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THE INORGANIC ION COMPOSITION OF THE HEMOLYMPH OF THE EARWIG, LABIA MINOR (DERMAPTERA : LABIIDAE), FROM MACOUPIN COUNTY, ILLINOIS

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ABSTRACT

The hemolymph of the earwig, Labia minor (Labiidae) was analyzed for inorganic ion composition and total osmotic pressure. The inorganic fraction is characterized by a high sodium and chloride concentration which contributes significantly to the total osmotic pressure. The relationship between inorganic ion composition and the phylogeny of the Arthropoda is discussed.

INTRODUCTION

Previous investigations concerning the composition of insect hemolymph, although numerous, have concentrated on relatively few species (Duchateau et al. 1953; Florkin and Jeuniaux 1974; Ikan and Ishay 1973; Jeuniaux 1971; Jungreis et al. 1973; Levenbook and Hollis 1961; Sutcliffe 1962; Wyatt 1961). With the recent emphasis on phylogenetic relationships within the Arthropoda based on morphological and physiological evidence (Anderson 1973; Sharov 1966), including the chemical composition of the hemolymph (Alikhan 1973; Bedford and Leader 1975; Bowerman 1976; Campaglia 1976; Ishay 1975; Jennifer and Leader 1975; Naire and Prabhu 1971; Padmanabhanaidu 1966; Sutcliffe 1963), it is imperative that additional species be studies so that more accurate taxonomic comparisons can be made.

The Dermaptera represent an insect group characterized by an overall scarcity of physiological data. Hemolymph

analyses are available for only two species; the forficulid, Forficula auricularia (Moriarty 1976), and the labidurid, Anisolabis littorea (Leader and Bedford 1972). The purpose of the present study was to investigate the inorganic electrolyte composition of the hemolymph of Labia minor (Labiidae), a relatively common Illinois earwig (Hebard 1934; Popham 1965) for which no previous hemolymph data exist.

MATERIALS AND METHODS

The specimens of Labia minor were collected during May and June, 1976. Earwigs measuring 4 to 5 mm were obtained from damp leaf litter and decaying logs bordering Macoupin Creek, in Carlinville (Macoupin County), Illinois. The insects were maintained in the laboratory at constant temperature (19 deg C). All animals were deprived of food for 24 hr prior to hemolymph determinations as prescribed by previous investigators (Florkin and Jeuniaux 1974; Jungreis et al. 1973). Water was available at all times.

The procedure used to collect hemolymph was similar to that reported by Campaglia (1976). An incision was made over the dorsal aspect of the thorax and 1-2 µl of hemolymph were collected from each specimen by aspiration with a glass micropipette. Due to the slow coagulation time and low number of hemocytes characteristic of dermapteran vascular fluids (Leadrer and Bedford 1972), it was not necessary to centrifuge the hemolymph. The hemolymph from 25 insects was pooled for analysis.

Osmotic pressure was determined by the microcryoscopic method of Ramsay (1949). Sodium and potassium ion determinations were measured with a flame microspectrophotometer (Malnic et al. 1964), and calcium and magnesium ion concentrations on an SA atomic absorption spectrophotometer (Jennifer and Leader 1975). Chloride ion determinations were performed by the potentiometric method of Ramsay et al. (1955). Phosphate concentration was measured by a standard colorimetric method (Fiske and Subbarow 1925). Ion concentrations were recorded in mM/l of hemolymph (Bowerman 1976; Jennifer and Leader 1975; Leader and Bedford 1972).

RESULTS AND DISCUSSION

The concentrations of the measured ions in the hemolymph of Labia minor are shown in Table 1. The four major cations contribute over half the osmotic pressure, with

sodium playing the major role. Similar results have been reported for several species of Ephemeroptera, Homopter and Odonata (Florkin and Jeuniaux 1974; Sutcliffe 1963), Orthoptera and Isoptera (Duchateau et al. 1953; Jeuniaux 1971; Wyatt 1961), and a labidurid Dermapteran (Leader and Bedford 1972).

The results also indicate that sodium and chloride are the inorganic ions present in the greatest concentration. This has been reported for several additional exopterygote species (Jeuniaux 1971) as well. This differs, however, from results reported for several endopterygote species including the Mecoptera, Neuroptera, Trichoptera and Diptera (Duchateau et al. 1953; Florkin and Jeuniaux 1974). In these

TABLE 1. The inorganic ion composition of the hemolymph of Labia minor. Ion concentrations expressed in mM/liter of hemolymph.

Total Osmotic Pressure	232.7
Cations:	
sodium	104.5
potassium	18.2
calcium	16.8
magnesium	7.3
Total	136.8
Anions:	
chloride	91.8
phosphate	6.3
Total	98.1

endopterygotes, sodium is the principle cation, but the chloride ion concentration is greatly reduced and is partially replaced by a significantly higher amino acid concentration. Sodium is replaced by magnesium as the dominant hemolymph cation in some phasmatid Orthopterans (Jeuniaux 1971; Wyatt 1961). The effect of cations and chloride on osmotic pressure is greatly reduced in several species of Lepidoptera, Coleoptera and Hymenoptera, with organic molecules having the greatest osmotic effect (Duchateau et al. 1953; Ikan and Ishay 1973; Ishay 1975; Jungreis et al. 1973; Levenbook and Hollis 1961).

Results such as this have led to tentative conclusions concerning the biochemical evolution of insects and other arthropods. Sutcliffe (1963) has proposed that, in general, the more primitive insects (apterygotes and exopterygotes) tend to have hemolymph characterized by high concentrations of inorganic ions and low concentrations of organic compounds, whereas the more advanced insect groups (endopterygotes) show a reduced inorganic ion concentration with a concomitant increase in organic substances such as amino acids. The hemolymph of other arthropod groups such as Onycophora, Diplopoda, Chilopoda, arachnids and terrestrial isopods, is characterized by a high concentration of sodium and chloride ions (Alikhan 1973; Bedford and Leader 1975; Bowerman 1976; Campaglia 1976; Jennifer and Leader 1975; Jeuniaux 1971; Naire and Prabhu 1971). This suggests a closer taxonomic relationship between these arthropods and the apterygote and exopterygote insects than with the endopterygote insects. The results obtained in this study show the electrolyte composition pattern of the hemolymph of L. minor (Labiidae) to be very similar to the general inorganic ion hemolymph composition reported for other earwigs (Leader and Bedford 1972), and that this pattern is more similar to the concentrations found in non-insectan arthropods and other exopterygotes than it is to the more advanced endopterygote insects. In addition, the concentration of the dominant sodium and chloride ions in this species, 104.5 and 91.8 mM/l respectively, varied somewhat from that reported for a labidurid (193, 80) earwig (Florkin and Jeuniaux 1974; Leader and Bedford 1972) and a forficulid earwig (96, 80). This supports the classification of Labia minor as a separate family, Labiidae. Additional hemolymph studies on more species will further clarify the phylogenetic relationships of the Insecta and the Arthropoda as a whole.

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