Morphology and Distribution of Mechanoreceptors of Diaspididae Females (Hemiptera: Sternorrhyncha)

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ABSTRACT

The structure of the female bodies of several Diaspididae species was examined using leica-microsystems. Several types of mechanical sensilla for nine species were described. They were Parlatoria zizyphi, Parlatoria oleae, Abugrallaspis mendex, Dynaspidiotus britannicus, Hemiperlesia cyanophilli, Lepidosaphes ficus, Lepidosaphes beckii, Aulacaspis tubercularis and Diaspidiotus pronorum. The structures of antennae of the different species and antennomers of the antennae were described in P. zizyphi, A. mendax, D. britannicus, H. cyanophilli, L. ficus and A. tubercularis. By tracing the tactical hairs on the studied insect species in P. oleae, L. beckii, A. mendax, D. pronorum and D. britannicus, it was found that they exist in several places and differ from one species to another, and they may be found single or double. Also, another mechanoreceptors on one campaniform sensillum in P. zizyphi, L. beckii and L. ficus some trichodea sensilla as mechanoreceptive setae were found in the prosoma and postseta in L. beckii, L. ficus and D. pronorum. According to these comparative studies it is hypothesized that the general organization of the sensilla is common to Diaspididae. Four sensillary patterns were recognized, with an attempt to use these data at the systematic level.

Keywords: Sense organs, Sensory pores, Sensilla, Diaspididae, Mechanoreceptors.

INTRODUCTION

Nearly every aspect of an insect's body is covered in mechanoreceptors. They might function as touch receptors, picking up on movement of outside objects, or they might give proprioceptive cues (sensory input about the position or orientation of the body and its appendages). One or more sensory neurons that fire in response to stretching, bending, compression, vibration, or other mechanical disturbance innervate these receptors. When stimulated, some mechanoreceptors respond phasically, firing twice: once when active and once when deactivated. While a stimulus is present, other receptors produce a tonic response, firing repeatedly. The brain's segmental ganglia or neural processing centres decode the tonic and phasic signals sent by neighbouring receptors. (NC Agriculture and Life Sciences)

Particularly intriguing models of adaptable sensory control are insects. Although thorough research since then has shown that insects' locomotor patterns are, in reality, very flexible, early accounts frequently portrayed insects as simple machines, "depriving them of any component of intelligence" (Kirby and Spence, 1822).

One of the most diverse and significant insect orders is the hemipteran family, which is distinguished by its piercing-sucking mouthparts (Weintraub and Beanland, 2006). The Sternorrhyncha, which includes aphids, psyllids, scale insects, and white flies, is one subgroup within this group that performs a critical ecological and economic function as plant pests and viral vectors (Eastop, 1977; Ng and Perry, 2004; Hühnlein et al., 2016).

Numerous publications discuss the exoskeletal characteristics of the adult male and female of the Diaspididae, internal morphology and anatomy, biological and behavioural aspects in relation to the species (Teron, 1958; Swiderski, 1980; Bushtik, 1958; Ghari, 1962; Borchenius, 1965; Borchenius, 1966; El-Minshawy and Osman, 1973; Davidson and Miller, 1977; Nada and Mohammad, 1984; Bullington, 1989; Rosen, 1990; Hamdy, 2020). However, there are just a few physical details on the sensilla of diaspid females. The male sensilla of the Diaspididae are known to engage in sexual activity, and females are drawn to the male for mating. In order to receive the male emasculation deity and complete the insemination process, Procelli (1995) claimed that female bodies should have sensory organs.

The aim of this study is to Examineing and defining the many types of mechanoreceptors on the various regions of the bodies of Parlatoria zizyphi, Parlatoria oleae, Abugrallaspis mendex, Dynaspidiotus britannicus, Hemiperlesia cyanophilli, Lepidosaphes ficus, Lepidosaphes beckii, Aulacaspis tubercularis and Diaspidiotus pronorum. Thus, this study aimed to show that: (i) structures of antennae of females diaspidae, (ii) tracing the tactical hairs on the studied insect species, (iii) campaniform sensillum on the different parts of female body of four different diaspidid species, and (iv) trichodea sensilla as mechanoreceptive setae

MATERIALS AND METHODS

Mounting slides of adult females for identification procedure

The taxonomic characteristics of adult females serve as the basis for the identification processes of various diaspid species. The materials from the collected adult females were made into both temporary and permanent mount slides. The scale was removed from the adult females' temporary mounts.
using a microneedle. After that, the specimens were picked up on glass slides, given drops of Hoyer's medium, coated with glass, and dried on a hot plate for a few hours. Adult females were used to make the permanent mounts, which were then chloral phenol-soaked overnight after being boiled for 15 to 30 minutes in 10% caustic potash solution (1:1 chloral hydrate: phenol). After that, the sample was cleaned in carbolxylene, dyed with 1% basic fuchsine, dehydrated using ascending series ethyl alcohol, on a glass slide, the object was cleaned in carbolxylene, mounted in cana balsam, and dried in a 40°C oven.

Photographic Leica light microscope
In this work, a Leica Microsystems light microscope was employed. It is equipped with a Leica microscope camera, which is renowned for its quick live image speeds, quick reaction times, high pixel resolution, and sharp contrast. This camera allows it to examine multi-dimensional dynamic processes in living cells. https://www.leica-microsystems.com/products/light-microscopes

The different sense organs of the researched insects were examined under a 100x magnification, which provided (high resolution) total clarity, allowing for easy description, measurement, definition, and elicitation of each organ's sensory function.

Morphometric sense organs
Using an ocular micrometre, measurements of the sensory organs of various species were taken. Additionally, measurements of the size of every female temporary and permanent mounts of each species were made.

RESULTS AND DISCUSSION
The region of the Postsoma, which symbolises the fusing of the end of the thorax and abdomen, and the beginning of Prosoma, which represents the union of the region of the head with the prothorax, are both thought to be full of sense organs or sensory foci in armoured scale females. At a high magnification of 100X, clusters of structures and organelles that mimic the sense organs of other insects were discovered when the morphological characterization of armoured scale females was examined. These organs' functional roles have never been established in earlier investigations or explained by an unexpected interpretation. A high point. Based on microscopic study, a number of the foci and organs were deemed to be

mechanical and chemical sensory organs, as well as the sense organs of temperature and humidity, and are comparable to the well-known sensory organs of other insect species.

According to their location and corresponding morphological characteristics, a group of sensory members that were discovered in these insects from the family Diaspididae, on various sites on their bodies, and which have been linked to the sensory organs in other insect species in order to conclude their functional role were listed.

Antenna
Insect antennae are highly developed sensory organs that are often coated in sensory structures that allow them to detect pertinent messages coming from the environment in a variety of modalities (Insaurralde et al., 2019). A recent paper showed that the small seta on the adult female antenna of Diaspis echinocacti, which is a member of the Diaspididae (Coccoidea) family, has the full sensory function. Previous authors had previously described the adult Diaspididae (Coccoidea) antenna as having very few or no structures (Procelli and Palma, 2001). According to this study, the female's antennae consist of a basal section (antennomomers) that varies in shape depending on the species and settles in a cavity or pit (the antennal fovea), which is held by pegs. An antenna's terminal portion carries a sensuous hair (antennal seta) that stands in for the uniaxial. When a nymph's second instar moults to become the adult female phase, the second instar antenna is created as a result of the fusing of all the components of the first instar antenna and extension. (Procelli and Palma, 2001) have both previously demonstrated this outcome.

The basal part of the antennomomers took the polygonal shape closed to the square in P. zizyphi (Fig. 1, a) and surrounded by five rings of sensory oscillations. While the corresponding part in A. mendex took the circular or oval shape (Fig. 1, b) and in the vicinity of it a sensory focus, as it takes a less developed form than the square. In D. britannicus (Fig. 1.c), took a conical shape with beveled top, as in H. cyanophlli (Fig 1.d), and took the form of an eye spot. It is appeared in the antennae of L. ficus (Fig. 1.e). It was found two pairs of twisted antennae of a second instar nymph of A. tubercularis a pair on each side of prosoma, each antenna carries at its top, four sensory hairs (Fig. 1, f).

Fig. 1. The different shapes of the antenna of the studied species belonging to the family Diaspididae

Tactial hairs (Sensory capillaries)
The major exteroceptive organs, mechanosensory bristles, are densely tiling the fly cuticle. The bristle sensory neuron fires in response to bristle deflection. Bristles are referred to as tactile hairs in other insects.. The simplest mechanoreceptors are likely choform sensilla. A sensory

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neuron innervates these touch hairs, or setae. When a neuron detects movement, its dendrites adhere close to the base of the hair and send a nerve impulse. Often found behind the head, on the legs, or close to joints, hair beds (clusters of tactile setae) react to motions of the body (NC state:Agriculture and life sciences). In this study, the sensory hairs on the insect species were tracked, and it was discovered that they are present in various locations, vary from species to species, and may be single or double as follows: In Parlatoria oleae, a pair of solitary hairs were discovered (Fig. 2 a) next to the posterior arms of the tentorium and between the antennae and its top. Tracing the nerve network revealed that one sensory hair on the second, third, and fourth lateral lobes of Lepidosaphes beckii (Fig. 2b), where all hairs are conical in shape, may connect to them and finally lead to the brain are located around the outside edge at a certain distance from the body's perimeter (Fig. 2 c). They are situated at a fixed distance from the A. mendax in the region beneath the body's edge (Fig. 2 d). In D. britannicus (Fig. 2 e), a pair of them are located on either side of the mouth parts, in the middle of the labium (rostrum), and close to the edge of the body.

Fig. 2. The different shapes of the tactile hairs of the studied species belonging to the family Diaspididae

Campaniform sensilla

Flattened oval discs called campaniform sensilla often act as flex sensors in the exoskeleton. When the exoskeleton bends due to mechanical stress, they react. All over the body, particularly on the legs, close to the tips of the wings, and at sutures where two sclerites of the exoskeleton connect, are campaniform sensilla. (NC state:Agriculture and life sciences).

Through examination of Leica microscope, Campaniform sensilla are found where they are flattened oval discs that usually serve as flex receptors in the exoskeleton. They respond when the mechanical pressure causes the exoskeleton to bend the female body of P. zizyphii where a pair of campaniform sensilla are found in the Prosoma region (Fig. 3 a) with dimensions of 0.068 ± 0.02 μm in diameter (Table 1). There are six traces of nerve extensions that appear on the cuticle of body in the side area confined between the bases of the antenna and the front of the mouthparts. In addition, four pairs in the post soma area on either side of the genital orifice (Fig. 3 b) with dimensions of 0.048 ± 0.02 μm in diameter (Table 1). The observed pair of campaniform located in the prosoma region has two nerve pathways that were signed by the drawing as in Figure (3a). While the observed four pairs located around the genital orifice in the post soma region, have nine neural pathways that were almost signed by the drawing as in Figure (3b). The dimension of the sensory organ was 0.053 ± 0.011 μm in diameter (Table 1).

Also, Campaniform sensilla are but without a median pore found in Lepidosaphes beckii are distributed in three pairs in the post soma area (Fig 4, a) with dimensions of 0.048 ± 0.02 μm diameter (Table 1). Two pairs of them are found below the female genital orifice on either side and parallel to that of the male genital mating duct to feel it in a side position where another pair on the duct of the female genital mating machine exactly are below the male genital mating machine, during its penetration into the female genital opening, to feels in a lower position. Tracing the neural extensions of these sensory foci, a connection was found between the first and second pairs after the female genital opening on each side and a neural connection between the pair that is located on the course of the male genital mating machine on one side and the middle pair on the other.
side (Fig 4, b), where the convergence of the neural extensions occurs to connect to the central nervous system. It was obvious that the three pairs of Campaniform sensilla are sense the male genital mating machine at three sides, the two lateral positions and the lower position.

Fig. 4. a, the campaniform sensilla; b, neural pathways of the Lepidosaphes beckii

In L. ficus, the same Campaniform sensilla are members with the same number and distribution were found (Fig. 5a) with dimensions of 0.039 ± 0.02 μm in diameter and the same nerve extensions were shown in Fig. 5b. In addition to a sensory organ present in the position of the anal cerci in the most other insects, which belong to the sense organs of heat and humidity. In addition to being a mechanical sensory organ.

Table 1. Morphometry measurements (± SE) of mechanoreceptors presented on some diaspidid females bodies.

<table>
<thead>
<tr>
<th>Diaspidid species</th>
<th>Sites sensilla</th>
<th>Name of sense organs</th>
<th>Length</th>
<th>Width/ Diameter</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parlatoria zizyphii</td>
<td>prosoma</td>
<td>Campaniform1</td>
<td>0.048 ± 0.088</td>
<td>0.068 ± 0.02</td>
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<td>postoma</td>
<td>Campaniform2</td>
<td>0.018 ± 0.058</td>
<td>0.038 ± 0.02</td>
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<td>Campaniform</td>
<td>0.019 ± 0.059</td>
<td>0.039 ± 0.02</td>
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<tr>
<td></td>
<td>postoma</td>
<td>trichodea sensilla</td>
<td>1.7 ± 0.22</td>
<td>1.96 ± 0.26</td>
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<tr>
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<td>0.019 ± 0.059</td>
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<tr>
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<td>1.48 ± 1.98</td>
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<td>0.048 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>trichodea sensilla</td>
<td></td>
<td>0.28 ± 0.062</td>
<td>0.048 ± 0.02</td>
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<tr>
<td>Diaspidiotus pronorum</td>
<td>postoma</td>
<td>trichodea sensilla</td>
<td>1.68 ± 2.18</td>
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</tr>
</tbody>
</table>
CONCLUSION

The results of this study provide an important foundation where they link morphological characteristics of sense organs to insect behavior and should stimulate the development of efficient semiochemical-based control strategies against species belonging to diaspididae.

REFERENCES


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(Hemiptera: Sternorrhyncha)

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المخلص


استنباط

Dimensions and morphological characteristics of the antennae and other sense organs of Diaspididae were measured. The antennae of the species studied were examined, and the sensory hairs and their proportions were determined. The antennae of Diaspididae are typically long and slender, with numerous flagella, and have a variety of sensory hairs, including tactile hairs, proprioceptive hairs, and chemosensory hairs.