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

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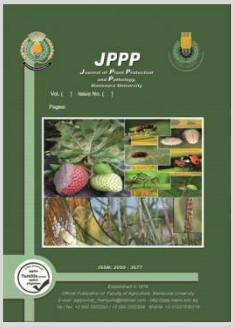

ABSTRACT

The structure of the female bodies of several Diaspididae species was examined using leica-microsystems. Several types of michanical sensilla for nine species were described . they were *Parlatoria zizyphii* ,*Parlatori aoleae, Abgrallaspis mendax* ,*Dynaspidiotus britannicus*, *Hemiperlesia cyanophlli*, *Lepidosaphes ficus*, *Lepidosaphes beckii, Aulacaspis tubercularis* and *Diaspidiotus pronorum* **.**The structures of antennae of the different species and antennommers of the antennae were described in *P. zizyphii, A. mendax, D. britannicus,H. cyanophlli, L. ficus*and *A. tubercularis*. By tracing the tactial 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 one campaniforn sensillum in *P. zizyphii*, *L. beckii* and *L. ficus* some trichodea sensilla as mechanoreceptive setae were found in the prosoma and postsoma 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 (Theron, 1958; Swiderski, 1980; Bustshik, 1958; Ghauri, 1962; Borchsenius, 1965; Borchsenius, 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 diaspidid 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 defineing the many types of mechanoreceptors on the various regions of the bodies of Parlatoria zizyphii, Parlatoria oleae, Abgrallaspis mendex, Dynaspidiotus britannicus, Hemiperlesia cyanophlli, Lepidosaphes ficus, Lepidosaphes beckii, Aulacaspis tubercularis and Diaspidiotus pronorum . Thus, this study aimed

to show that: (i) structures of antennae of females diaspididae, (ii) tracing the tactial 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 METHODES

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

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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 canda 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.

Morhpometric 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 DISSCUTION

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 and *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 (antennommers) 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 uniarticulate. 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 antennommers took the polygonal shape closed to the square in P. zizyphii (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).

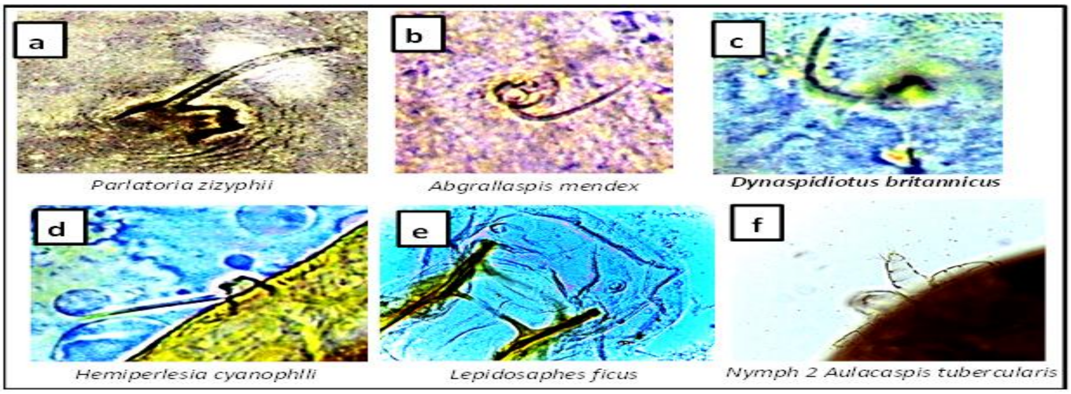

Fig. 1. The different shapes of the antenna of the studied species belonging to the family Diaspididae

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 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.

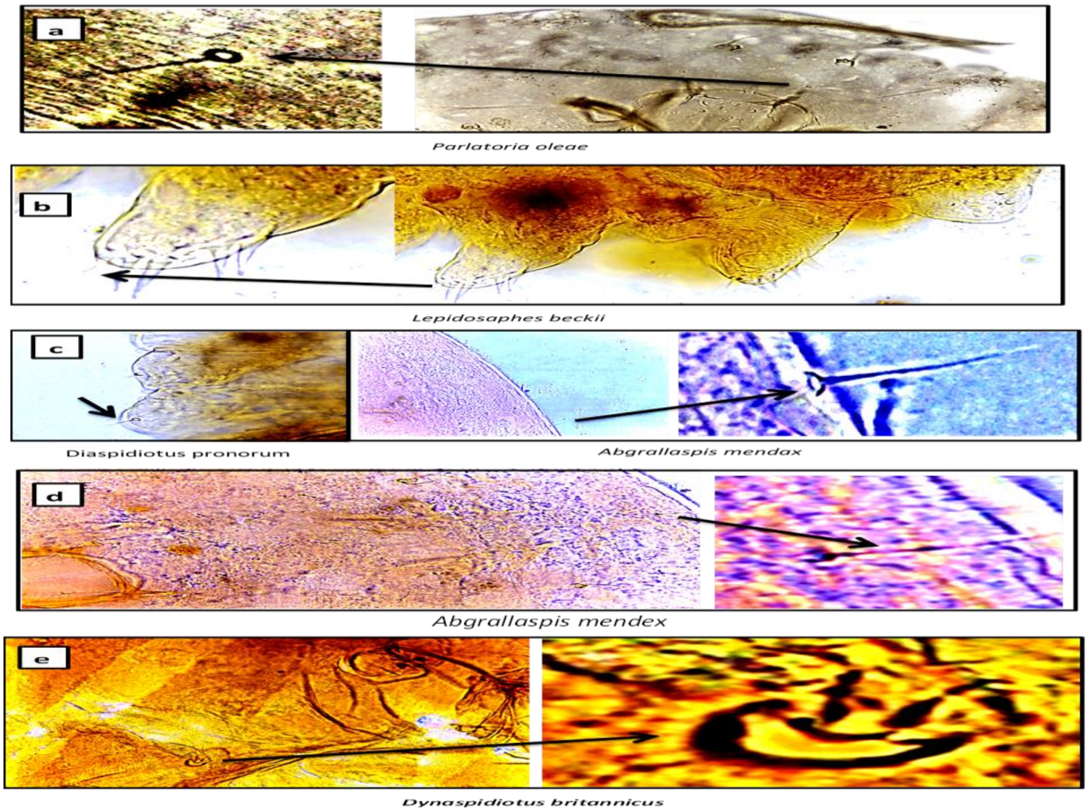

Fig. 2. The different shapes of the tactial hairs of the studied species belonging to the family Diaspididae

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 sensillaare 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 (Table1). 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. 038 ± 0.02 µm in diameter (Table1). It is possible that the female senses the mating machine while it penetrates the opening of its genitals to complete the fertilization process. The examination also revealed a group of neural pathways that were traced by the drawing to clarify. 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 pathwaysthat 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 postsoma area (Fig4, a) with dimensions of 0. 048 ± 0.02 µm diameter (Table1). 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 (Fig4, 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 sensillaare sense the male genital mating machine at three sides, the two lateral positions and the lower position.

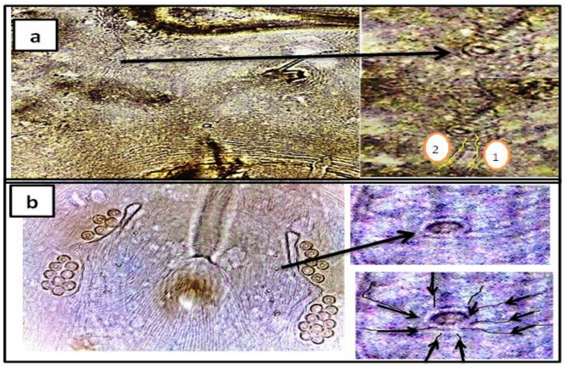

Fig. 3. The different shapes of the campaniform sensilla and their neural pathways of *Parlatoria zizyphii* a, in the prosoma region; b, in the postsoma region.

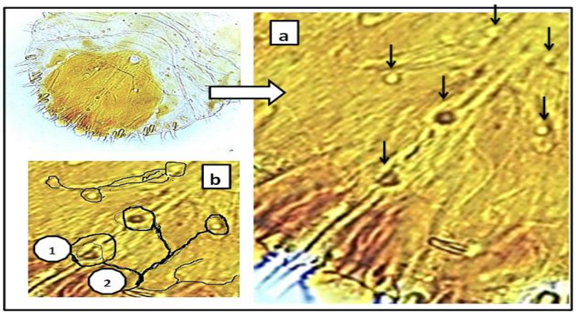

Fig. 4. a, the campaniform sensilla ; b, neural pathways of the *Lepidosaphes beckii*

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.

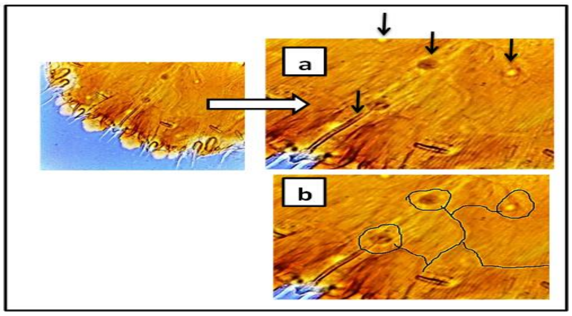

Fig. 5. a, the campaniform sensilla ; b, neural pathways of the *Lepidosaphes ficus*

Trichodea sensilla

Trichoform sensillaare are probably the simplest mechanoreceptors. They are tactile hairs (setae) that are innervated by a sensory neuron. Dendrites of the neuron attach near the base of the hair and generate a nerve impulse whenever they detect movement. Hair beds (clusters of tactile setae) are often found after the head, on the legs, or near joints where they respond to movements of the body in other insects This organ are found in the pygidium region confined between the lobes of Lepidosaphes beckii (Fig 6, a) (1.73 ± 0.25 µm in length) and Lepidosaphes ficus (Fig 6, b) (1.96 ± 0.26µm length) as in Table 1 where the double hairs are found within the structure of the conical shape and all hairs are conical in shape. In Diaspidiotus pronorum, they are found on the pygidium region separately between the lobes (Fig 6, c), (1.93 ± 0.25 µm length) (Table 1).

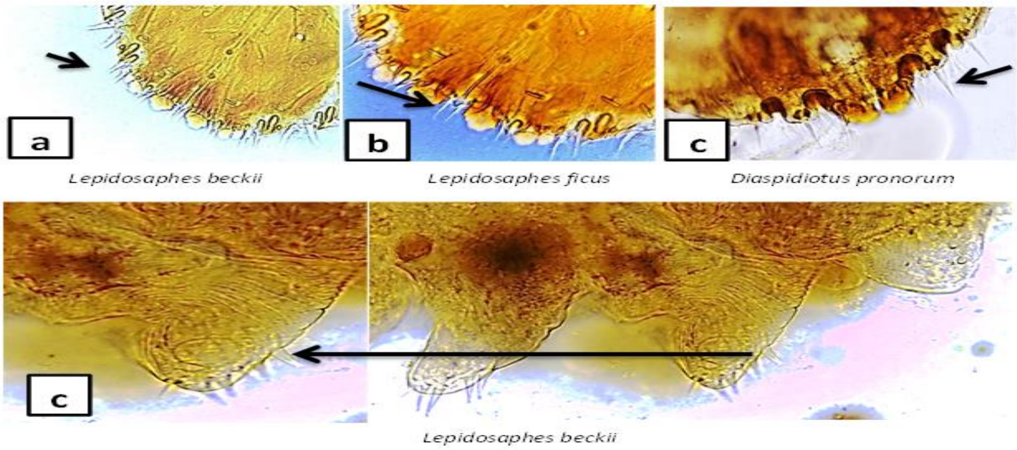

Fig. 6. The trichodea sensilla of the studied species belonging to the family Diaspididae

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

Diaspidid species	Sites sensilla	Name of sense organs	Length		Width/ Diameter	
			Range	Mean ± SE	Range	Mean ± SE
Parlatoria zizyphii	prosoma	Campaniform1			0.048- 0.088	0. 068 ± 0.02
	postsoma	Campaniform2			0.018- 0.058	0. 038 ± 0.02
Lepidosaphes ficus	postsoma	Campaniform			0.019 – 0.059	0. 039 ± 0.02
	postsoma	Campaniform			0.019 – 0.059	0. 039 ± 0.02
	postsoma	trichodea sensilla	1.7-2.22	1.96±0.26		
Lepidosaphes beckii	postsoma	Campaniform			0.28- 0.062	0. 048 ± 0.02
	postsoma	Campaniform			0.28- 0.062	0. 048 ± 0.02
	postsoma	trichodea sensilla	1.48- 1.98	1.73 ± 0.25		
	prothoma	trichodea sensilla	2.12- 2.64	2.36 ± 0.28µm		
Diaspidiotus pronorum	postsoma	trichodea sensilla	1.68- 2.18	1.93 ± 0.25		

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 semiochemial-based control strategies against species belonging to diaspididae.

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مورفولوجيا وتوزيع المستقبلات الميكانيكية في اناث فصيله الحشرات القشرية الصلبة (Hemiptera: Sternorrhyncha)

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الملخص

تمت دراسة مورفولوجيا أجسام إناث العديد من أنواع Diaspididae باستخدام أنظمة لايكا الميكروسكوبيه الدقيقة. وتم وصف عدة أنواع من اعضاء الحس الميكانيكيه لتسعة أنواع هي: *Parlatoria zizyphii* و *Parlatoria oleae* و *Abgrallaspis mendax* و *Dynaspidiotus britannicus* و *Hemiperlesia cyanophlli* و *Lepidosaphes ficus* و*Lepidosaphes beckii* و *Aulacaspis tubercularis* و *Diaspidiotus pronorum*. و في الدراسه تم وصف قرون الاستشعار *P. zizyphii* و *A. mendax* و *D. britannicus* و *H. cyanophlli* و *L. ficus* و *A. tubercularis*. وتم تتبع الشعيرات الحسيه الميكانيكيه التي تعرف ب tactial hairs على أنواع الحشرات المدروسة في *P. oleae* و *L. beckii* و *A. mendax* و *D.pronorum* و *D. britannicus* وجد أنها موجودة في عدة أماكن وتختلف من نوع إلى آخر ويمكن العثور عليها مفردة أو مزدوجة. . أيضا ، تم العثور على مستقبلات ميكانيكية والتي تعرف اعضاء حس ذات قبوه وهي أحد المستشعرات الكامنة في *P. zizyphii* و *L. beckii* و *L. ficus* بالاضافه الى بعض المستقبلات لميكانيكيه تعرف ب Trichodea في بروسوما (مقدم الجسم) و بوستوما (مؤخر الجسم) في *L. ficus* *L. beckii* و *D. pronorum* وفقا لدراسات الفرضية العامة هذه لنظام المستقبلات الحسية الميكانيه أمر شائع في Diaspididae ، وتم التعرف على أربعة أنماط حسية ، مع محاولة استخدام هذه البيانات على المستوى التصنيفي.توفر نتائج هذه الدراسة أساسا مهما حيث تربط الخصائص المورفولوجية للأعضاء الحسية بسلوك الحشرات ويجب أن تكون دافعا لتطوير استراتيجيات مكافحة فعالة قائمة على اساس كيميائي ضد الأنواع التي تنتمي إلى دياسبيدي