

## RESEARCH ARTICLE

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## ULTRASTRUCTURE AND ELECTROPHYSIOLOGICAL STUDIES ON THE SENSE ORGANS OF THE COTTON LEAF WORM SPODOPTERA LITTORALIS (BOISD.)

## ABSTRACT

The present work was directed to study the possibility of using ultrastructure and electrophysiological techniques to distinguish all the sensory sensilla on the antennae and tarsi of female *S. littoralis*, as a trail to understand the insect chemical communication system. Relatively little is still known about the types, location and functions of *S. littoralis* sensory organs. The sensory organs on the antennae and on the tarsi of female *S. littoralis* were visualized by scanning and transmission electron microscopy. The surface of the tarsus is covered with scales overlapped together and is provided with sense sensilla that found on the ventral and lateral surface of the tarsus. Two basic types of sensilla were found on the tarsus of the prothoracic legs, the mechano-sensory sensilla (squamiformia) that have one neuron, and the contact chemosensory sensilla (trichodeum, chaeticum and styloconica) that are multimodal receptors and have five neurons. While three basic types of sensilla were identified on the antennae, mechano-sensory sensilla (squamiformia, chaeticum, auricillica and coeloconia), chemosensory sensilla as on the tarsus (styloconica, basiconica and small chemoreceptor pag) and olfactory sensilla (trichodeum) that have many neurons. The identification of the different types of sensilla on the tarsus and antenna will serve for electrophysiological studies, which can be made on them to clarify their functions.

## Key words:

*S. littoralis*, Sense organs, SEM, TEM, Electrophysiology, Tip recording technique.

## INTRODUCTION

Insect sensory receptors encode in their signals different types of information about the environment that can modify the animal's behaviour; these signals are integrated and distributed to several segmental ganglia by projection interneurons. Signals from the antennal or tarsal receptors could influence the various modes of behaviour including avoidance (White and Chapman, 1990; Newland and Burrows, 1994; Gaaboub, 2000; Newland, 2000; Gaaboub et al., 2005), detection and selection of food sites (Blaney and Chapman, 1970; Blaney, 1974; White and Chapman, 1990; Gaaboub and Hustert, 1998) and selection of egg-laying sites (Ma and Schoonhoven, 1973; Roessingh et al., 1992; Staedler et al., 1994, 1995; Kalogianni, 1995, 1996; Tousson and Hustert, 1998; 2000; Tousson et al., 1999; Newland et al., 2000; Tousson, 2001, 2004). Insects, like other invertebrate and vertebrate animals have evolved chemical sensing devices for detecting stimuli that have adaptive value, so that most of their receptors are sensitive to a specific range of available stimuli and this sense has become further differentiated into the two senses of taste and smell (White and Chapman, 1990; Tousson and Gaaboub, 2004). The morphology and distribution of the sensilla present on some insect appendages as antennae and tarsi have been studied in different species of Lepidopterous insects, e.g., *Agrotis segetum* (Hallberg, 1981), *Yponomeuta vigintipunctatus* (Cuperus, 1983 and 1985), *Apis mellifera* (Galizia et al., 1999), *Manduca sexta* (Shields and Hildebrand, 2001), *Choristoneura fumiferana* (Banga et al., 2003).

Several electrophysiological studies of tarsal or antennal chemoreceptors have been carried out on moths although no surveys of responsiveness to a range of chemicals have been attempted. Talaat and Gaaboub (1993) reported that tarsal sensory receptors of Lepidoptera have an important role in host plant selection by responding to various chemical and mechanical stimuli. Blaney and Simmonds (1990) showed that the contact chemoreceptors on tarsus of *S. littoralis* have an important role in many aspects of the

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insect's life and these roles can be investigated morphologically and correlated with the insect behaviour. This study is focused to investigate the following:

- a) Identification of sensory system on the tarsi and antennae of the female cotton leaf worm *S. littoralis*.
- b) Identification of the different types of these sensilla and the number of their neurons.
- c) Determination of the effect of different chemicals on these sensilla.

## MATERIALS AND METHODS

### Rearing technique:

Laboratory strains of the cotton leaf worm *S. littoralis* were used in the present study. The culture of *S. littoralis* was originated by the eggs that obtained from laboratory strain established in the Department of Plant Protection, Faculty of Agriculture Moshthour, Benha University. The eggs were kept in glass jars covered with gauze under laboratory condition of  $27 \pm 1^\circ \text{C}$  and  $65 \pm 5\%$  RH. When the eggs became dark enough in color fresh castor leaves were introduced daily into the jars as dietary medium for the hatched larvae. This procedure continued till the second larval instar. The jars were cleaned daily, The number of larvae was limited to 10 larvae per jar. When larvae reached the last instar, they were transferred to a clean jar, provided with moistened sawdust 4 cm thick and allowed to pupate. To perpetuate the stock culture of the insects, full-grown pupae of both sexes were transferred to cylindrical cages covered with gauze for oviposition. The adults were fed by 10% sugar solution.

### Scanning Electron Microscopy (SEM):

To identify the different sensory receptors on the tarsus and antenna of the female cotton leaf worm *S. littoralis*, moths were immersed in hexane and shaken for several minutes to remove the cuticular wax layer. Antennae and tarsi were cut, rinsed in chloroform, dehydrated in ethanol and dried or air-dried. After drying, they were sputtering coated with gold-palladium and examined using a scanning electron microscope (LEO –UIF: Leo 438VP).

### Transmission Electron Microscopy (TEM):

Antennae and tarsi of hexane-washed moths were cut and fixed overnight at  $4^\circ \text{C}$  in 2.5% glutaraldehyde containing 0.1% teepol soap. After 4 times rinsing with cacodylate buffer (pH = 7.2), and postfixation for several hours in a solution of 0.7% osmium tetroxide and 2% potassium bichromate, the specimens were contrasted overnight in 1% uranyl acetate. After dehydration in graded ethanol series, each specimen was separately embedded in Epon. Sections (about 80 nm thick) were cut with an LKB ultramicrotome, transferred into single-hole film-coated grids and studied in a Philips 201 (South Hampton

University, England) transmission electron microscope.

### Electrophysiological studies:

Stimulation and sensory responses from individual sensilla to chemical stimuli on the tarsus or on the antenna were recorded using both the tip recording technique (Hodgson et al., 1955) and the cut-tip sensillum-recording technique (Kaissling, 1995; Shields and Hildebrand, 2001) for the stimulation of the olfactory sensilla. The potentials were amplified and filtered using AC amplifiers. A blunt glass microelectrode or the plastic tip of a suction electrode, filled with different solutions was placed over the shaft of the sensillum. All chemicals substances used to stimulate the chemosensory afferents were diluted in 0.01 M NaCl, while the odours were used to stimulate the olfactory neurons. Controlled movements of this electrode were used to deflect the sensillum so as to elicit spikes in the mechanosensory afferents. The same electrode was therefore used simultaneously to evoke mechanically and record the spikes of the afferents.

## RESULTS

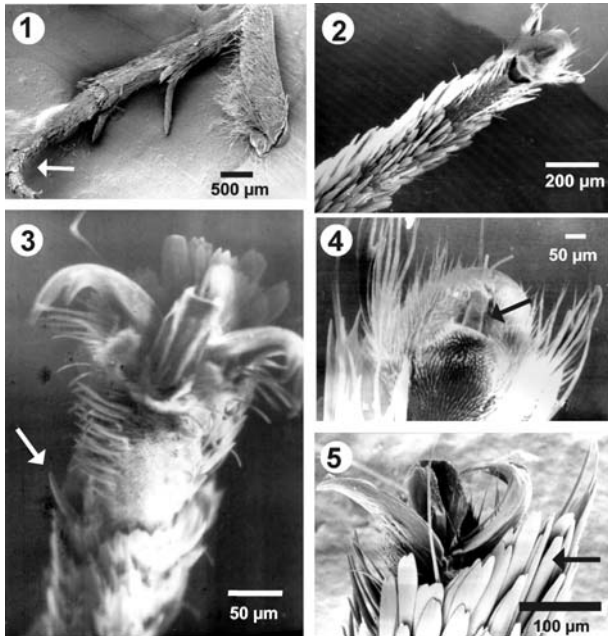
### Tarsal structure:

The morphology of the tarsus fore-leg of the female cotton leaf worm moths was studied by the aid of the scanning and transmission electron microscopes (Figs. 1-5). It is subdivided into five tarsomeres. The distal tarsomere is usually long and bears a pretarsus on its distal end. The pretarsus consists of tightly sclerotized base, a pair of claws and frequently a median lobe, the arolium, which has a sensory function. The surface of the tarsus is covered with scales overlapping together and provided with sense sensilla (Fig. 5). Most of these sensilla are found on the ventral and lateral surfaces of the tarsus, while the dorsal surface is covered by overlapping scales (Figs. 2, 3). Four main types of sensilla were found on the 2<sup>nd</sup> tarsomere of the fore-leg. The sensory receptors on the tarsus were detected and encodes three different sensory modalities; wind, touch and gustatory and these sensilla are sensilla chaetica, sensilla trichodea, sensilla styloconica and sensilla squamiformia (Figs. 4, 5, 15, 16).

### Antennal structure:

The female antennal flagellum of *S. littoralis* is about 9.2 mm and the mean number of flagellar subsegments are 65 (range 65-66 on 20 moths). The subsegments are cylindrical in shape with diameter about 120  $\mu\text{m}$ , whereas the terminal subsegment is the longest of all (Fig. 6). Most of the antennal sensilla are found on the ventral and lateral surfaces of the flagellum and the dorsal surface was covered by overlapping scales (Fig. 6). Scales on the scape and pedicel are similar to those on flagellar segments but are not arranged in uniform rows. The surface of the sensory area

(non-scaled area) is covered by a network of minute ridges giving it a reticulated appearance. The sensory receptors on the antennae were detected and encode four different sensory modalities; wind, touch, gustatory and olfactory and these sensilla are sensilla auricillica, sensilla chaetica, sensilla trichodea, sensilla basiconica, sensilla styloconica, small chemoreceptor pag, sensilla coeloconia and sensilla squamiformia (Figs. 6, 7, 8 & 11).



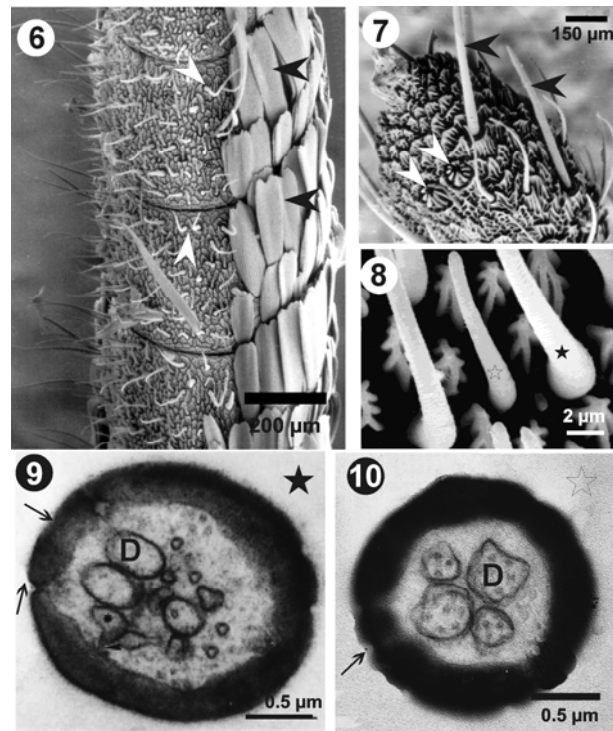
Figs. 1-5: Scanning electron micrographs of a normal prothoracic leg in female *S. littoralis*. 1: low magnification of the prothoracic leg in *S. littoralis* showing tarsus (white arrow)., 2: low magnification of the tarsus with scales., 3: High magnification of the dorsal view showing the tarsus, claws and arolium structures., 4: High magnification of the ventral view of distal tarsomere, claws and arolium showing the different types of Sensilla, especially sensilla styloconica (arrow)., 5: High magnification of the dorsal view of the distal tarsomere showing the scales (arrow) and grooved arolium.

The fine description and observations on the structure of the different types of sensilla are as follows:

### 1) Sensilla Chaetica:

These types of sensilla are found on the tarsi and antennae of the female moths with different sizes and different shapes. They are the most common sensilla on the tarsus and they are observed all over it. Sensilla chaetica (Fig.15) are sensory spines with a flexible circular membrane or socket at the base. They have blunt ends where the pores are located. Longitudinal striations on its surface are detected at lower magnification while circular striations are observed at higher ones. Sensilla chaetica are located in rows in both the lateral and ventral sides and in the median ventral line of each tarsomere. The lengths of these sensilla, all over the tarsus, are found to increase gradually as we go through the tarsus segments from the first distal segment (with length of 130  $\mu\text{m}$  and 13  $\mu\text{m}$  in diameter)

towards the fifth one (with length of 350  $\mu\text{m}$  and 42  $\mu\text{m}$  in diameter).



Figs. 6-8: Scanning electron micrographs of antennae in female *S. littoralis*. 6: High magnification of the lateroventral view of 25-28 female flagellar segments, showing scales (black arrows) on the dorsal surface and different types of sensilla (white arrows) on the ventral and lateral surfaces., 7: High magnification of the terminal antennal segment showing sensilla coeloconica (white arrows) and sensilla trichodea (black arrows)., 8: SEM showing the sensilla chaetica (black star) and sensilla basiconica (white star).

Fig. 9: TEM showing a cross section of sensilla chaetica with numerous (about 9) distal dendritic branches.

Fig. 10: TEM showing a cross section of a basiconic sensillum with a few (about 4) distal dendritic branches.

SEM indicated that, sensilla chaetica are present on all segments of flagellar antennae. The number of sensilla chaetica on the terminal antennal segment are 10 sensilla (Fig. 8), and six sensilla are brone on each segment. Two morphological types of sensilla chaetica are determined, Type I is found in the medio-darsal (two sensilla prosegment) and lateroventral (two sensilla prosegment) surfaces of the segment, and Type II (two sensilla prosegment), occurs on the medio-ventral surface (Fig.8). TEM shows that, sensilla chaetica are innervated by 5 neurons (Fig. 9), each with a large ovoid-shaped cell body (4–5  $\mu\text{m}$  in diameter) that found below the socket in tarsi and antennae. Stimulation of sensilla chaetica by using the tip recording techniques showed that the sensilla on tarsi were responded to a variety of chemicals and mechanical responses but those found on the

antennae had only chemoreceptive function (Fig. 21A & B).

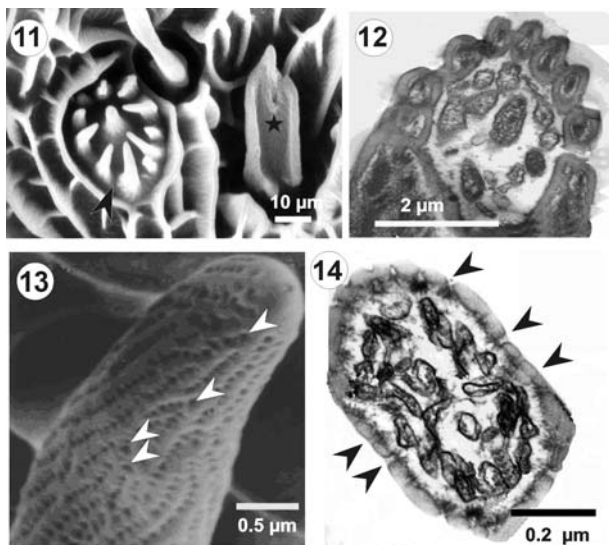


Fig. 11: High magnification of the terminal antennal segment showing sensilla auricillica (black star) and sensilla coeloconica (black arrows).

Fig. 12: TEM showing a cross section of sensilla coeloconica with numerous (about 11) distal dendritic branches.

Fig. 13: SEM showing the sensilla trichodea on the antennal segments showing, the pores (arrow head) extend to the tip of the sensillum and are distributed in oblique, linear rows along the long axis of the sensillum.

Fig. 14: TEM showing a cross section of sensilla trichodea on antennal segments with numerous neurons and pores (arrow head).

## 2) Sensilla Trichodea:

These types of sensilla are found on the tarsi and antennae with different sizes and shapes. They are present on every subsegment and they are found in numerous numbers on the lateral and ventral surfaces. Three morphological types of these sensilla could be recognized in the tarsi of female cotton leaf worm moths (Figs 16 & 17). The three types of sensilla trichodea could be distinguished on the tarsi by their length, curvature and shape of tips. Type I is the most numerous, it is a long pointed type (20-30  $\mu\text{m}$  length). It is relatively straight with hooked tip and is innervated with five neurons and acts as a chemoreceptor. Trichodeum type II sensillum could be distinguished from Type I as it is shorter (8-15  $\mu\text{m}$ ) and more curved. Type I is found in the lateral edge of each segment while Type II is arranged in four rows in the two lateral edges of the ventral side segment on the segment. Trichodeum sensillum Type II is innervated with 4-9 neurons and acts also as a chemoreceptor. The trichodeum Type III is the most numerous and longest (43-50  $\mu\text{m}$  in length) and it is relatively straight with hooked tip. This type is innervated with one neuron and acts as mechanoreceptors.

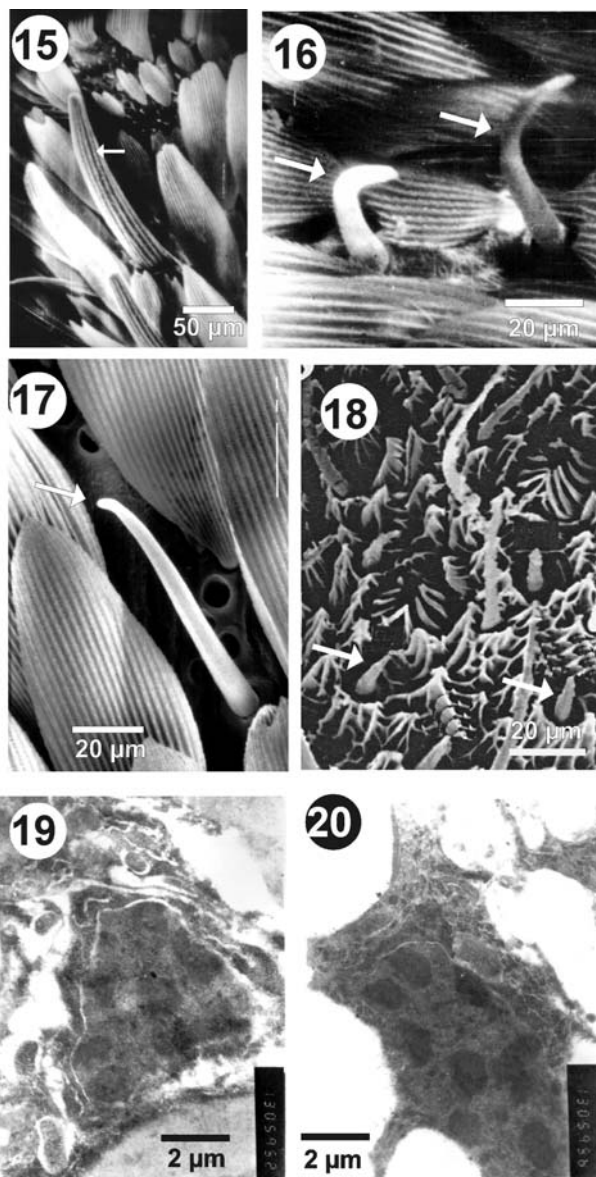


Fig. 15: SEM showing the sensilla chaetica on the tarsal segments between the numerous sensilla squaniformia.

Fig. 16: SEM showing two types of sensilla trichodea (arrows) on the tarsal segments.

Fig. 17: SEM showing the 3<sup>rd</sup> type of sensilla trichodea on the tarsus between the sensilla squaniformia.

Fig. 18: SEM showing the sensilla basiconicum on the antennal segments.

Fig. 19: TEM showing a cross section of sensilla trichodea type II with 9 neurons.

Fig. 20: TEM showing a cross section of sensilla trichodea type I on the tarsus with more than 5 neurons.

The most numerous morphological types of antennal sensilla on *S. littoralis* are sensilla trichodea. Three morphological types of these sensilla could be recognized in female antennae (Figs 7 & 13). These sensilla are found near the midventral line of the sensillar field, they are longer than those found at the lateral edges. Regarding the shape and diameter of the three types of trichodea, one can say that the trichodeum Type I is the most numerous and longest (30-32  $\mu\text{m}$ ). It is

relatively straight with hooked tip. Type II sensillum could be differentiated from Type I as it is shorter (16  $\mu\text{m}$ ) and more curved. However, Type III trichodeum is the shortest sensillum (4.9  $\mu\text{m}$ ) and has blunt tips. The longest tip diameter was found in sensillum trichodeum Type I, while the least tip diameter was recorded from sensillum trichodeum III. The base diameter of trichodeum I averaged  $2.53 \pm 0.05 \mu\text{m}$  in female antennae. Corresponding figure of trichodium II averaged  $2.67 \pm 0.04$ , however the smallest base diameter was recorded from trichodeum III which averaged  $2 \pm 0.12$  in female antennae. Trichodeum sensilla are innervated with 5 neurons (Fig. 14), they act as chemoreceptors. Stimulation of sensilla trichodea by using the tip recording techniques showed that, both tarsal and antennal sensilla were responded to a variety of chemicals (Fig. 22A & B).

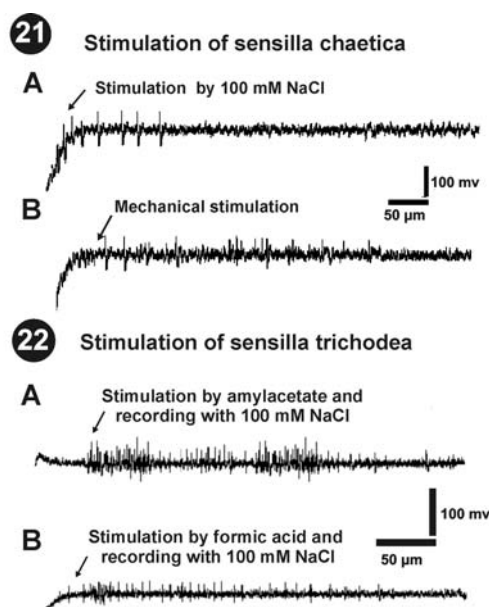


Fig. 21: Responses of individual chaeticum sensillum to chemical and mechanical stimulants. A: Placing an electrode filled with 100 mM NaCl over a chaeticum sensillum evokes a burst of action potentials of different amplitudes. B: Responses of chaeticum sensillum on antennal segments to the mechanical effect.

Fig. 22: Responses of individual trichodeum sensillum to chemical and odors stimulants. A: Stimulation of antennal trichodeum sensillum to amylacetate in 100mM NaCl as electrolyte evokes a burst of action potentials of different amplitudes. B: Stimulation of antennal trichodeum sensillum to formic acid in 100mM NaCl as electrolyte evokes a burst of action potentials of different amplitudes.

### 3) Sensilla Styloconica:

These types of sensilla are found on the tarsi and antennae. Only two sensilla styloconica are present in the midventral line of the distal margin of pretarsomere and midventral line of arolium (Fig. 4). Sensilla styloconica are present on the apical antennal segment (Fig.

7). These sensilla are cylindrical structures, each with a minute peg set in a shallow socket at the tip. The conical tip of the projections exhibits variety of appearances indicating possible retractability and a pore in the tip (Fig. 4). These sensilla have mean length of 21  $\mu\text{m}$ . The tip diameter of conical extremity is  $0.72 \pm 0.02 \mu\text{m}$ ; while the base diameter is  $5.08 \pm 0.24 \mu\text{m}$ . These sensilla are innervated by 3-5 neurons and act as chemoreceptive sensilla.

### 4) Sensilla Squaniformia:

These sensilla appear among the scales of the tarsi and on the dorsal surface on basal antennal segments. They are more slenderical than the normal scales, the longitudinal ridges are much closer together and suggesting a sensory function, therefore they are called sensilla squaniformia (Figs. 2, 5 & 6). They are embeded in a socket and pointed distally. At higher magnification, striated concave septa could be seen between the longitudinal tiled ridges. The average length of these sensilla is 16-28  $\mu\text{m}$  and the average diameter is 9-12  $\mu\text{m}$ . Sensilla squaniformia are mechanoreceptors and are innervated with one neuron (5-7  $\mu\text{m}$  cell body diameter).

### 5) Sensilla auricullica:

Each of these sensilla consists of one or two flattened socket. Examination by TEM indicated that they are innervated by several olfactory receptor neurons. Sensilla auricullica are somewhat concave multiporous, ear like and thin walled. Sensilla auricullica on female *S. littoralis* have mean length of  $7.5 \pm 0.15 \mu\text{m}$  and with mean diameter  $4.85 \pm 0.37 \mu\text{m}$ . Its surfaces have remarkable grooves and fidges (Fig. 11).

### 6) Sensilla coeloconica:

Sensilla coeloconica (Figs 7 & 11) in female moths of *S. littoralis* have different numbers of projections around the pit, generally they are innervated by three neurons (Fig. 12). Sensilla coeloconica are commonly called pit pegs. They are situated in deep pits having mean diameter about 6.8-7  $\mu\text{m}$ . The coeloconica are present on all antennal segments and generally located in the median portion of the segment. The commonest type has peripheral fringes of 12  $\mu\text{m}$  that tapered distally, and a longitudinally striated pegs around a shallow cuticular depression.

### 7) Sensilla basiconica:

Sensilla basiconica could be detected in the antennal flagellum. They are randomly distributed on the ventral surface of the flagellum (Fig. 18). Sensillum basiconicum has the appearance of a short peg measuring  $8.8 \pm 0.26 \mu\text{m}$  and is characterized by a blunt tip that measures  $0.45 \pm 0.02 \mu\text{m}$  in diameter. Also, the typical sensillum basiconicum is situated in a pit and has a base diameter of 1.6  $\mu\text{m}$ . Sensilla basiconica are multiporous that innervated by 4-5 neurons (Fig. 10) and respond to numerous

chemicals but not to sex pheromone, these sensilla act also as a mechanoreceptive function.

#### 8) Small chemoreceptor pegs:

This sensillum is cone shaped sensory structure and resembles the small pegs on the tip of the styloconica sense organs. The peg (Fig.7) is slightly curved but not tapered, and has a tip diameter of 0.52  $\mu\text{m}$ . The length of the small chemoreceptor peg is 1.55  $\mu\text{m}$  with abase diameter and  $1.33 \pm 0.03 \mu\text{m}$ . The terminal segment of female antenna bears three pegs on its narrow tip. These sensilla act as contact chemoreceptors and are innervated by 5 neurons.

### DISCUSSION

The general structure of the antenna and tarsus of female cotton leaf worm *S. littoralis* are similar to that described in other Noctuids, *Helicoverpa zea*, *S. ornithogalli* and *S. exigua* (Jefferson et al., 1970) and *Manduca sexta* (Shields and Hildebrand, 2001). The present study was carried out on the morphology of the antennae of *S. littoralis* by the aid of the electron microscope as a trial for a better understanding of the insect chemical communication system. For instance, smell may assist insects in finding food or mate, while contact chemoreceptors may be of important in final recognition of the food, an oviposition site or a mate. These results coincide with previous findings, which reported that contact chemoreceptors are present on the tarsus and antennae of adult female cotton leaf worm (Gaaboub, 1990; Makkar, 1990). In the current study, the morphological and electrophysiological evidences indicated that of these eight types of sensilla that are found on tarsus and antennae, five appear to be chemoreceptive, two appear to be olfactory and two appear to be mechanosensory.

The presence of five types of sensilla having chemoreceptive function on tarsi and antennae of the female cotton leaf worms are important for many aspects of the insect's life. They help it in detection and selection of food sites and in selection of egg-laying sites and these roles can be investigated morphologically and correlated with the insect behaviour. The sensilla concerned with chemoreception are widely spread on *S. littoralis* moth, and they are particularly abundant on the antennae, mouthparts and tarsi. The number of neurons that innervate such sensilla varies from few neurons to over 50 (Chapman, 1980). Mahmoud (1985) found that sensillum trichodeum has a single multipolar neuron with approximately five dendrites while the small chemoreceptor peg is innervated by many neurons.

Five types of sensory sensilla (Sensilla basiconica, small pegs chemoreceptor, Sensilla styloconica, *S. trichodea* and *S. chaetica*) on the tarsus and antennae should record the

chemical composition of the surface of the substrate but it is not known what the adequate stimuli are and which regular behavioral responses occur. Enough understanding of how different tastes are coded at the level of individual receptors (Blaney, 1974 & 1975; Gaaboub, 1990; Kohstall, 1996; Tousson et al., 1999; Newland et al., 2000; Gaaboub et al., 2005) has been achieved, but little is known about how and where chemosensory information from the contact chemo-receptors of these sensilla are processed and how different tastes are coded in the CNS.

Sensilla chaeticum of *S. littoralis* are similar in structure to those reported for other noctuids by Callahan (1969), Jefferson et al., (1970), Liu & Liu (1984), Gaaboub (1990) and Talaat and Gaaboub (1993). They were suggested to be contact chemoreceptors in *S. ornithogalli* and *S. frugiperda* (Jefferson et al., 1970) but to have a mechanoreceptive function in a mosquito (Davis & Socolove 1975, Van der pres; Den Otter, 1978). Sensilla chaeticum in *S. littoralis* posses a pore at the tip and have the staining properties as that found in the cabbage looper (Jefferson, et al., 1970). Our study reported that sensilla of this type acts as contact receptors. Mahmoud (1985), also found a pore at the tip of these sensillum, while Makkar, (1990) did not find the pore at the tip and decided that the hair is mechanoreceptor.

Sensilla **Trichodea** (Den Otter, 1977) were the first to be demonstrated that these multi-chemical signals are perceived via sensory systems composed of different types of receptor cells, each apparently tuned to one particular blend component. These results are in complete harmony with those reported by Van der Pers and Den Otter, (1978) who stated that the antennal sensilla trichodea type of insect olfactory hair may house two or three receptor cells, which are sensitive to the female sex pheromone. Kochansky et al., (1975) reported that cells responsive to sex attractants have been found only in the *Sensilla trichodea* on the antennae in Lepidoptera. In complete agreement with the present results, the female's sensilla trichodea are not activated by sex pheromone (Van der Pres and Den Otter, 1978). From the result and discussion about the function of the sensillum trichodeum (except type 3 on the tarsus) and small chemoreceptor peg, one can conclude that these sensilla are considered as sensitive chemoreceptor.

The current work, reported that sensilla trichodea are considered as chemosensory receptors. These sensilla on the female antennae of *S. littoralis* are typically the sex pheromone receptors (Schneider et al., 1964; Jefferson et al., 1970, Cornford et al., 1973; Cuperus, 1985). These sensilla are described as multiporous and thin-walled olfactory chemosensilla (Zachoruk, 1980; Liu & Liu, 1984). Mahmoud (1985) found that sensillum

trichodeum has a single multipolar neuron with approximately five dendrites. Daves and Sokolove (1975) found that sensilla trichodea type II on the antennae of female *Ades aegypti* mosquitos to be specific for the perception of chemical substances associated with the location of a suitable oviposition site by gravid female mosquito's. The presence of Styloconica sensilla in *S. littoralis* with double or triple apical structure is similar to other Noctuids: *S. exigua* (Jefferson et al., 1970). Three sensory cells innervate these sensilla and no pores were observed in the wall of the cone and the tip of sensilla styloconica (Cuperus, 1985). It is assumed, as yet that these pores play a role in the puzzling mechanism of hygroreception.

Basiconic sensilla are shorter than the ventral chemoreceptive trichoids type 1&2 on tarsus, the apex is rounded and they are located among the trichoids. Similar structures have been reported for a Tortricid (George and Nagy, 1984). Sensilla basiconica in both sex of *M. configurata* are multiporous and respond to a variety of chemicals but not to sex pheromone (Liu and Liu, 1984; Cuperus, 1985). In *Locusta* (Gaaboub, et. al., 2005) found that sensilla basiconica act as chemoreceptor to different chemicals but (Newland, 2000; Tousson, 2004) reported that these sensilla may have mechanoreceptive function. The basiconic chemoreceptive sensilla of the tarsal pulvilli should record the chemical composition of the surface, of the substrate but it is not known what the adequate stimuli are and which regular behavioural responses occur. Good understanding of how different tastes are coded at the level of individual receptors (Blaney, 19747 & 1975; Maes and Ruifork, 1986; Gaaboub et al., 2005) has been achieved, but little is known about how and where chemosensory information from the contact chemoreceptors of the basiconic sensilla is processed, how different tastes are coded in the CNS, or how chemosensory information is integrated with signals coding other senses. The current work found that small chemoreceptor pegs in *S. littoralis* is innervated by 5 neurons. By electroantennogram studies, these sensilla were proved as chemoreceptors and sensitive to amyl acetate (Den Otter et al., 1980). This study contrasts with an earlier report which stated that the tarsal chemoreceptors of moths were not sensitive to sugars (Hodgson et al., 1955). We showed that the tarsal sensilla of *S. littoralis* gave a dose-dependent response to sugars and this neural input correlated with behavioural output, namely, proboscis extension.

The communication between the insect and its host plant may depend upon these sensilla, which indicate that sensilla trichodea are specific for the perception of chemical substances associated with the location of a suitable oviposition site by gravid female *S. littoralis*. On the other hand, small chemoreceptor pegs in both male and female may be associated

with the communication between the insect and its host plant. The ultrastructure suggests that the aporous sensilla trichodea function as mechanosensilla while the uniporous sensilla basiconica act as contact Chemosensilla. The sensilla styloconica are regarded as bimodal contact chemo/mechano sensilla since their sensory cones are equipped with a single terminal pore and a tubular body at the base.

Sensilla squamiformia appears among the scales on the tarsus and on the dorsal surface on basal antennal segments of female *S. littoralis*. These sensilla were mechanoreceptors and it was innervated with one neuron. Mahmoud (1985) found squamiformia sensilla on the dorsal surface of the basal antennal segments. Typically, scales occur along with sensilla on the surface of the Noctuidae antennae. Van der Pers et al., (1980), did not believe that scales protect the sensilla from mechanical damage, but rather suggested that their disposition contributes to the insects' ability to detect the direction of the stimulus. Wall (1978) argued that scales might be a mechanism to trap and concentrate odors' molecules.

The majority of insect olfactory sense organs are located on the antennae, which are specific modified head appendages. The number of olfactory sensilla on the antennae among different species ranges from a few tens up to 100,000 or more than 300,000 sensory neurons (Chapman, 1982). The highest sensilla numbers are found in male insects that need to find females over long distances. Intra-specific differences in the number of sensilla are related to size, sex, different feeding habits or behavioral specializations (Chapman, 1982). Olfaction is a very important sensory modality in an insect's life. It is essential in most behavioral tasks like feeding (Chapman, 1982), mating (Shields and Hildebrand, 2001) and communication (Mahmoud, 1985).

Electrophysiological experiments on insect antennae can be performed both as physiological studies on the function of the olfactory sense and as a tool in identifying behaviorally active odors. These results show that females of *S. littoralis* have receptor neurons to detect and discriminate between damaged and undamaged cotton by odors.

In sensilla auricillica, each sensillum consists of one or two flattened socket and sensilla are fluted thin-chemoreceptor (Slifer, 1970) and are innervated by several olfactory receptor cells (Mayer et. al., 1981). Coeloconic sensilla act as olfactory receptors, mostly present on each antennal segment of females *S. littoralis* from the medial to the distal part. Three to four sensilla occur per segment of males and females in *C. consueta* and in Pyralids (Cornford et al., 1973). The electrophysiological experiments have shown that sensilla coeloconica are sensitive to carbon dioxide, temperature and humidity (Lacher,



1964; Davis and Sokolove, 1975; Liu & Liu, 1984). These sensilla have been considered to be temperature receptors in a mosquito (Davis and Sokolove, 1975). In cockroach, they are also sensitive to humidity (Altner *et al.*, 1977).

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## دراسات مرفولوجية للتركيب الدقيق و كهروفيولوجية لأعضاء الحس بفراشة دودة ورق القطن

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وستيلوكونيكا) وهذه الشعيرات مزودة بخمسة نيرونات عصبية والتي هي متعددة النماذج أي أن هذه النيرونات بعضها يكون هو ذو خاصية الاستقبال الكيميائي ونيرون واحد هو المستقبل الميكانيكي. بينما على قرن الاستشعار وجد ثلاثة أنواع للشعيرات الحسية وهي شعيرات حسية ميكانيكية الاستقبال (تشايتيكم وسكواميفورميا وكويلوكونيكا و أوريسيليكا) و شعيرات حسية كيميائية الاستقبال (ستيلوكونيكا و البسي كونيكا و الكيماوية الصغيرة) و شعيرات حسية شمعية (ترايكوديم). بواسطة الدراسات الإلكتروفسيولوجية تم التعرف على وظائف هذه الشعيرات الحسية على الرسغ و قرن الاستشعار و وجد أن لها دور هام في التعرف على الغذاء

تعتبر المعلومات المعروفة نسبياً قليلة جداً حتى الآن عن وظائف و أنواع و مكان الشعيرات الحسية لفراشة دودة ورق القطن. باستخدام الميكروسكوب الإلكتروني الماسح والنافذ و التكنيك التشريحي العصبي تم التعرف على المستقبلات الحسية الموجودة على الرسغ و قرن الاستشعار لإنات فراشات دودة ورق القطن. وجد أن سطح الرسغ مغطى بحراشيف والتي يتواجد بينها شعيرات حسية موجودة بكثافة على الجهة البطنية والجانبية للرسغ. الشعيرات الحسية على الرسغ تنقسم إلى نوعين أساسيين شعيرات حسية ميكانيكية الاستقبال مثل (سكواميفورميا) وهذه بها نيرون عصبي واحد شعيرات حسية كيميائية الاستقبال مثل (تشايتيكم و ترايكوديم

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المحكمون: