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Original article

Ultrastructure of the flight muscle of worker honey bees heavily infested by the tracheal mite *Acarapis woodi*

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Summary — Worker honey bees, heavily infested with tracheal mites, were collected in Vacaville, CA during the summer of 1988 and spring of 1989. The dorsal longitudinal indirect flight muscle of both healthy and heavily infested worker honey bees was studied by transmission electron microscopy. In the flight muscle of healthy honey bees, mitochondria were large and arranged in rows between the myofibrils. Glycogen particles were embedded in the myofibrils and accumulated in the sarcoplasm. In the flight muscle of tracheal mite-infected honey bees, glycogen particles were completely depleted and both the cristae, inner and outer membranes of the mitochondria, as well as the myofibrils, were electron-dense. The sarcoplasm of the flight muscle was electron-lucid. The significance of these ultrastructural changes is discussed in relation to tracheal infestation.

***Apis mellifera* / *Acarapis woodi* / tracheal mite / flight muscle / mitochondria glycogen**

INTRODUCTION

Tracheal mites were found in the Rio Grande Valley (Fore, 1984), Texas in 1984, and rapidly spread throughout the North American continent. According to Bailey, tracheal mite infestation has little effect on honey production and honey bee mortality (Bailey, 1981). However, studies conducted in North America have proven that tracheal mite infestation does have an economic impact on the beekeeping industry (Gruszka, 1987; Furgala *et al*, 1989). Although numerous studies have been carried out on tracheal mites, most of them have focused on chemical controls and detection techniques. Only a few studies have been undertaken to study the patho-physiological aspects of tracheal mite infestation (Liu, 1989a, b). In this brief communication, the effects of tracheal mite infestation on the ultrastructure of the flight muscle is described.

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* This study was performed during sabbatical leave.

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MATERIALS AND METHODS

Tracheal mite-infested and healthy honey bee workers were collected in Vacaville, California during the summer of 1988 and spring 1989. The dorsal longitudinal indirect flight muscle was dissected and fixed in 4% glutaraldehyde in 0.2 mol•l^{-1} phosphate buffer, pH 7.4, at 4 °C for 12 h. Fixed specimens were rinsed with the same buffer and postfixed with 1% osmium tetroxide for 2 h. Specimens were then dehydrated through a graded series of ethyl alcohol and embedded in poly-bed (Polyscience, Warrington, PA). Sections were stained with uranyl acetate and lead citrate before being examined under a Philips EM 400 electron microscope.

RESULTS AND DISCUSSION

In the flight muscle of healthy honey bees there were numerous mitochondria which possessed well defined cristae and outer mitochondrial membranes. The mitochondrial matrix was relatively electron-dense. In the sarcoplasm, glycogen in the form of particles was aggregated in clusters. Glycogen particles were also embedded in the myofibrils (fig 1). In the flight muscle of honey bees heavily infested with tracheal mites, both mitochondria and muscle fibers were electron-dense. Glycogen particles were no longer observed (fig 2). These changes were detected in the flight muscle of 6 heavily infested honey bee workers. They may indicate that the flight muscle of heavily infested honey bees was in the process of degeneration, and may also indicate that this degeneration is due either to lack of oxygen, or to lack of energy reserve. Honey bees use carbohydrates as fuel for flight. It is a known fact that the to-

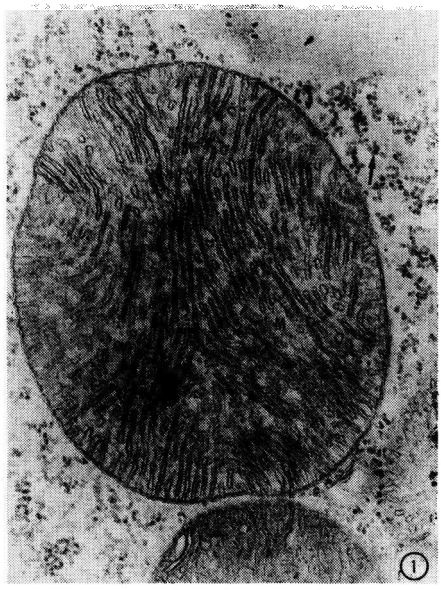

Fig 1. A portion of the flight muscle in a healthy bee. Mitochondria (M) is large with numerous well defined cristae. The mitochondrial matrix is relatively electron-dense. In the sarcoplasm numerous glycogen particles can be seen (arrow). Glycogen particles are also found in the muscle fiber (small arrows) x 51 500.

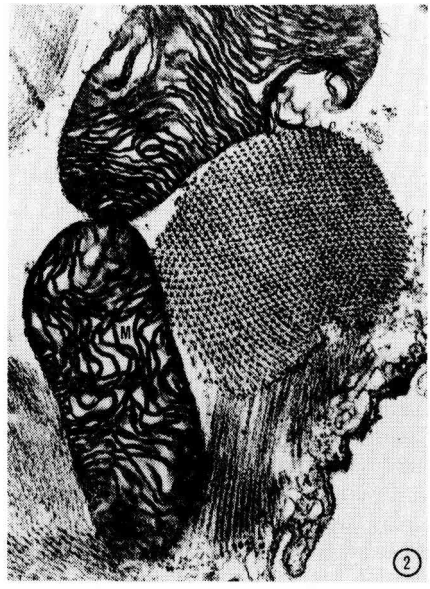

Fig 2. A portion of the flight muscle in a honey bee heavily infested with tracheal mites, viewed at high magnification. Note that both mitochondria and muscle fiber are electron-dense. The mitochondrial matrix is electron-lucid, as is the sarcoplasm. Glycogen particles are completely depleted. x 51 000.

tal duration of flight in some insects is closely related to the amount of their glycogen reserves. Once the glycogen reserves are exhausted, the insect is quite incapable of flight (Gilmour, 1965). The lack of glycogen in the flight muscle of heavily infested honey bees may indicate that a large population of mites in the tracheal system have consumed all the energy reserves. Consequently, honey bees may not be able to fly due to lack of fuel. This may explain why mite infested honey bees exhibit a crawling symptom (Bailey, 1981). Some insects are known to use between 80–400 l of oxygen per kg of body weight per h. In the main tracheal trunks of heavily infested honey bees, the branch trachea and air sacs in the head are filled with debris and mites at different developmental stages (Liu *et al,* 1989b). Consequently, oxygen supply may be restricted. Without oxygen, the aerobic metabolism in the flight muscle may be inhibited and the infested honey bee could lose its flight ability.

Résumé — Ultrastructure du muscle du vol d'abeilles ouvrières (*Apis mellifera* L) fortement infestées par l'acarien *Acarapis woodi.* Des ouvrières d'abeilles saines et fortement atteintes d'acariose ont été récoltées à Vacaville, Californie au cours de l'été 1988 et du printemps 1989. Le muscle dorsal longitudinal, muscle indirect, du vol a été étudié au microscope électronique à transmission. Chez les abeilles saines, les mitochondries sont grosses et disposées en lignes entre les fibrilles musculaires. Les particules de glycogène sont incluses dans la fibrille musculaire et s'accumulent dans le sarcoplasme. Chez les abeilles atteintes d'acariose, les particules de glycogène ont complètement disparu et les crêtes, membranes interne et externe des mitochondries, comme les fibrilles musculaires sont denses aux électrons, contrairement au sarcoplasme qui lui ne l'est pas. La discussion porte sur la signification de ces modifications ultrastructurales en relation avec l'infestation par l'acarien.

***Apis mellifera* / *Acarapis woodi* / muscle du vol / mitochondrie / glycogène**

Zusammenfassung — Die Ultrastruktur der Flugmuskeln von schwer mit Tracheenmilbe *(Acarapis woodi)* befallenen Arbeitsbienen. In Vacaville, Kalifornien, wurden während des Sommers 1988 und Frühjahres 1989 schwer mit Tracheenmilben befallene Arbeitsbienen gesammelt. Die dorsalen Längsmuskeln, also die indirekten Flugmuskeln, wurden mittels Transmissions-Elektronenmikroskopie untersucht. Im Flugmuskel der gesunden Biene waren die Mitochondrien groß und in Reihen zwischen den Myofibrillen angeordnet. Glykogen-Partikel waren in den Myofibrillen eingebettet und im Sarkoplasma angereichert. In den Flugmuskeln von mit Tracheenmilben befallenen Bienen waren die Glykogen-Partikel vollständig verschwunden und sowohl die Cristae, die innere und äußere Membranen der Mitochondrien wie die Myofibrillen waren elektronendicht. Das Sarkoplasma der Flugmuskeln war elektronendurchlässig. Es wird die Bedeutung dieser ultrastrukturellen Veränderungen in Folge der Milbeninfektion diskutiert.

***Apis mellifera* / *Acarapis woodi* / Flugmuskel / Mitochondrie / Glykogen**

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