOTIC INTERRELATIONSHIP BETWEEN BLOOD AND GUT FLUID IN THE ISOPOD *PORCELLIO SCABER* LATR. (CRUSTACEA)

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Abstract—1 The osmotic interrelationship between the blood and the gut fluid (as obtained from the mouth) on desiccation was investigated in the terrestrial isopod *Porcellio scaber* Latr.

2. In normal, undesiccated animals the concentration of the oral fluid is 244·5 ± 6·1 mM NaCl/l and that of the blood 313·1 ± 3 3 mM NaCl/l (N = 45).

3. On desiccation the blood osmotic concentration remains fairly unchanged up to a 10% loss of body weight, while that of the oral fluid increases rapidly and reaches the maximum of 500 mM NaCl/l in about 90 min in dry air After a severe desiccation the two compartments come to an osmotic equilibrium.

4 It is suggested that the main reason for the osmotic changes is related to withdrawal of water from the gut lumen into the blood, though on severe desiccation also volume changes in the two compartments may come into play.

INTRODUCTION

THE TWO main routes of water loss in terrestrial isopods are through the general body surfaces and from the gut by regurgitation (Lindqvist, 1972), the regurgitated fluid spreads mostly over the ventral surface through the water capillary system and evaporates out. In the same study, it was suggested that the gut serves as a site of water storage, which appears as an important adaptation to the terrestrial mode of life. The volume of this fluid is larger in the more terrestrial species *Armadillidium vulgare* (L.) than in *Porcellio scaber* L. (Lindqvist, 1968, 1972).

This study aims at elucidating more specifically the possible role of the gut fluid in water regulation of the terrestrial isopod *P. scaber*. Emphasis is placed on the osmotic interrelationship between the gut fluid and the blood during desiccation in dry air.

MATERIALS AND METHODS

Porcellio scaber were obtained from near St Louis, Missouri. The animals were reared in laboratory as described earlier (Lindqvist, 1972) and also treated the same way before commencement of each experiment. The animals were desiccated in individual cages in dry air over Drierite®. Blood was obtained with disposable 1 μl capillary by puncturing the pericardial cavity dorsally. The gut fluid was obtained from the mouth with a similar capillary by mechanical stimulation of the mouth parts, which leads to regurgitation. The amounts withdrawn varied from 1 to 0·1 μl depending on the degree of desiccation. Blood and oral fluid (in this order) were taken from each animal, and the osmotic concentrations were determined with the Gross' method (cf. Lindqvist, 1968).

RESULTS

The mean osmotic concentration of the oral fluid of normal (undesiccated) *P. scaber* is equivalent to 244·5 ± 6·1 mM NaCl/l (N = 45). On desiccation, the osmotic concentration of this fluid increases rapidly (Fig. 1) until there is no further change after a total weight loss of some 12–15%. This is reached in about 90 min in dry air. In contrast to the oral fluid, the osmotic concentration of blood remains fairly unchanged during this time (Fig. 2). The control mean is 313·1 ± 3·3 mM NaCl/l (N = 45) and only after a water loss of some 10% of body weight is there a gradual increase in the osmotic value of the blood. After a mild desiccation there seems rather to be a drop in the blood osmotic concentration as compared to the undesiccated controls. The highest values

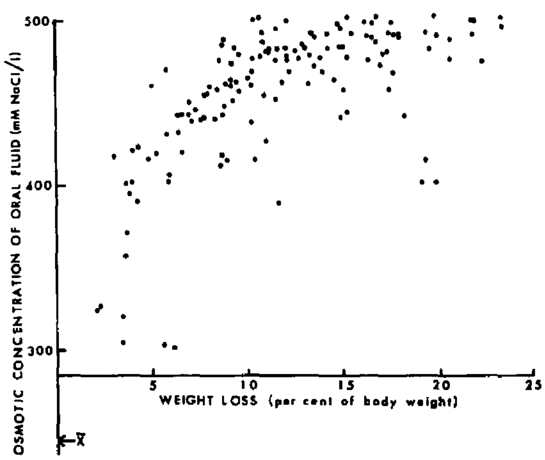

Fig. 1. The osmotic concentration of the gut (oral) fluid of *P. scaber* in relation to weight loss on desiccation in dry air. The mean value of control (undesiccated) animals is shown by X̄.

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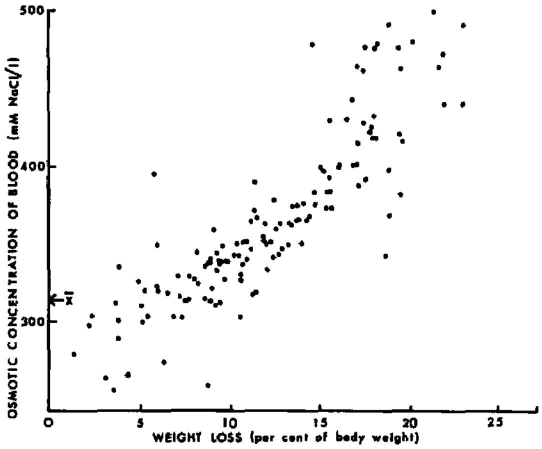

Fig. 2. The osmotic concentration of the blood of *P. scaber* in relation to weight loss on desiccation in dry air. The mean value of control (undesiccated) animals is shown by x̄.

Table 1. The temporal pattern of osmotic changes in the oral fluid and the blood of P. scaber on desiccation in dry air. The osmotic values are given as equivalent to mM NaCl/l (± S.E.).

Length of desiccation	Blood	Oral fluid	N
Control (no desiccation)	313.1 ± 3.3	244.5 ± 6.1	45
30 min.	309.3 ± 6.6	390.6 ± 11.3	24
90 min.	343.0 ± 3.3	461.0 ± 3.0	66
180 min.	406.4 ± 7.6	479.2 ± 3.3	36

recorded for both the oral fluid and the blood did not exceed 500 mM NaCl/l; the animals may survive even higher concentrations, but it proved impossible to obtain samples after more severe desiccation.

Figure 3 depicts the interrelationship in the osmotic concentration between the oral fluid and the blood in each animal. It appears that the water in the gut clearly serves as an osmotic buffer against the effects of desiccation. The osmotic concentration of the blood (of the value of some 310 mM NaCl/l) is buffered against the range from about 100 to 480 mM NaCl/l of the fluid in the gut.

DISCUSSION

Horowitz (1970) in his study of the water balance in *P scaber* showed that on desiccation the osmotic values of the blood do not increase linearly in relation to the total water loss from the body. He attributed this buffering of the blood to the movement of water from the tissues into the blood; e.g. there was a decrease in the water content of muscles. This buffering of the blood is in agreement with our results, though the present data indicate that the role of the gut as a water storage site may be more pronounced than

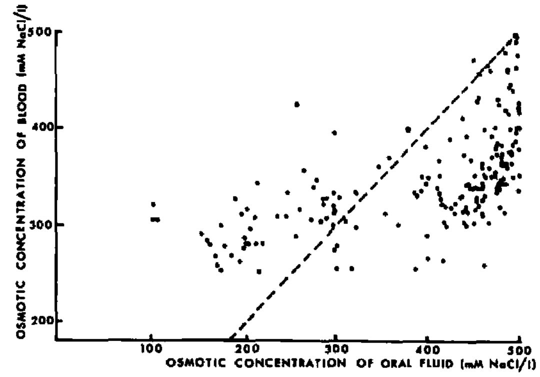

Fig. 3. The relationship in osmotic concentration between the oral fluid and the blood of *P. scaber* on desiccation in dry air.

realized earlier. The isopod *Oniscus*, which is considered less terrestrial than either *Porcellio* or *Armadillidium* (Edney, 1968), apparently lacks the capacity for water storage in the gut, since its blood osmotic concentrations rise linearly with increasing desiccation (Berridge, 1970). In our studies the animals died after a weight loss of some 27%, when their blood reached an osmotic value of about 500 mM NaCl/l. Horowitz (1970) reports that in his studies the animals survived up to between 500 and 600 mM NaCl/l.

An interesting parallel can be drawn with the terrestrial crab *Gecarcinus lateralis* (Mantel, 1968). In this animal the foregut is permeable to water and ions from the hemolymph to lumen and vice versa. In eyestalkless animals, according to Mantel, the permeability is lost after ecdysis. Furthermore, she showed that these movements may be under neuroendocrine control. We do not know the exact site of water movement (or the site of osmotic regulation) in *Porcellio*, but considering the ready availability of the oral fluid it must originate from the foregut, though the hepatopancreas may also participate to some extent. An interesting feature in our results is that, at the very beginning of desiccation, the osmotic concentration of the blood may even drop slightly (Fig. 2) as compared to the controls. That is, the onset of desiccation may trigger water movement from the gut lumen into the blood before the osmotic concentration is actually affected by desiccation. It is also possible that in this case not only having water transport from the gut lumen into the blood, but also some movement of ions in the opposite direction. The exact composition of the oral fluid is unknown, but our preliminary experiments do show that the interrelationship of the common ions Na^+ and Cl^- between the gut fluid and the blood do not follow in a straightforward manner the changes in the osmotic values of the two compartments. It became more and more difficult to obtain blood and oral fluid with increasing desiccation, which probably resulted also from shrinking of the volume of the two compartments. Nicolson *et al.* (1974) report recently that in the insect *Carausius* the water loss on desiccation is largely confined to the blood, which declines in volume drastically.

The present data do not allow any speculation as to the nature of this apparent water movement, i.e., whether it is active or passive following the movement of some solutes through the gut wall (cf. Ramsay, 1964; Phillips, 1969; Berridge & Oschman, 1969; Maddrell, 1971).

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