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Antennal sensilla of *Sesamia nonagrioides* (Lef.) (Lepidoptera: Noctuidae) Morphology and possible behavioural significance

Abstract - The antennae of *Sesamia nonagrioides* are filiform in the female and comb-like (bipectinate) in the male, both dorsally covered with scales, among which there is a sensillum chaeticum per flagellomere, while the other sensilla are all set on the flagellomeres' ventral side, and they show the same typology in either sex. The number and distribution of sensilla are quite different in female and male because of three obvious ventral processes (two lateral, sub symmetrical and one sub median) in the latter, which considerably extend the flagellomere surface to support a larger number of sensilla. SEM and TEM observations let identify 8 sensillum types at least, distributed and in numbers per flagellomere as follows: *sensilla chaetica* (morphologically gustative), 5 in the female: one dorsal and four ventral, and 4 in the male: one dorsal and one near the tip of each of the mentioned three processes; three types of *sensilla trichodea* (morphologically olfactory) in great numbers, especially in the male, distinguishable between them according to their hair-shaft size and shape, as well as the presence of one or two or three sensory neuron terminations, respectively; *sensilla basiconica* (morphologically olfactory, most probably pheromone receptors) rather numerous in the male, having a hair-shaft very varied in size but structurally homogeneous and easily recognizable under SEM observation; *sensilla auricillica*, ultrastructurally very similar to basiconica but exteriorly distinguishable by their "auricular" aspect, although somewhat conceiled among the cuticular elevations of the echinulate sculpture (morphologically olfactory, presumably sensitive to host-plant odours); ***sensilla coeloconica*** (here investigated with SEM only) in small numbers, rather minute but easily detectable as set each in a pit "fenced" by microtrichia; *sensilla styloconica* (well known with other Lepidoptera and interpreted as thermo-hygro-receptors), having a quite typical aspect, a pair on each flagellomere distal end in the female, and a pair on the flagellomere median process in the male.
The behavioural significance of *Sesamia* sensilla is discussed in comparison with analogous sensory structures investigated with other lepidopteran species.

Riassunto - *I sensilli antennali degli adulti di* Sesamia nonagrioides *(Lef.) e loro presumibile significato comportamentale.*

Le antenne della *Sesamia nonagrioides* sono filiformi nella femmina e bipettinate nel maschio. In entrambi i casi, il lato dorsale è ricoperto di squame, tra le quali

è presente un sensillo chetico (gustativo) per antennomero, mentre gli altri sensilli si trovano tutti sulla parte ventrale dei flagellomeri e presentano sostanzialmente la stessa tipologia nei due sessi. Il numero e la distribuzione dei sensilli risultano però notevolmente diversi nella femmina e nel maschio, per lo sviluppo in quest'ultimo di due vistosi processi latero-ventrali (i denti del "pettine") sub-simmetrici e di un terzo processo sub-mediano (molto più piccolo degli altri due), i quali ampliano notevolmente la superficie dell'antennomero onde potervi alloggiare un numero molto maggiore di sensilli rispetto alla femmina.
Osservazioni al microscopio elettronico a scansione (SEM), unitamente all'esame di sezioni fini al microscopio elettronico a trasmissione (TEM), permettono di individuare almeno 8 tipi diversi di sensilli, in numero per antennomero e distribuiti come segue: *sensilli chetici* (morfologicamente gustativi), in numero di 5: uno dorsale, due laterali (sub-simmetrici) e due ventrali nella femmina; in numero di 4: uno dorsale e uno all'estremità di ciascuno dei tre citati processi nel maschio; 3 tipi di *sensilli tricoidei* (morfologicamente olfattivi), in numero elevato (molto maggiore nei maschi), tra loro distinguibili in base alla lunghezza del pelo sensoriale e alla presenza nei medesimi delle terminazioni di uno, due o tre neuroni sensoriali, rispettivamente; *sensilli basiconici* (pure olfattivi, molto probabilmente recettori di feromoni) piuttosto numerosi nel maschio, col pelo sensoriale di dimensioni molto variabili ma strutturalmente omogenei e facilmente riconoscibili anche al SEM; *sensilli auricillici*, ultrastrutturalmente molto simili ai basiconici, meno numerosi di questi, esteriormente riconoscibili per il tipico aspetto "auricolare" ma spesso nascosti tra i vistosi rilievi cuticolari della superficie echinata del flagellomero; *sensilli celoconici* (anche questi morfologicamente olfattivi), piuttosto piccoli ma facilmente reperibili perché situati ciascuno in una fossetta circondata da una corona protettiva di microtrichi; *sensilli stiloconici* (già noti in altri Lepidotteri e interpretati come termo/igrorecettori), dall'aspetto piuttosto caratteristico, presenti in numero di un paio presso l'estremità distale di ciascun flagellomero nella femmina, e nel maschio all'apice del processo mediano.
Il significato comportamentale di detti sensilli, in base ai dati morfologici qui riportati e con riferimento ai risultati di indagini elettrofisiologiche ottenuti su sensilli morfologicamente simili di altri Lepidotteri, viene verosimilmente ipotizzato in attesa di conferma da opportuni biosaggi elettrofisiologici e comportamentali sulla specie in questione.

Key words: *sensilla auricillica, basiconica, chaetica, coeloconica,* gustative, olfactory, pheromone receptive, plant odour receptive, *styloconica*, thermo-hygroreceptive, *trichodea*; ultrastructure.

INTRODUCTION

Sesamia nonagrioides (Lef.) is a lepidopteran, quite common and frequently harmful stem borer of maize (*Zea mays*) and rice (*Oryza sativa*), and it may develop also on other cereals including sorghum, wheat, barley and oat, as well as on wild plants such as *Arundo donax*, *Avena fatua*, *Echinochloa crus-galli*, *Phragmites communis*

and *Typha angustifolia* in the Mediterranean region (Prota & Cavalloro, 1973, and references therein).

Its ecology and bionomics are well known but control measures are still inadequate. In fact, *S. nonagrioides*' adults may emerge during a quite long season (from March to September: Prota & Delrio, 1968, and references therein), they lay eggs on the host-plant leaves, and the larvae, after a brief period of time (first instar) feeding on the leaves, penetrate into the stem and develop within it.

The available chemical control measures are effective against *Sesamia* larvae, only when the latter are still outside of the host-plant; while physical or biological control measures have proven to be insufficient. Therefore, a true IPM (integrated pest management) approach is actually necessary in this case, and it might be greatly improved by means of an efficient monitoring system to detect adult presence and their population levels referred to an economic threshold, in order to evaluate the latter and to establish peaks of larval emergence to allow more efficient chemical applications. The best monitoring systems with adult lepidopterans are based on sex pheromone traps (also utilizable for mass-trapping), and a sex pheromone of *Sesamia nonagrioides* has been identified and synthesized (main component: (Z)-11-hexadecenyl acetate, and one minor component: (Z)-11-hexadecenol; Rotundo *et al.*, 1985) but there are still problems with application concerning the pheromone blend composition and species specificity, the trap shape and the nature of dispenser used (Rotundo *et al.*, 1985; Guery *et al.*, 1999).

To help resolve these problems, a deeper knowledge of the sensory biology of *S. nonagrioides* adults seemed to be essential, and our aim was to give a first basic contribution with a morpho-functional study on the antennal sensilla, in detail of the male while the female's would be investigated to the extent necessary to determine whether the types, numbers and distribution of sensilla were of the same general pattern.

The antennal sensilla of adult Lepidoptera, including Noctuidae, have been largely investigated, both for structure (mainly SEM observations) and function, and the sensillum types found out (most of which displaying olfactory function: e.g., trichoidea, basiconica, coeloconica, auricillica) are usually the same even among the different families (Anderson *et al.*, 2000 and references therein). But the remarkable economic importance of *S. nonagrioides* as well as the need to improve its control measures suggested us the opportunity to apply analogous morphological investigations to this species.

MATERIALS AND METHODS

Adults of *Sesamia nonagrioides* from a stock colony, maintained in a rearing room (24-25°C, 64-65% R.H., 12-h photophase/scotophase regimen) at the Department of Arboriculture and Plant Protection laboratory of Perugia University, were used. Insects were always anaesthetised by appropriate low temperatures, before being dissected.

For scanning electron microscopy (S.E.M.) observations, unfixed, air-dried antennae, mounted on normal specimens' holders, gold/palladium coated in a Balzers Union SCD 040 sputter unit were examined and micrographed with a Philips XL30.

For transmission electron microscopy (T.E.M.) observations, single intermediate flagellomeres, or just a portion of the latter (e.g., a flagellomere lateral process), were excised from living specimens and immediately immersed in Karnovsky's (1965) fixative solution containing 2% acrolein. After a comparatively long (24-48 h) fixation at 4°C, the specimens were washed overnight in a cacodylate buffer with 5% sucrose, then postfixed in 1% Osmium tetroxide for 1 h and 15 min., rinsed again in cacodylate buffer, dehydrated in a graded ethanol series until 90%, then block stained with 1% uranyl acetate in 95% ethanol solution for 1h, next two passages (each of 15 min) in absolute alcohol and finally embedded through propylene oxide in Epon-Araldite. Sections about 70nm thick, cut with an L.K.B. "Nova" ultramicrotome, sequentially stained with uranyl acetate and lead citrate, were finally examined and micrographed through a Philips EM 400T.

The preparation of specimens was markedly difficult concerning fixation of sensory neuron terminations (especially microtubules), difficulty overcome by adding 2% acrolein to Karnovsky's fixative solution and prolonging the fixation time to 24-48 hours. This way we could obtain satisfactorily informative although not always very nice pictures.

RESULTS

GROSS MORPHOLOGY. The antennae of *Sesamia nonagrioides* (Fig. 1) present about 40 flagellomeres which display an obvious sexual dimorphism: in the female they are filiform, 6.60 mm long and 0.15 mm in diameter at middle length (0.20 mm at base and 0.10 mm at tip) on average (n=8); in the male they are markedly comb-like (bipectinate), 7.20 mm long and 0.70 mm wide at middle length (0.50 mm at base and 0.10 mm at tip) on average (n=8). In both sexes they are covered dorsally with overlapping scales (Fig. 2, SC), among which there is one *sensillum chaeticum* per flagellomere (Figs. 2 and 3) while the other sensilla are all set on the antennal ventral side, i.e., the side of the flagellum facing forward during flight, and they show almost the same typology in either sex (Figs. 4 and 12).

The number and distribution of sensilla are quite different in the female and in the male because of three obvious ventral processes (two lateral sub-symmetrical, and one medial: Figs 2a and 4) in the latter, which considerably extend the flagellomere surface to support a larger number of sensilla.

SEM and TEM observations let identify 8 types of sensilla at least, distributed and in numbers per flagellomere as follows:

- *Sensilla chaetica*, 5 in the female: one dorsal (Fig. 2b) and four ventral (Fig. 12); and 4 in the male: one dorsal (Fig. 2a) and one near the tip of each of the mentioned three processes (Fig. 4).
- *Sensilla trichodea* (Figs 4, 5, 7, 8 and 12) present in great numbers (especially

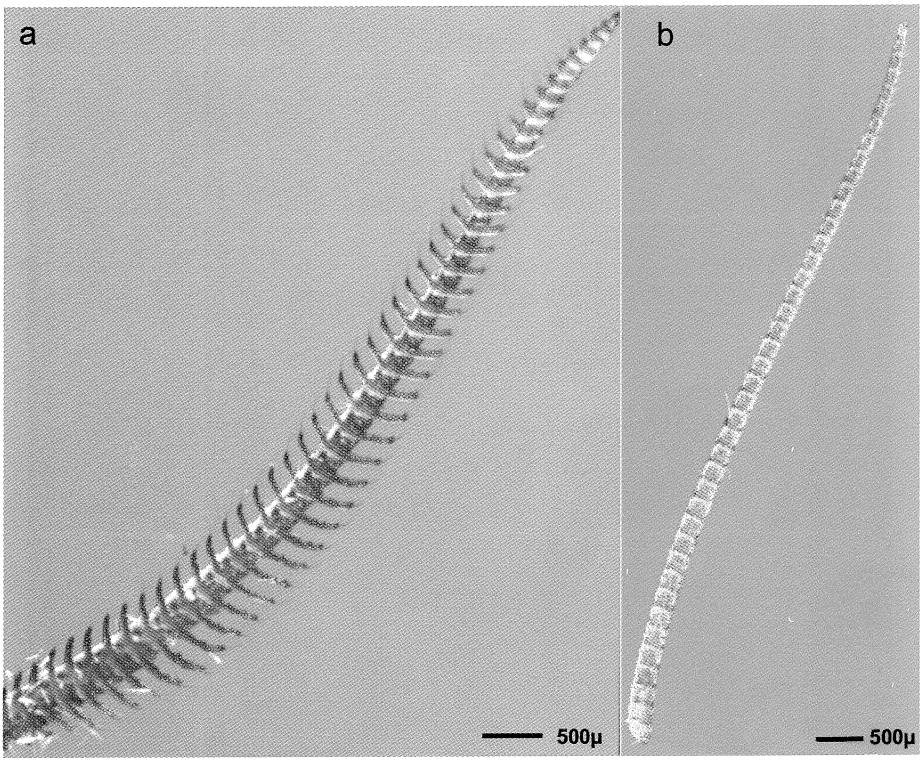

Fig. 1 - *Sesamia nonagrioides* (Lef.). Light micrographs of: a) male antenna (ventral view); b) female antenna.

in the male: Figs. 4 and 8) with three sub-categories distinguishable between them according to their hair-shaft size and shape, namely: "type 1", the biggest ones, relatively strait but frequently curved at tip; "type 2", the intermediate ones, strongly curved those set on the lateral processes but almost strait on the medial process; and "type 3", the smallest ones (exteriorly similar to basiconica, see below), almost strait and having distal portion comparatively thicker than type 2 and with tip not rounded but conic (Fig. 7), mainly set on the proximal portion of the lateral processes and on the medial process.

- *Sensilla basiconica*, set on a comparatively wider free space among the antennal sculpture (echinate) elevations, having a hair-shaft very varied in size (Figs. 8 and 9) but rather typical in shape (in the male, the longest roughly look like the shortest of s. trichodea "type 3"), rather numerous in the male, especially on the medial process.

- *Sensilla auricillica*, present in moderate numbers in either sex, exteriorly well distinguishable by their hear-shaped or "auricular" aspect (Fig. 10), although being

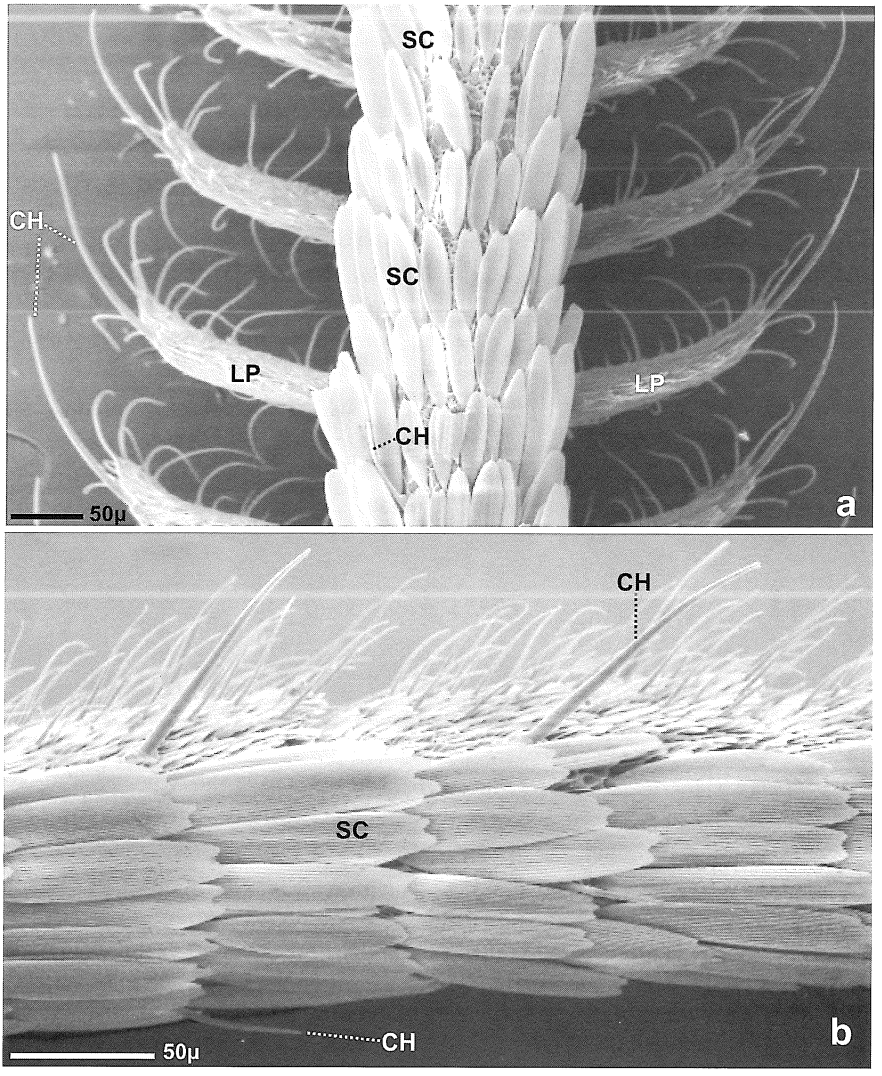

Fig. 2 - Scanning electron micrographs (S.E.M.) of : a) male antenna, intermediate flagellomeres, (dorsal view); b) female antenna, intermediate flagellomeres (dorsolateral view). CH, sensilla chaetica; LP, lateral process; SC, scales.

somewhat concealed among the cuticular elevations of the flagellomere echinate sculpture (Fig. 8), arising from the cuticle without any discrete joint membrane, and set in the male on the flagellomere lateral processes (Fig. 8).

- *Sensilla coeloconica*, present in small numbers in either sex, rather minute but

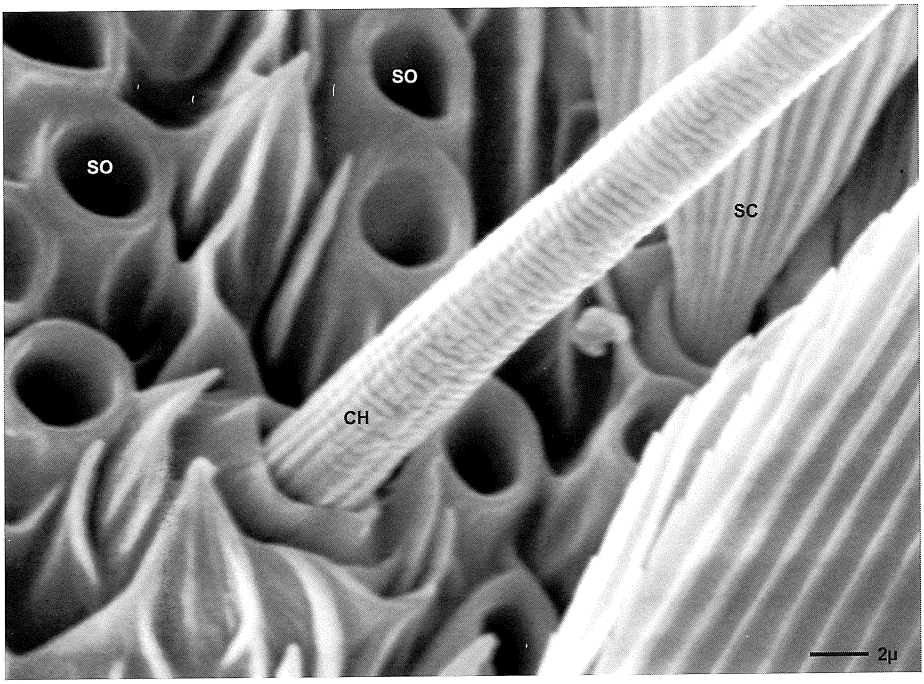

Fig. 3 - S.E.M. micrograph of male antenna (dorsal view), displaying a detail of the dorsal sensillum chaeticum (proximal portion) among sockets of removed scales. CH, sensillum chaeticum; SC, scale; SO, socket.

easily detectable as set each in a pit "fenced" by microtrichia (Figs. 7, 11 and 12).

- *Sensilla styloconica*, one pair per flagellomere in either sex, having a quite typical aspect (Figs. 4, 5, 12 and 13), with "styli" connate from base to almost top, set on the flagellomere distal end in the female, and on the flagellomere medial process in the male.

FINE MORPHOLOGY. The fine structure of sensilla has been studied almost exclusively on the male while the female's has been investigated to the extent necessary to determine whether the types, numbers, and distribution of sensilla were of the same general pattern in either sex. Thus, when not specified, we refer to the male.

Sensilla chaetica

The outer cuticular components of *sensilla chaetica* consist of a long hair-shaft set in an obvious flexible socket (Figs. 3, 5, 6 and 7), varied in size according to position on the flagellomeres (the dorsal one about 70µ long and 4µ in diameter at base, the two laterals up to 150µ long and 7µ in diameter at base, and the medial one about

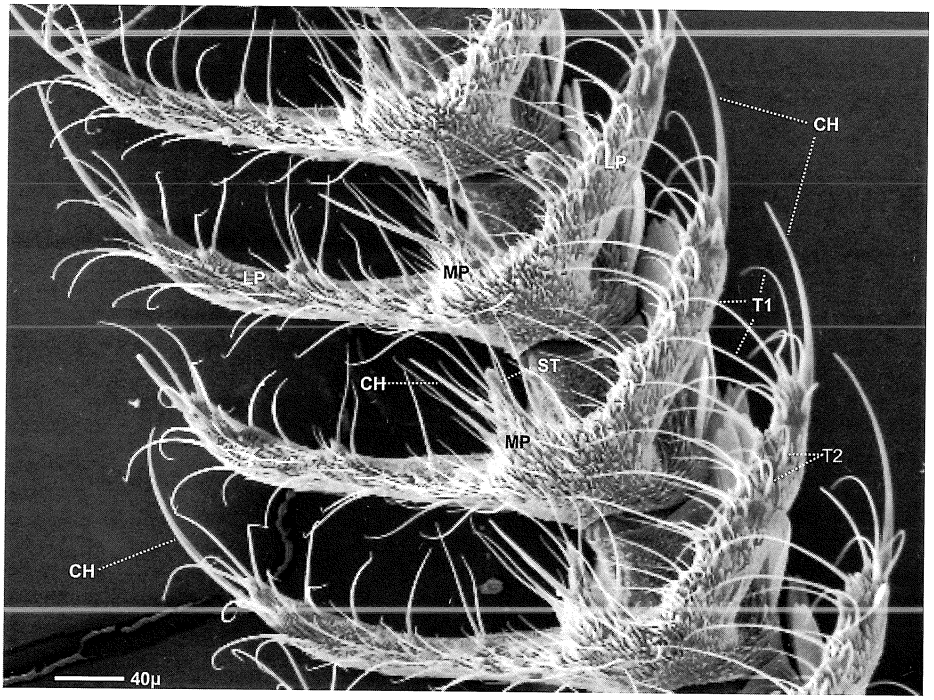

Fig. 4 - S.E.M. micrograph of male antenna (ventral view), showing the flagellomere processes bearing sensilla. CH, sensilla chaetica; LP, lateral process; MP, medial process; T1 and T2, sensilla trichodea "type 1" and "type 2".

100µ long and 5µ in diameter), having outer surface sculptured by dense longitudinal and circular grooves (Figs. 3 and 6) except on the shaft distal portion where the grooves turn into a spiral. The hair-shaft represents a typical gustative hair having an undivided lumen (Fig. 14a) and gradually tapered all its length to a blunt perforated tip.

The cellular components consist of 5 sensory neurones (Fig. 14, b, c and d) normally enveloped by three concentric accessory cells, i.e., the thecogen, the trichogen and the tormogen.

Of the sensory neurones four send their outer dendritic segments into the hair-shaft lumen, reaching almost to the tip encased in the dendritic sheath (DS: Fig. 14a); whereas the fifth neuron separates its outer dendritic segment from the other ones (Fig. 14b) somewhat beneath antennal surface and terminates at the hair-shaft base, thus representing a mechanosensitive element. The innermost sheath cell encloses the inner dendritic segments attaching to them with extended septate junctions (SJ, Fig. 14d) in a mesaxonal fashion. The two outer enveloping cells (trichogen and tormogen, not easily distinguishable with each other) line with dense microvilli a wide sensillar sinus (Fig.14b).

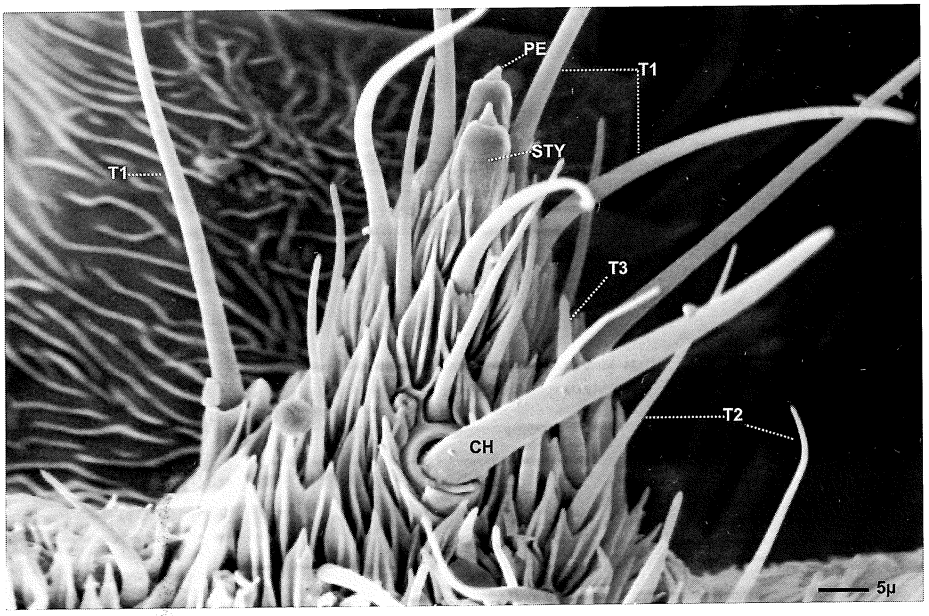

Fig. 5 - Male antenna. Detail of Fig. 4, displaying a flagellomere medial process with the sensillum chaeticum, the sensilla styloconica and several sensilla trichoidea set among dense sculpture elevations. CH, sensillum chaeticum; PE, peg; STY, stylus; T1, T2, T3, sensilla trichodea "type 1", "type 2", "type 3".

Morphologically speaking, these sensilla must be considered contact-chemoreceptive or gustative.

Sensilla trichodea

The outer cuticular components of *sensilla trichodea* consist of a hair-shaft quite varied in size and shape, set among the dense elevations of the antennal sculpture, without any discrete membranous socket (Figs. 6 and 16b), having thick walls perforated by a moderate number of pores (Figs. 15, 16a and 17a) and displaying outer surface with ridges rather irregularly arranged at the shaft proximal portion (Figs. 6 and 11) and spiral or annular (except "type 3", see below) for the rest (Fig. 7b). As above mentioned (gross morphology) these sensilla may be divided into three subcategories, namely "type 1", "type 2" and "type 3", according to size and shape. The hair-shaft of type 1 sensilla are the biggest, being about 90µ long and 2.7µ in diameter near the base (as it was very difficult to measure the very base, being it concealed among the sculpture elevations), while their shape is rather strait and gradually tapering from base to a rounded tip; with type 2 sensilla the hair-shaft is about 30µ long and 2µ in

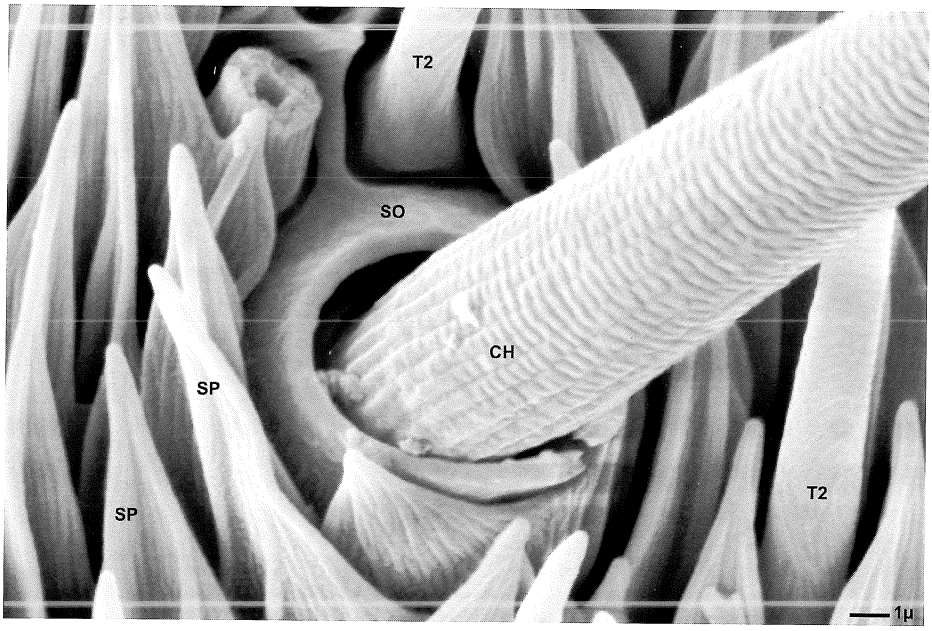

Fig. 6 - Male antenna. Detail of Fig. 5, showing basal portion of the sensillum chaeticum and of sensilla trichodea "type 2" (proximal portion), surrounded by dense elevations of the sculpture (strongly echinate). CH sensillum chaeticum; SO, socket; SP, sculpture elevations; T2, sensillum trichodeum "type2". Dida

diameter near the base, while their shape looks like the previous ones but they (especially on the lateral processes) are strongly curved towards the antennal tip; with type 3 sensilla the hair-shaft (Figs. 5, 7 and 8) is 20-25µ long and about 2µ in diameter near the base, and the outer surface displays only longitudinal and very weak ridges.

The cellular components consist of 1, 2 or 3 sensory neurones with sensilla "type 1", "type 2" or "type 3", respectively; and three normal sheath cells. The sensory neurons extend their outer dendritic segments encased in a thick dendritic sheath up to the hair-shaft base (Fig. 16b) and then into the hair-shaft lumen without branching (Figs. 15, 16a and 17a). The accessory cells i.e., the thecogen (innermost), the trichogen and the tormogen concentrically envelop the sensory neurons. With sensilla "type 3" the thecogen cell forms a wide ciliary sinus, and the trichogen and tormogen cells (not easily distinguishable with each other, hence indicated as outer sheath cells in the pictures) line with dense microvilli a wide sensillar sinus (Fig. 17b).

These sensilla trichodea, morphologically speaking, must be all olfactory.

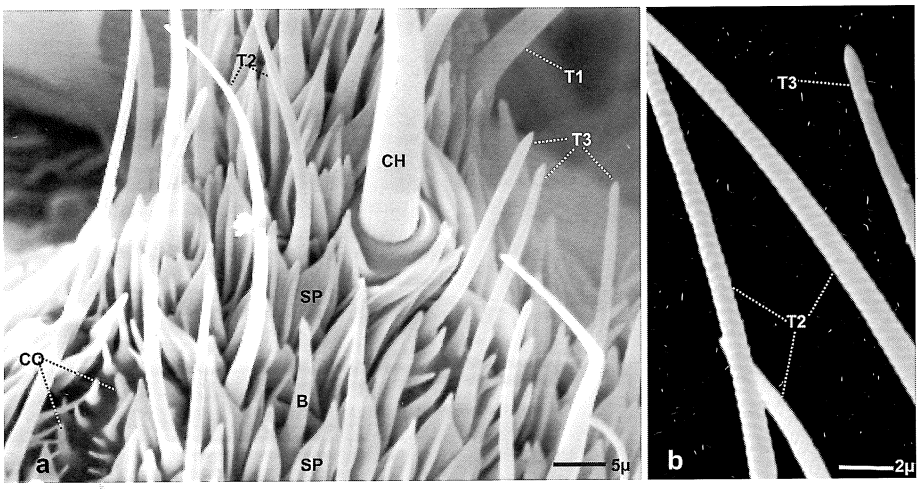

Fig. 7 - Male antenna. Details of Fig. 4, displaying: **a**, flagellomere medial process with sensillum chaeticum (proximal portion), sensilla trichodea, basiconica and coeloconica, among dense elevations of sculpture; **b**, hair-shafts of sensilla trichodea showing distal sculpture of type 2, and the tip of type 3. CH, sensillum chaeticum; B, sensillum basiconicum; CO, sensilla coeloconica; SP, sculpture elevations; T1, T2 and T3, sensilla trichodea "type 1", "type 2" and "type 3".

Sensilla basiconica

The outer cuticular components of *sensilla basiconica* (Fig. 9) consist of a hair-shaft somewhat varied in size but rather homogeneous in shape, having thin and very multiporous walls (Fig. 18) displaying outer surface with irregular sublongitudinal, weak ridges, and usually (with unfixed specimens) covered by abundant viscous material clogging the pores and condensing outside (Fig. 9). The hair-shaft varies from 9μ to 16μ in length and from 1.5μ to 2μ in diameter near the base (measurement at the very base was difficult being it somewhat swollen and curved almost at right angle).

Of the cellular components only the sensory neurons (present in numbers of 2 or 3) have been investigated and to the extent necessary to study the sensory neurons' terminations. The outer dendritic segments profusely branch just entering the hair-shaft lumen. It is remarkable that the sensillar liquor shows very high electron density within hair-shaft lumen (Fig. 18), whereas in the sensillar sinus the same liquor looks of normal electron density.

These sensilla, morphologically speaking, must be olfactory.

Sensilla auricillica

The outer cuticular components of *sensilla auricillica* consist of an ear-shaped hair-shaft about 15μ long and 2.5μ wide at middle length, having walls very thin and

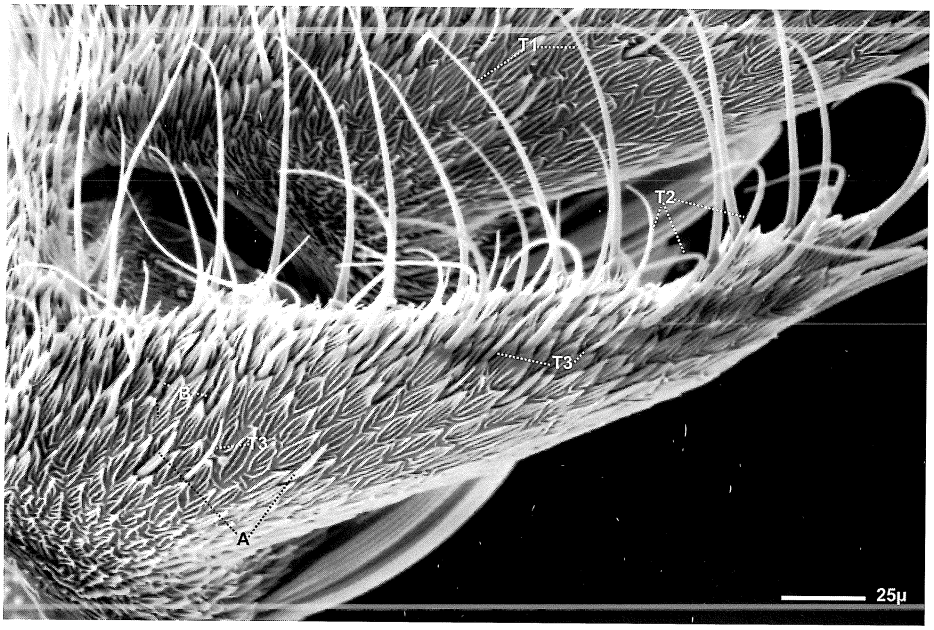

Fig. 8 - Male antenna. Detail of Fig. 4, displaying a flagellomere lateral process with sensilla trichodea "type 1", "type 2" and "type 3", sensilla auricillica and basiconica. A, sensilla auricillica; B, sensilla basiconica; T1, T2 and T3, sensilla trichodea.

provided with very numerous pores arranged in sub-longitudinal, dense and shallow grooves (Figs. 10 and 19a, c, d).

The cellular components consist of 3 sensory neurons and 3 normal accessory cells. The sensory neurons extend their outer dendritic segments encased in a thick dendritic sheath up to the hair-shaft base (Fig. 19b) and then into the hair-shaft lumen where the dendrites immediately and profusely branch (Fig. 19 a, c, d).

Like in sensilla basiconica, the sensillar liquor shows very high electron density within the hair-shaft lumen (Fig. 19a, c, d) whereas in the sensillar sinus (Fig. 19b) the same liquor looks of normal electron density.

These sensilla, morphologically speaking, must be olfactory.

Sensilla coeloconica

The *sensilla coeloconica* have been investigated on the outer cuticular components only. These consist of a grooved peg typically double-walled, having radial pores in the grooves, 7-8µ long and 1µ in diameter at half length, set in a pit surrounded by a sort of "fence" of microtrichia (Figs. 7, 11 and 13).

These sensilla, morphologically speaking, must be considered olfactory.

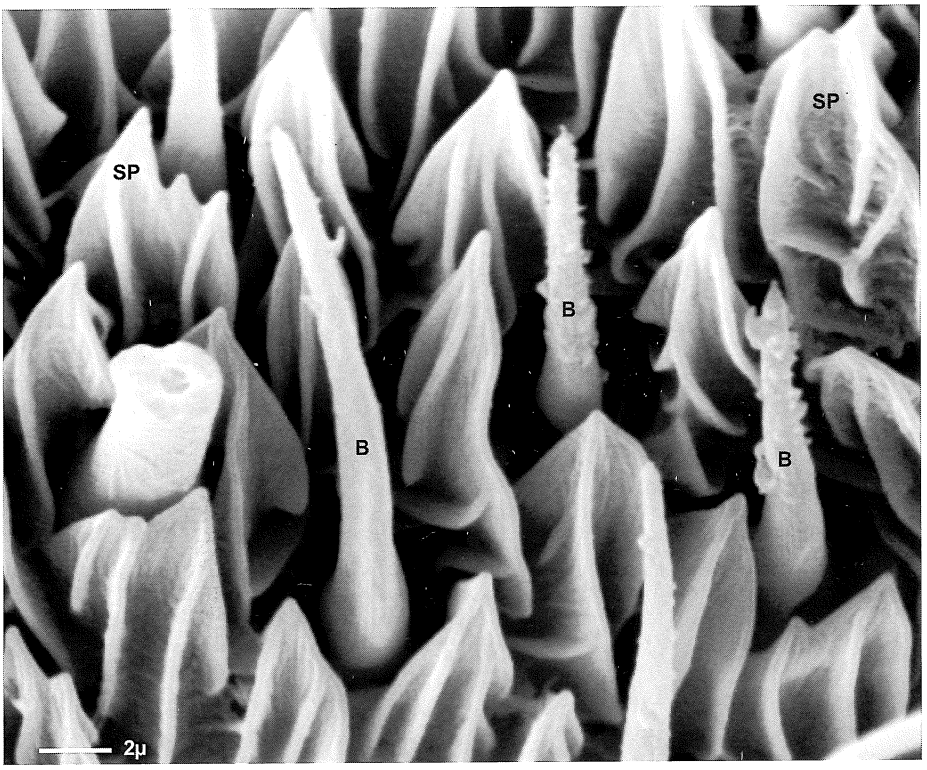

Fig. 9 - Male antenna. Detail of Fig. 9, showing sensilla basiconica (B). SP, sculpture elevations.

Sensilla styloconica

The outer cuticular components of *sensilla styloconica* consist of a cylindrical protrusion from the antennal surface, the "stylus", about 15μ long and 6μ in diameter at half length, bearing an apical, poreless, conical peg (Figs. 5 and 13).

The cellular components consist of 2 sensory neurons (Fig. 20c) and 3 normal enveloping cells.

The sensory neurons have their dendritic constrictions near the stylus base (Fig. 20c), while the outer dendritic segments, completely encased in a thick dendritic sheath, extend up to the peg within which only one dendrite, the lamellate one (Fig. 20a), has been identified.

These sensilla, morphologically speaking, must be considered mechanoreceptors.

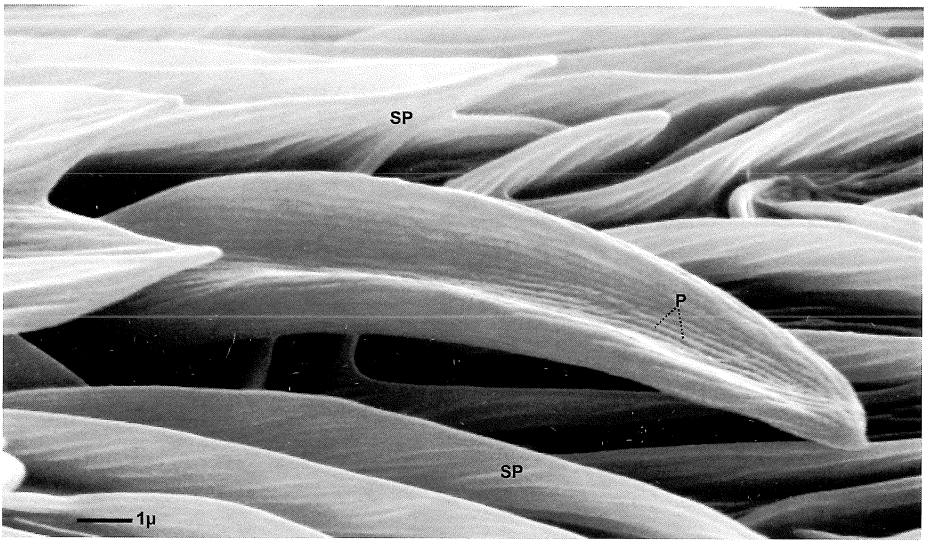

Fig. 10 - Male antenna. Detail of Fig. 9, showing a sensillum auricillicum set among sculpture elevations (SP). P, pores.

DISCUSSION

The antennal sensilla of *Sesamia nonagrioides* essentially conform to other Lepidoptera in all the principal aspects, i.e., sensillum types, their structure and arrangement; and thus a common nomenclature would be highly desirable. But, although it is relatively easy to identify the same kinds of sensilla among the different terms applied with different species or families of lepidopterans (Jefferson *et al.*, 1970; Cornford *et al.*, 1973; Flower & Helson, 1974; Hallberg, 1981; Hallberg *et al.*, 1994; Anderson *et al.*, 2000; and references therein), there are obvious difficulties to classify the outer cuticular components of sensilla, i.e., the cuticular appendages, according to traditional terminology (Snodgrass, 1935; Schneider, 1964) which prove insufficient to resolve this problem. Therefore, in this paper we principally follow the sensillum terminology applied with *Ostrinia nubilalis* by Hallberg *et al.* (1994); while for the sensillum ultrastructural descriptions we follow the terminology adopted in a review on the subject by the first author (Solinas, 1995).

With *Sensilla chaetica*, according to traditional terminology for sensory integumental appendages (Schneider, 1964), we include both "sensilla chaetica" and "long dorsal bristles" of Hallberg *et al.* (1994), for we did not find remarkable structural differences between these two categories supporting such distinction in *Sesamia nonagrioides*. Thus we just distinguish these sensilla according to their position on each flagellomere: i.e., one *dorsal* sensillum chaeticum, two *lateral* and one *medial* (ventral).

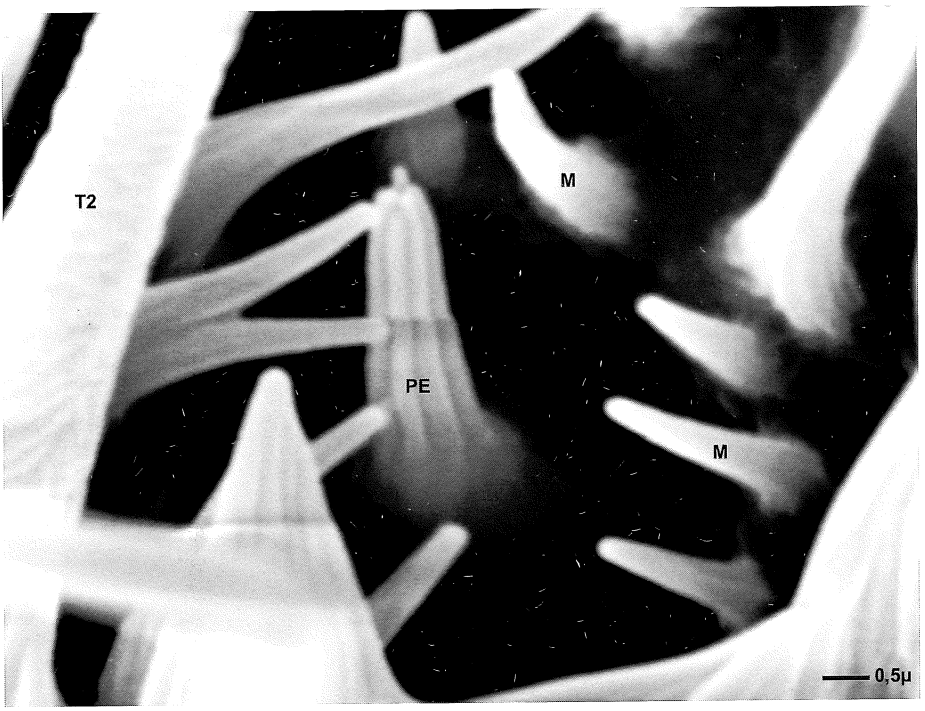

Fig. 11 - Male antenna. Detail of Fig. 7, displaying a sensillum coeloconicum. PE, peg; M, microtrichia forming the sensillum "fence"; T2, sensillum trichodeum "type 2".

Morphologically speaking, considering both cuticular and cellular components, they must be contact-chemoreceptive or gustative. But, as far as we know, these sensilla in Lepidoptera have not been investigated through electrophysiological and/or behavioural bioassays yet. Thus, there are no indications yet on which to base any concrete hypothesis about a behavioural meaning of them.

The *sensilla trichodea* (*sensu* Hallberg *et al.*, 1994, not Schneider, 1964) *type 1*, *type 2* and *type 3*, considering size and shape of the hair-shafts, correspond to the "sensilla trichodea" "A", "B" and "C" of Hallberg *et al.* (1994) respectively. Whereas considering the sensory neuron number the sequence correspondence just reverse. Furthermore, our *type 3* sensilla might include both sensilla "A" and "Intermediate sensilla (trichodea/basiconica)" of Hallberg *et al.* (1994). Sensilla trichodea are the most abundant all over the antennae, as known for other lepidopterans including noctuid species, with which they have proven to be sex pheromone receptive (Hanson *et al.*, 1986; Halmaas & Mustaparta, 1991; Hanson *et al.*, 1994).

Sensilla basiconica of *S. nonagrioides* conform with same type of Hallberg *et al.*, as well as with traditional terminology (Schneider, 1964) for their cuticular appendage. The morphological features of these sensilla indicate olfactory function, maybe

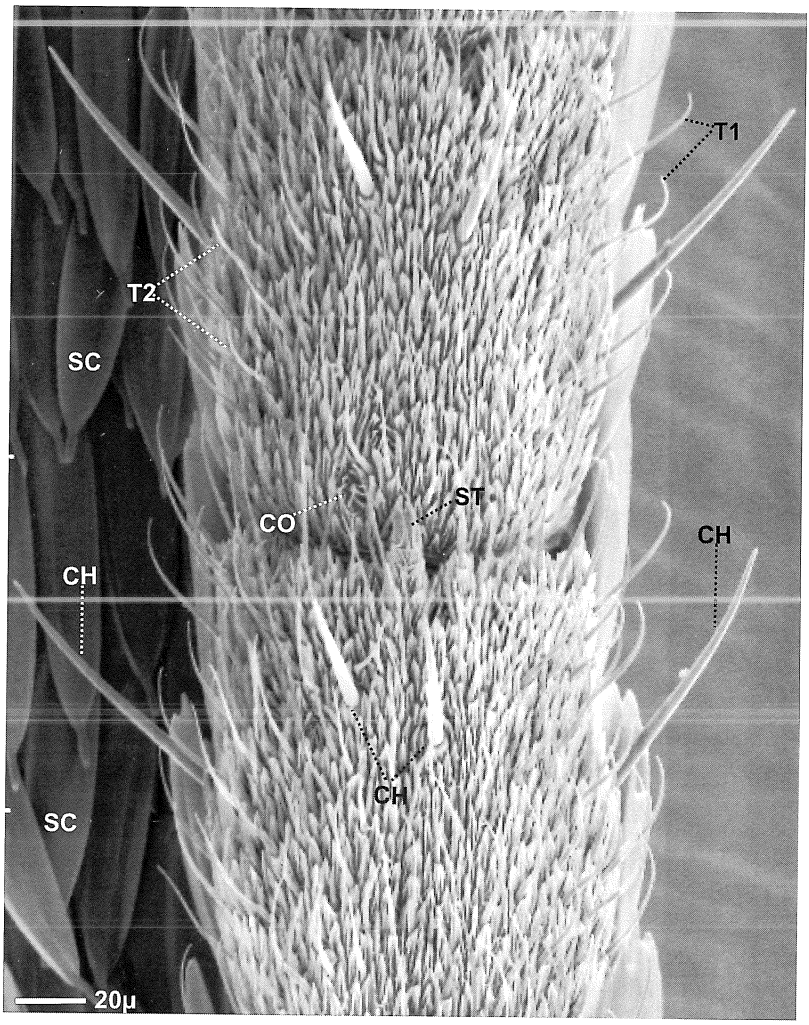

Fig. 12 - S.E.M. micrograph of female antenna, detail displaying the ventral sensilla chaetica (4 per flagellomere), sensilla trichodea "type 1" and "type 2", sensilla coeloconica and styloconica. CH, sensilla chaetica; CO, sensillum coeloconicum; SC, removed scales on the background; ST, sensilla styloconica; T1 and T2, sensilla trichodea "type 1" and "type 2".

sensitive to pheromone components and/or behavioural antagonists.

The *Sensilla auricillica* conform with same sensory structures of other lepidopterans especially noctuids (Jefferson *et al.*, 1970; Hallberg *et al.*, 1994; Anderson *et al.*, 2000). Their strong ultrastructural similarity with s. basiconica has been noted also

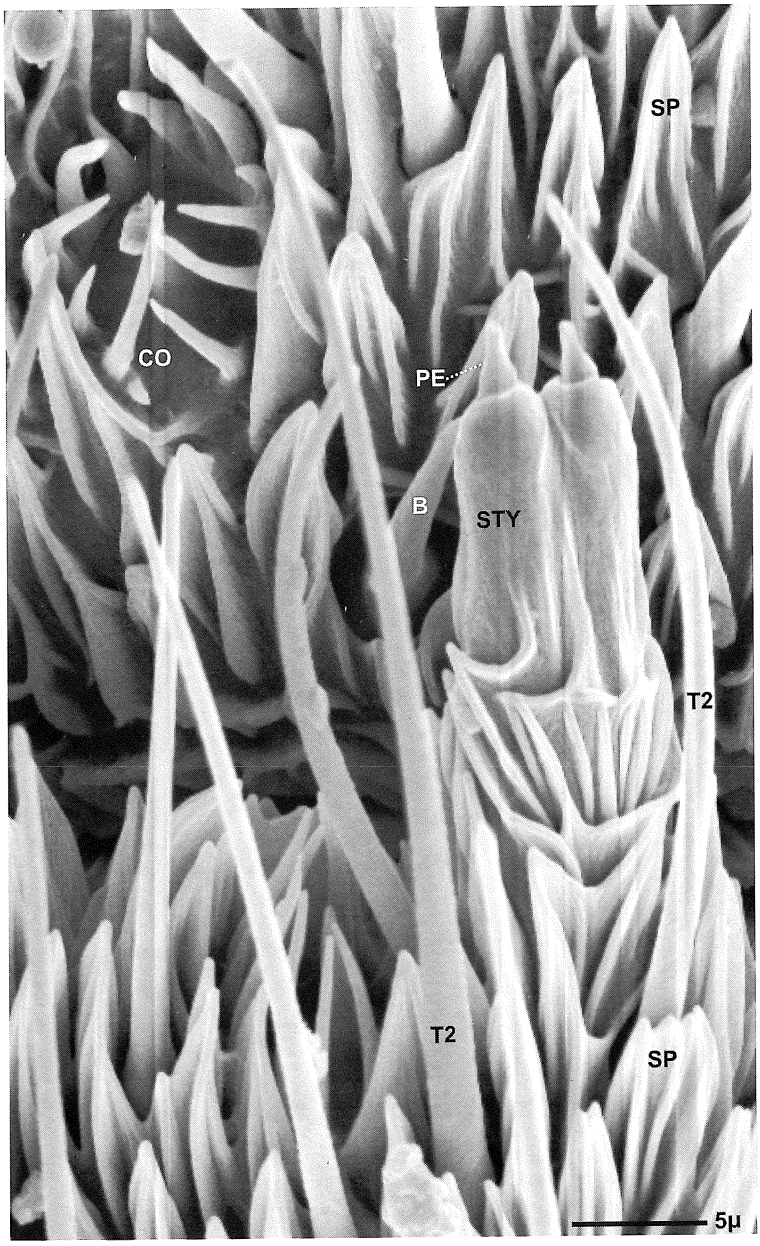

Fig. 13 - Female antenna. Detail of Fig. 12, showing sensilla basiconica, coeloconica and styloconica. B, sensillum basiconicum; CO, sensillum coeloconicum; PE, peg; SP, sculpture elevations; STY, stylus; T2, sensilla trichodea "type 2".

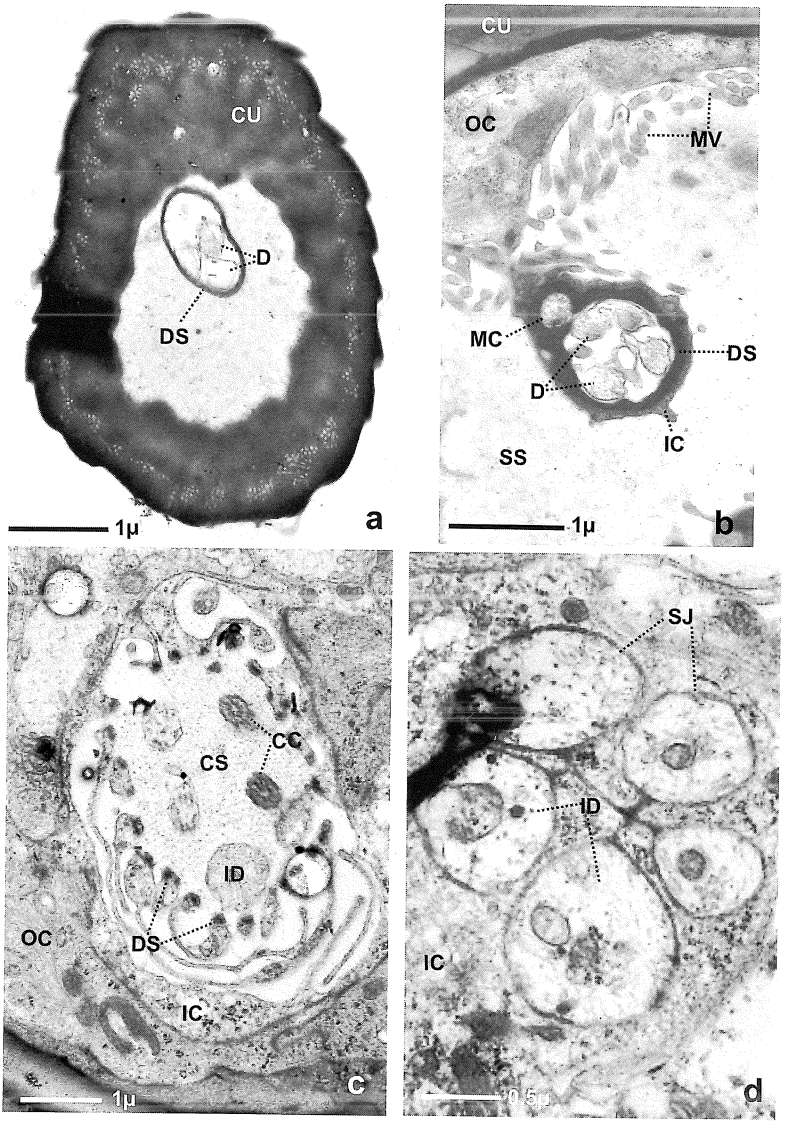

Fig. 14 - Male antenna. Transmission electron (T.E.M.) micrographs displaying sensillum chaeticum cross sections: a) through hair-shaft (intermediate, slightly oblique); b) somewhat beneath antennal wall; c) trough ciliary constrictions' region; d) trough inner dendritic segments (note the inner sheath cell surrounding the latter in a mesaxonal fashion). CC, ciliary constrictions; CS, ciliary sinus; CU, cuticle; D, outer dendritic segments; DS, dendritic sheath; IC, inner sheath cell; ID, inner dendritic segments; MC, mechanosensitive element; MV, microvilli; OC, outer sheath cell; SJ, septate junctions; SS, sensillar sinus.

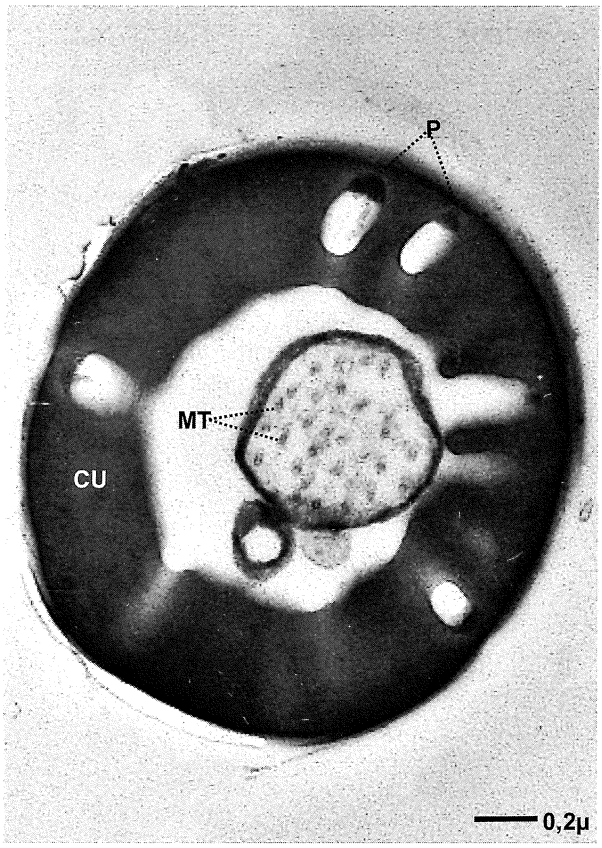

Fig. 15 - Male antenna. T.E.M. micrograph of sensillum trichodeum "type 1", hair-shaft cross section (intermediate). CU, cuticule; D, outer dendritic segment ; MT, microtubules; P, pores.

with other species (Hallberg *et al.*, 1994). These sensilla have proven to be sensitive to host-plant volatiles in another noctuid moth, *Scoliopteryx libatrix* (Anderson *et al.*, 2000).

The *Sensilla coeloconica* are very similar to the same type of olfactory structures found in other lepidopterans (Hallberg *et al.*, 1994 and references therein) but their behavioural meaning is still obscure.

The *sensilla styloconica* have been demonstrated to be thermo-/hygrosensitive in several moth species (Hallberg *et al.*, 1994 and references therein).

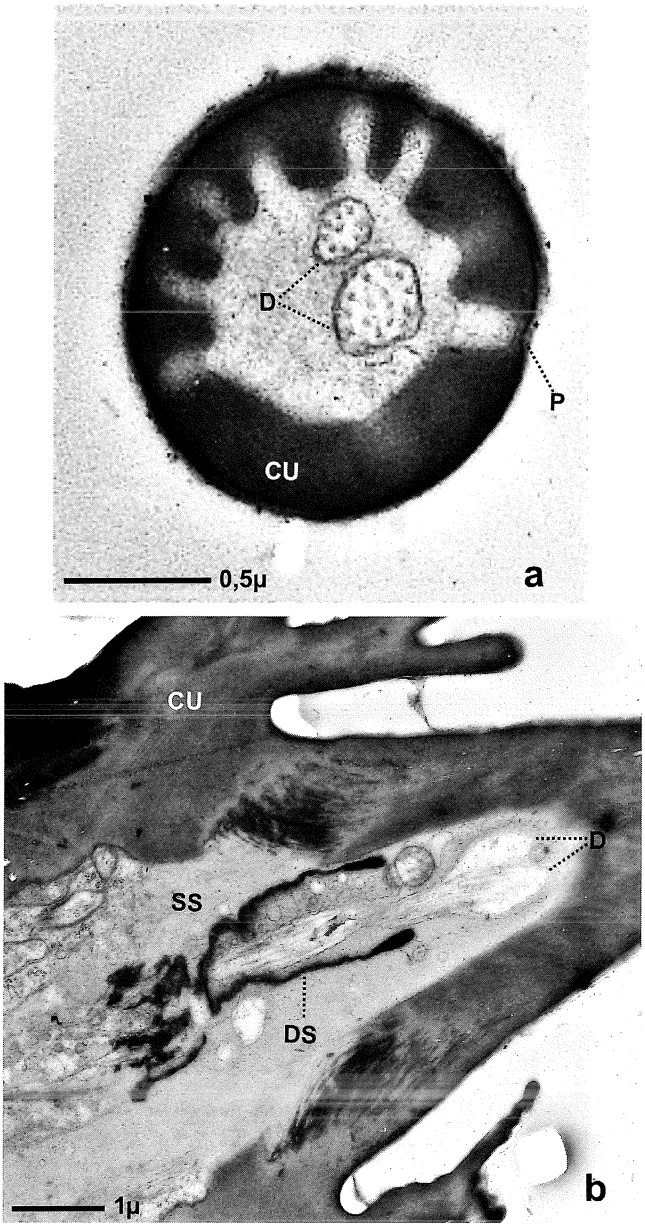

Fig. 16 - Male antenna. T.E.M. micrographs of sensillum trichodeum "type 2": a) cross section through hair-shaft (intermediate); b) sub longitudinal section through socket region. CU, cuticle; D, outer dendritic segments; DS, dendritic sheath; P, pore; SS, sensillar sinus.

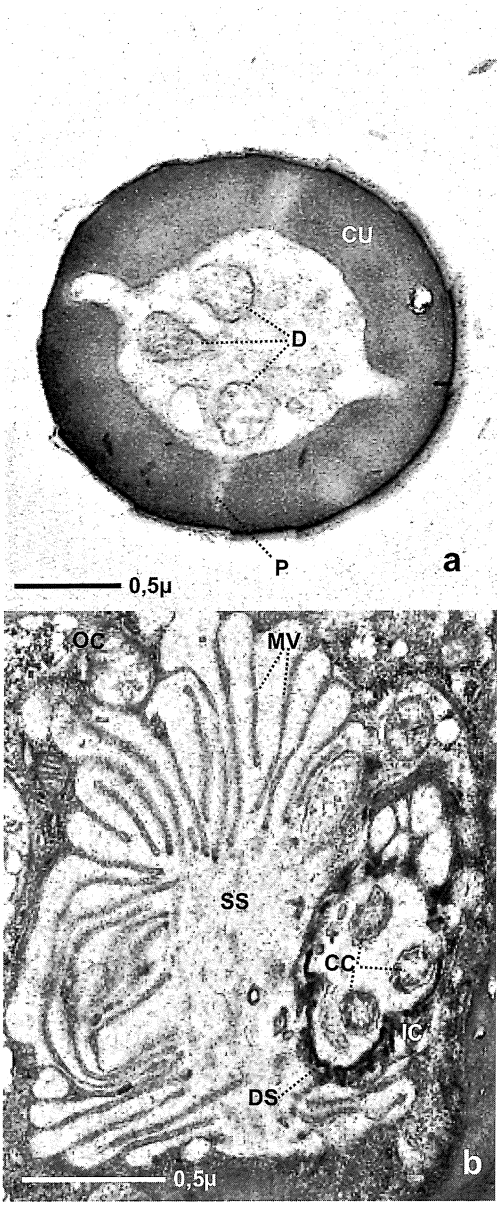

Fig. 17 - Male antenna. T.E.M. micrographs of sensillum trichodeum "type 3", cross sections: a) through hair-shaft (intermediate); b) at ciliary constrictions' level. CC, ciliary constrictions; CU, cuticle; IC, inner sheath cell; D, outer dendritic segments; DS, dendritic sheath; MV, microvilli; OC, outer sheath cell; SS, sensillar sinus.

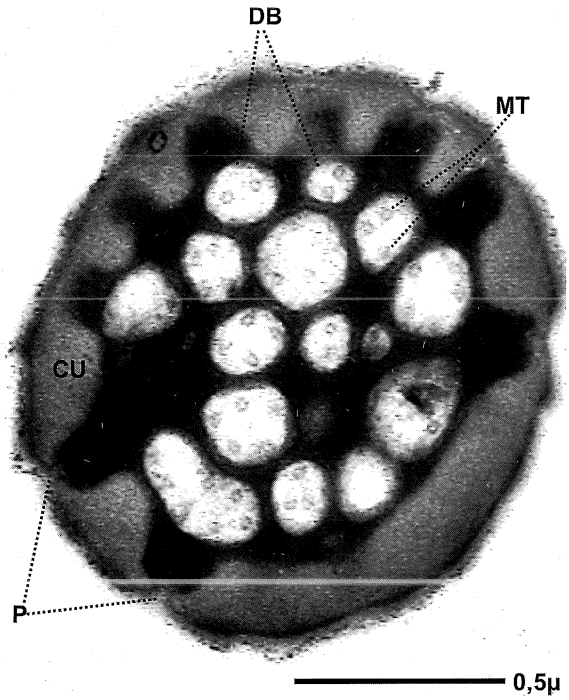

Fig. 18 - Male antenna. T.E.M. micrograph of sensillum basiconicum, cross section through hair - shaft (intermediate). Note the sensillar liquor high electron density. CU, cuticle; DB, dendritic branches; P, pores; MT, microtubules.

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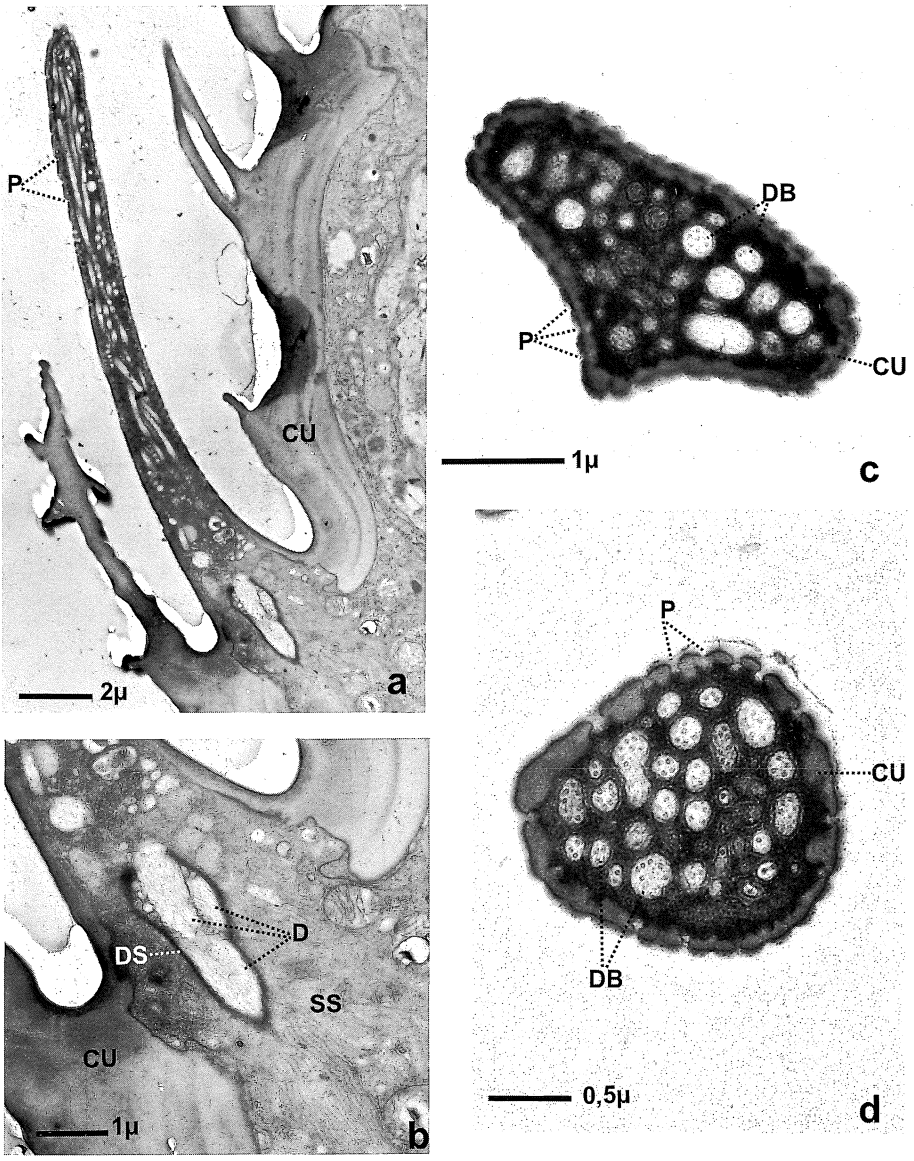

Fig. 19 - Male antenna. T.E.M. micrographs of sensillum auricillicum, hair-shaft sections: a) sub longitudinal; b) detail of *a,* showing the 3 outer dendritic segments entering the hair-shaft lumen; c) and d) cross sections, intermediate and sub basal, respectively. Note the high electron density of sensillar liquor within hair-shaft, whereas it looks normal within sensillar sinus: SS); CU, cuticle; D, outer dendritic segments; DB, dendritic branches; DS, dendritic sheath; P, pores.

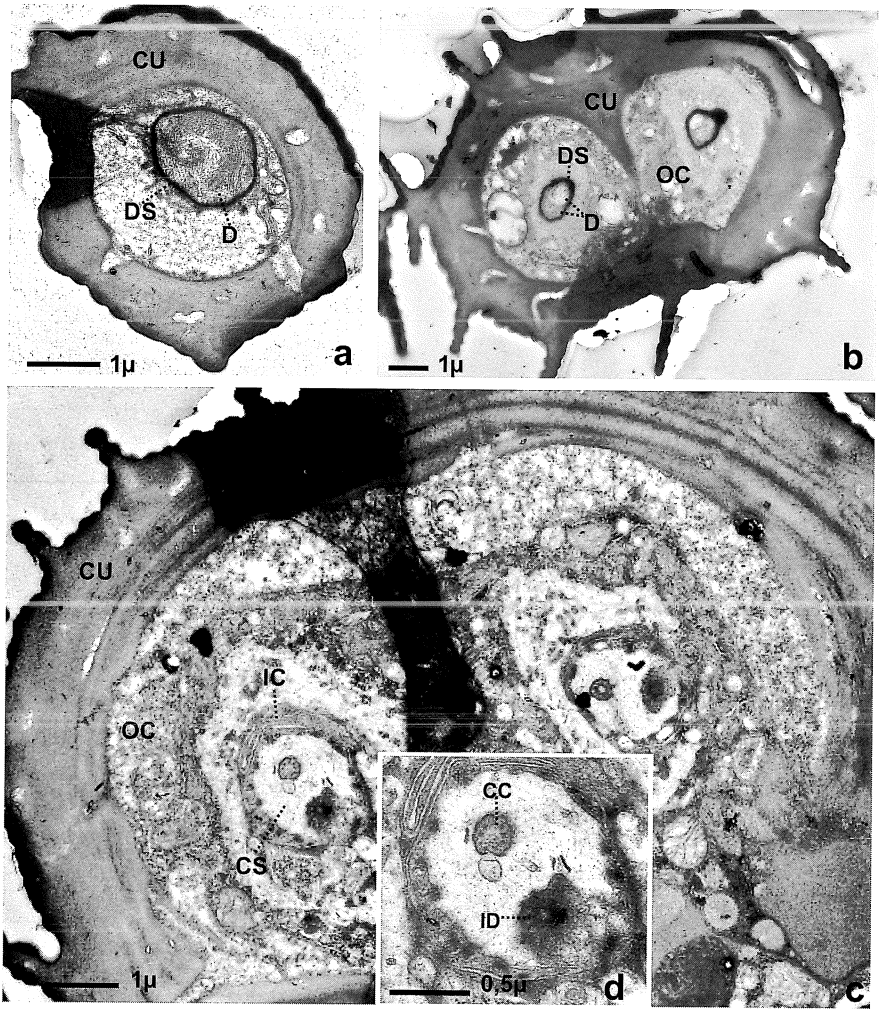

Fig. 20 - Male antenna. T.E.M. micrographs from cross sections of sensilla styloconica, outer cuticular components: a) through one of the two pegs, showing a lamellate outer dendritic segment; b) through both "styli", just beneath their separation; c) somewhat lower than *b*, at the ciliary constrictions' level; d) detail of *c*, showing ciliary constriction with 9 doublets of microtubules well arranged in a circle. CC, ciliary constriction; CS, ciliary sinus; CU, cuticle; D, outer dendritic segments; DS, dendritic sheath; IC, inner sheath cell; ID, inner dendritic segment ; OC, outer sheath cell.

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