RELATIVE COMPARISONS IN MAJOR AND TRACE ELEMENTS BETWEEN ADULT AND IMMATURE STAGES OF TWO SPECIES OF FIRE ANTS

R. LEVY, H. L. CROMROY, AND H. A. VAN RINGSVELT

ABSTRACT

Ion induced X-ray fluorescence was used to analyze adult and immature stages of Solenopsis richteri Forel and S. geminata (F.) for total body concentration of 16 major and trace elements. Results indicated that P, S, Cl, K, Ca, Ni, Cr, Ti, Fe, Cu, Zn, Mn, Pb, Sr, Mo, and Rb could be detected in ashed samples of major and minor workers, pupae, and larvae. Multi-elemental analyses among 3 developmental stages in each of the 2 species indicated that adults contained a greater relative concentration of major and trace elements when compared to the immature stages. In addition, the following trend concerning the total body elemental concentration was generally observed: workers > pupae > larvae.

Ion induced X-ray fluorescence data has been presented by Levy et al. (1974) indicating that significant levels of P, S, Cl, K, Ca, Ni, Br, Ti, Fe, Cu, Zn, Mn, Pb, Sr, Mo, and Rb could be detected in the tissues of major and minor workers, larvae, and pupae of the red imported fire ant, Solenopsis invicta Buren. Generally, we found that adult red imported fire ants contained a higher relative total body concentration of major and trace elements than the immature stages, with the following trend being noted: workers > pupae > larvae (Levy et al. 1974). With the exceptions of Ca and Mn, red imported fire and queens had lower concentrations of all major and trace elements than workers (Levy et al. 1975). In addition, Levy and Cromroy (1975) estimated the total body concentration (ppm) of K, Na, Mg, Fe, and Cu in major and minor worker red imported fire ants using atomic absorption spectrophotometry.

This research was designed to use the ion induced X-ray fluorescence (IIXF) technique for intraspecific comparisons of relative total body levels between the worker, pupal, and larval stages of the black imported fire ant, S. richteri Forel and the fire ant S. geminata (F.).

METHODS AND MATERIALS

Two 3-g samples of larvae, pupae, and a mixture of major and minor worker of S. richteri and S. geminata were obtained from colonies maintained at the Insects Affecting Man and Animals Research Laboratory, SEA, USDA, Gainesville, FL.

Each developmental stage of the fire ants was lyophilized and ashed in a low temperature radio frequency furnace. A few milligrams of the residual

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Fig. 1. Ion induced X-ray fluorescence analysis of black imported fire ant larvae.

Fig. 2. Ion induced X-ray fluorescence analysis of black imported fire ant pupae.
ask was glued to self-supported pure carbon films with a drop of diluted polystyrene glue. Samples were then bombarded with 4 MeV helium ions (Ec) produced by the University of Florida Van de Graaff accelerator. The charge accumulated on a target during analysis was 240 or 300 nC with a beam intensity of 130, 140, or 150 nA. Emitted X-rays were detected by a Si(Li) detector and stored in a 812 channel pulse height analyzer which finally delivered a complete spectrum of the emitted X-rays; this permitted identification of the elements present in the samples via their characteristic X-rays. Pulse heights of specific elements were used to compare the developmental stages within a fire ant species and not between species since the diets for the 2 species were not considered identical. Multi-elemental comparisons between workers (W), larvae (L) and pupae (P) within a species, were determined on a greater than (≥) slightly greater than (>) less than (<) slightly less than (≪), and/or approximately equal (≡) basis. Van Rinsvelt et al. (1973) have reported techniques and methods of IIXF for insects.

RESULTS AND DISCUSSION

The IIXF analyses indicated that relative levels of P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Pb, Rh, Sr, and Mo could be detected in the tissues of adult and immature stages of S. richteri and S. geminata. Although background interference obscured the characteristic Pb, Sr, and Mo peaks (Figs. 2, 4, 5), they were presumed to be present in these fire ant tissues in extremely low concentrations. In addition, some interference of P, S, Cl peaks was observed.

The characteristic multi-elemental spectra for the adult and immature stages of S. richteri and S. geminata are presented in Figs. 1-3 and 4-6, respectively. Table 1 shows the relative amounts of elements for 3 developmental stages of each fire ant species.

Results obtained for S. richteri and S. geminata seemed to follow the same general trend as S. invicta, i.e., adults contained a greater total body concentration of major and trace elements than the immature stages (Levy et al. 1974). With respect to total body elemental concentrations the general trend of workers > pupae > larvae was less apparent in S. richteri and S. geminata analyses than was found in S. invicta (Levy et al. 1974).

The physiological significance of the various levels of elements detected in the developmental stages of the 2 species of fire ants is not known. Although the importance of metals and non-metals in maintaining homeostasis in biological systems has been established (Christian and Feldman 1970, Levy and Cromroy 1973) several theories have been presented on their possible roles in other physiological processes. Callahan (1965) postulated that sensilla on insect antennae are actually dielectric waveguides that resonate to narrow band infrared emissions from scent molecules. He (1967) further theorized that diodes and other such solid state detector configurations depend on “doping” with minute trace elements. Since the antenna sensilla are doped with certain such elements (Callahan, personal communication) he feels that elemental levels have direct bearing on the organic solid state detecting capabilities of the sensilla. Sensilla should be studied as combination waveguide-doped organic detector systems.
Fig. 3. Ion induced X-ray fluorescence analysis of black imported fire ant workers.

Fig. 4. Ion induced X-ray fluorescence analysis of fire ant larvae.
Fig. 5. Ion induced X-ray fluorescence analysis of fire ant pupae.

Fig. 6. Ion induced X-ray fluorescence analysis of fire ant workers.
TABLE 1. WITHIN SPECIES COMPARISONS IN THE AMOUNTS OF SOME MAJOR AND TRACE ELEMENTS IN ADULT AND IMMATURE STAGES OF Solenopsis richteri and S. geminata AS DETERMINED BY ION INDUCED X-RAY FLUORESCENCE METHODS.

<table>
<thead>
<tr>
<th>Species</th>
<th>Stage relationship*</th>
<th>Multi-elemental comparison according to stage</th>
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</thead>
<tbody>
<tr>
<td>S. richteri</td>
<td>P vs. L</td>
<td>P &gt; L: Ca, Mn, Fe, Zn, Mo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P &lt; L: Pb, Cl, Ti, Cu, Rb</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P = L: Cr, Sr</td>
</tr>
<tr>
<td></td>
<td>W vs. L</td>
<td>W &gt; L: Ca, Mn, Fe, Zn, Pb, Sr, Mo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W &lt; L: Cr, Ni, Cu</td>
</tr>
<tr>
<td>S. geminata (F.)</td>
<td>P vs. L</td>
<td>P &gt; L: Pb, S, Cl, Cr, Fe, Zn, Pb, Rb, Sr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P = L: Ca, Ti, Mn, Ni</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P = L: Cu</td>
</tr>
<tr>
<td></td>
<td>W vs. L</td>
<td>W &gt; L: Pb, S, Cl, K, Ca, Cr, Fe, Cu, Zn, Pb, Rb, Sr, Mo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W &lt; L: Ti, Ni</td>
</tr>
<tr>
<td></td>
<td>W = L: Mn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>W vs. P</td>
<td>W &gt; P: Pb, S, Cl, K, Ca, Ti, Cr, Mn, Pb, Rb, Sr, Mo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W &lt; P: Sr</td>
</tr>
</tbody>
</table>

*Stages are abbreviated as follows: W = worker; P = pupa; L = larva.

Vinson (1970) showed that the gustatory response of the imported fire ant was stimulated by certain anions and cations. Levy and Cromroy (1973) and Levy et al. (1974 a, b) suggested the importance of major and trace elements in determining the radiosensitivity of the imported fire ant as well as other species of insects.

A recent advancement over these qualitative analytical procedures has been made by Van Rinsvelt et al. (1977) using proton-induced X-ray emission. This technique will permit quantization of individual elements of an insect or its parts, and therefore will be a useful tool in numerous physiological studies.

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LITERATURE CITED


TAXONOMIC CLARIFICATION WITHIN THE GENUS DROMOGOMPHUS SELYS (ODONATA: GOMPHIDAE)¹

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ABSTRACT

Keys and illustrations are given for the separation of adults and nymphs of Dromogomphus armatus Selys, D. spinosus Selys and D. spoliatus (Hagen). The present known distributions and flight dates of the 3 species are listed.

Wright (1946) published a key with illustrations to separate the nymphs of Dromogomphus spinosus Selys and D. spoliatus (Hagen), saying that the

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