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MORPHOLOGICAL STUDY OF THE APHID ANTENNAE OF *APHIS NERRI* BOYER (HOMOPTERA: APHIDIDAE) I. FLAGELLAR SENSILLA

CHUNG-HSING WANG and REV. FRANZ HUBER
Department of Biology, Fu-Jen University Taipei, Taiwan 242 Republic of China

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ABSTRACT

Chung-Hsing Wang and Rev. Franz Huber (1976). *Morphological Study of the Aphid Antennae of* Aphis nerri *Boyer* (*Homoptera: Aphididae*). Bull. Inst. Zool., Academia Sinica, 15(2): 47-56 The antennae of *Aphis nerri* Boyer were studied with the light microscope, scanning and transmission electron microscopes, to determine their external and internal structures.

The antennae of *A. nerri* B. are bristle like. There are three pegs with sharp tips near the distal end of the flagellum.

Various sense organs can be seen on the subsegments of the flagellum with SEM. On the 4th and 3rd subsegments there are primary rhinaria which occure on the newly-hatched larva and persist throughout life. Longitudinal thin sections were made to demonstrate the distribution of sensory neurons on the primary rhinaria of the 4th subsegment. Secondary rhinaria are located on the 2nd and 1st subsegments. They are present only in the adult. They are thin cuticular plates, having a round form, set over a large cavity in the thin cuticula. Cross sections of these plates were made and observed with TEM. A plate has an outer and inner membrane. The space between these two membranes is filled with non-cellular material. Many branched nerve-fibers are distributed underneath the inner membrane.

The insect antennae have been extensively reviewed by Schneider (1964). It is obvious that antennae are the site of various types of sensilla, sense organs. The function of sensilla may be mechanoreception, chemoreception, gustation, olfaction, hydroreception, thermoreception[6].

The morphological studies of insect antennae have been reported for many orders[1~3,7~9]. Formerly the insect antennae were studied with the light microscope. Only recently, the application of the transmission electron microscope lead to a precise understanding of the internal structures of the antennae, as the works of Mock and Slifer show[4,7]. At present the scanning electron microscope is widely used for the study of the external morphology of the antennae. The micrographs obtained from SEM are very informative[2].

The purpose of the present study is to describe the distribution and structure of sense organs located on the antennae as a basis for further work on their fnnctions.

MATERIALS AND METHODS

Aphis nerris Boyer were collected in the campus of Fu-Jen university from *Nerium indicum* Mill (Apocpnaceae). For the following study we used various approaches and methods.

Light Microscopy:

For the whole mount study, the aphids were fixed in 70% alcohol, dehydrated in the alcohol series, cleared in xylol and mounted on slides.

Electron Microscopy:

For this study, the antennae were removed from the aphids. (a) For the external study, the antennae were fixed in 70% alcohol and cleared in the ultrasonic apparatus for 3 minutes, then air-dryed, coated with carbon and gold in the vacuum evaporator and observed with the scanning electron microscope (JSM 15) at 15KV. (b) For the internal structures, the antennae were double-fixed with phosphate buffer 2.5% Glutaldehyde and 2% Osmic acid, then washed in the buffer solution, dehydrated with graded acetone, embedded in Epon 812. Ultra-thin sections were made and then stained with uranyl acetate. Observations and photographs were made with transmission electron microscope (JEM 100S) at 80KV.

OBSERVATION AND DISCUSSION

The antennae of *Aphis nerri* Boyer are bristle like, in which the subsegments are successively decreasing in size, the whole organ tappering off to a point (Fig. 1). The average length of an antenna is 1.95 mm. It consists of a scape, pedicle and a flagellum made up of 4 subsegments.

The major part of the antenna is well sclerotized with exception of the intersegmental regions. Here we find a soft and flexible cuticle. The cuticle of the antenna is not smooth but it has usually scales of a certain pattern. Many hairs which vary from 23 μ to 35 μ in length are found on the subsegments. These hairs are mostly located on the ventral and lateral surface. Each hair is a kind of sensillum. It consists of a long and thin process set in a socket with a tormogen cell (Socket-secreting cell). The trichogen cell is large, triangular. A single dendrite leads from the proximal part of the hair through a trichogen cell to a bipolar neuron beneath the trichogen cell. The sensory cellbody is slightly elongated, and about 8 μ in diameter, with a comparatively large nucleus whose diameter is about 4.2 μ. Mitochondria are abundant in the cytoplasm. An ellipsoid differentiated body, about 1.8×0.66 μ, appeares in the distal end of the dendrite (Fig. 8).

The plate sense organs of the aphid antennae can be divided mainly into two groups; primary and secondary rhinaria (Fig. 3). The primary rhinaria occur on the newly-hatched larva and persist throughout life. The secondary rhinaria can be found only on winged aphids.

The morphological study of rhinaria of *A. nerri* B. by SEM and the sensory neurons of primary sensilla observed with TEM will be described below.

There are three pegs with sharp tips near the distal end of the flagellum (Fig. 2). The pegs are not on the same level on the antenna. They are about 1.2 μ in diameter, 6.1 μ in length.

At the middle of the 4 th subsegment, there is a cluster of 7 sensilla. All of them are primary rhinaria. They are different from *Tuberolachnus salgnus* and *Megoura viciae* described by Slife *et al.*[8]. These primary rhinaria consist of three flat, circular plate-organs and 4 coeloconic pegs (Fig. 4). The three flat, circular plate-organs are different in size, one is large and two are small. Their average diameters are 17 μ, 10 μ 7.5 μ, respectively. The plate organs and pegs are set into invaginations of the cuticula. Surrounding each cavity (invagination) is a ring of hairs with branched tips. The number of their branches is not constant. These hairs curve centrally into the flattened sense organ. Many neve fibers appear beneath these hairs (Fig. 9a, 9b). Slifer *et al.* (1964) have discussed and described these hairs. They thought the hairs belong almost certainly to an olfactory organ[8]. The shapes of the 4 celoconic pegs

Fig.1

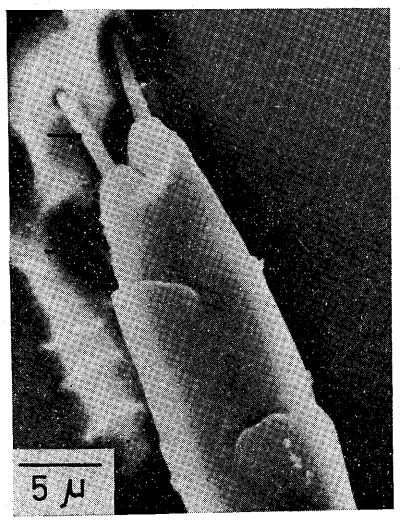


Fig.2

Fig. 1. Scanning electron micrograph of whole antenna of *Aphis nerri* showing a scape, pedicle and a four-subsegmented flagellum.

Fig. 2. Scanning electron micrograph of the tip of an antenna of *A. nerri*. The arrows show three stout pegs.

Fig. 3. Scanning electron micrograph of part of a subsegment of flagellum of *A. nerri* showing two primary rhinaria on III & IV subsegments and fourteen secondary rhinaria on I & II subsegments.

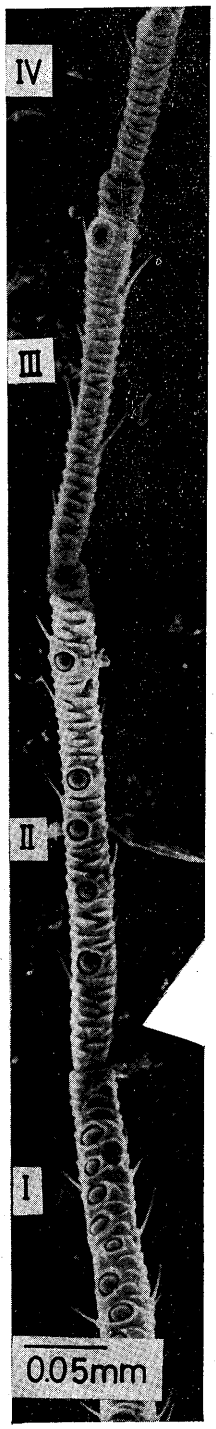


Fig. 3

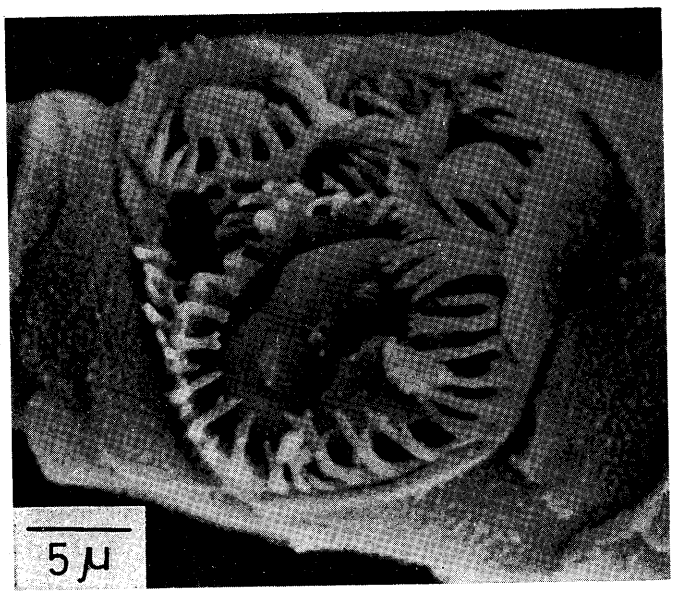


Fig. 4. Scanning electron micrograph of primary rhinaria on subsegment IV of the flagellum of *A. nerri*, showing a cluster of seven sensilla which consist of three flat circular plate organs and four coeloconic pegs.

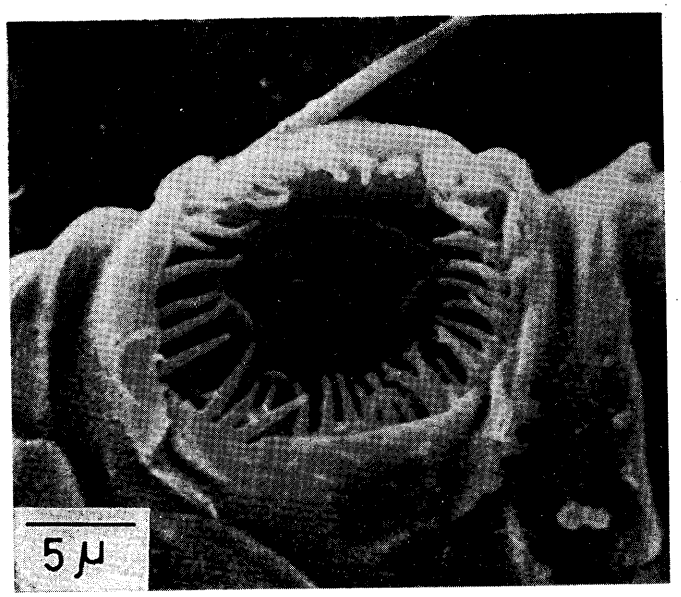


Fig. 5. Scanning electron micrograph of primary rhinarium on subsegment III of the flagellum of *A. nerri*, showing one plate organ set in a cavity which is surrounded by a ring of hairs, many of them with branched tips.

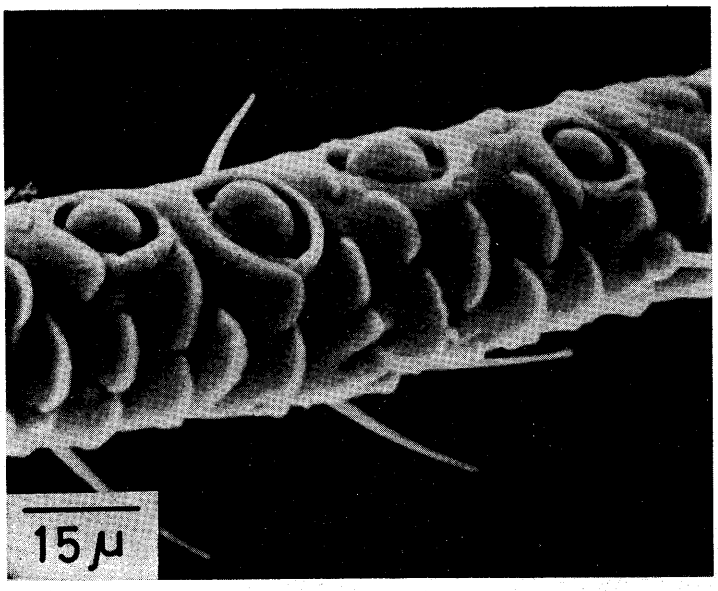


Fig. 6. Scanning electron micrograph of secondary rhinaria located on the dorsal surface of the flagellum of *A. nerri*.

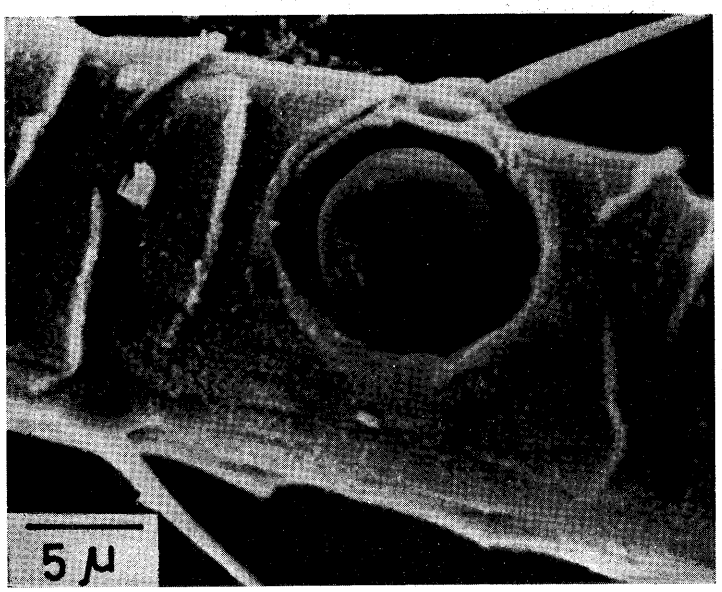


Fig. 7. High magnification of Fig. 6 showing a round plate organ set into a cavity. Between the plate and cavity, there is a deep groove.

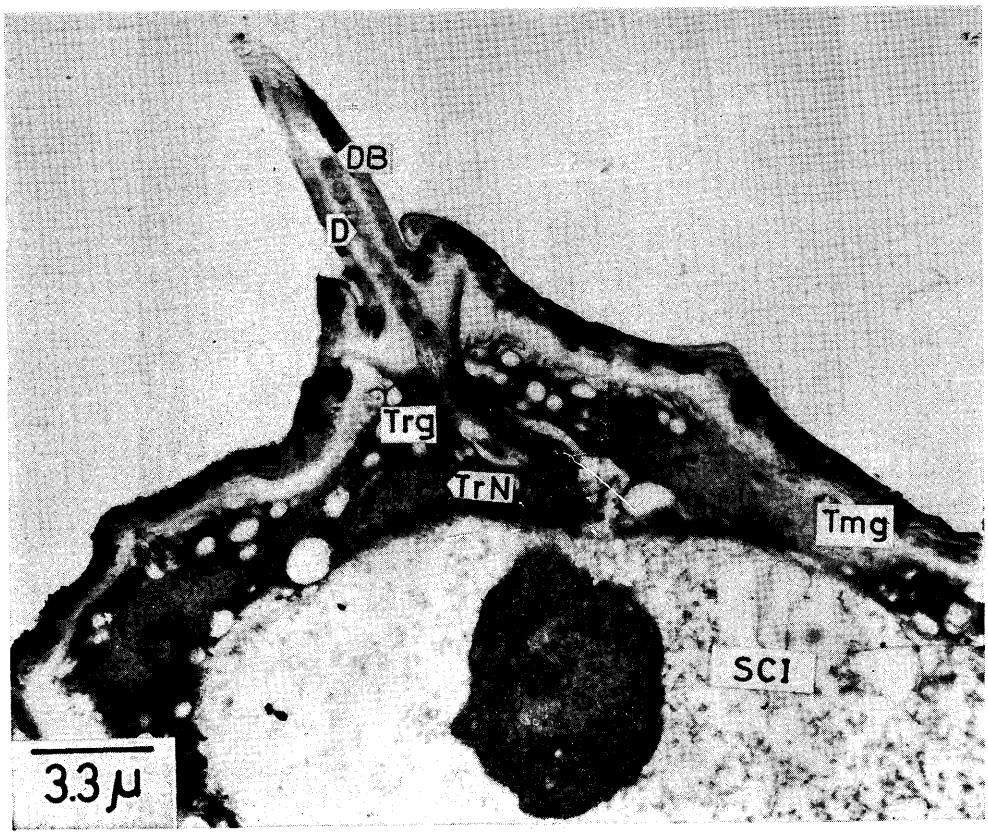


Fig. 8. Electron micrograph of a section showing the relaction of cellular elements in a simple hair sensillum.
D, dendrite of sensory cell; DB, differential body; Tmg, tormogen cell; Trg, trichogen cell; TrN, nucleus of trichogen cell. SCI, sensory cell of type I.

are quite different. One of them is a cylindrical tube with a circlet of minut hairs appearing as a ciliary crown on the top of the peg. Two of them have pointed tips. There is one coelconic peg in which we still can not demonstrate its shape clearly.

The function of each sensillum is still unknown, but it is very interesting to observe that some brownish liquid is flowing out from the largestplate organ of primary rhinaria when we put some pressure on the scalp.

The fine structure of primary rhinaria of the antenna was studied with TEM. A central antennal nerve passess towards the head through the antennal lumen (Fig. 9b). Usually it is in close association with a trachea.

The sensory neurons of the primary rhinaria on the 4 th subsegment can be separated into two types. Sensory cells of type I (SCI) which are bipolar. The distal end of this cell goes directly to the sense organ (Fig. 9c). Sensory cells of type II which are either bipolar or multipolar; they are povided with elaborately branched distal processess. These fine nerve fibers terminate on the sense organ. (Fig. 9a, 9b, 10, 10b, 10c, 10d). The number of SCI is much smaller than that of SCII.

The sensory neurons of these sensilla usually

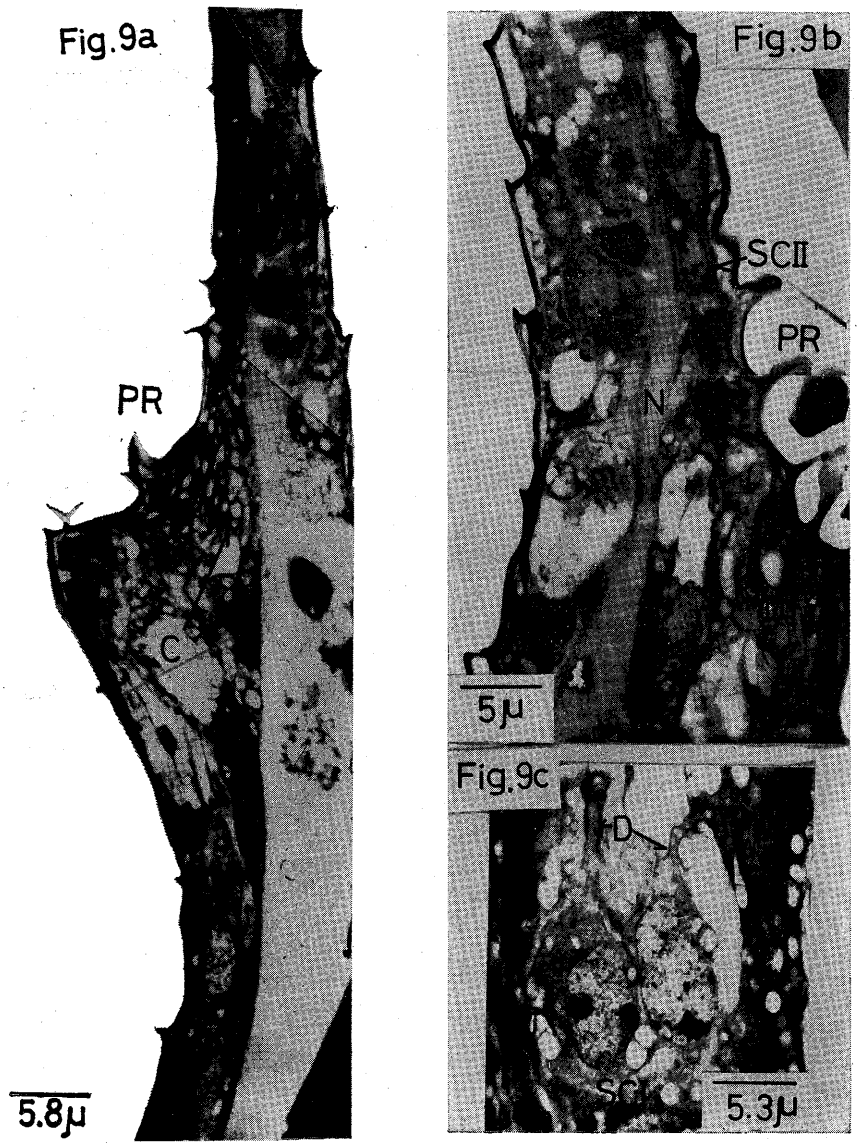
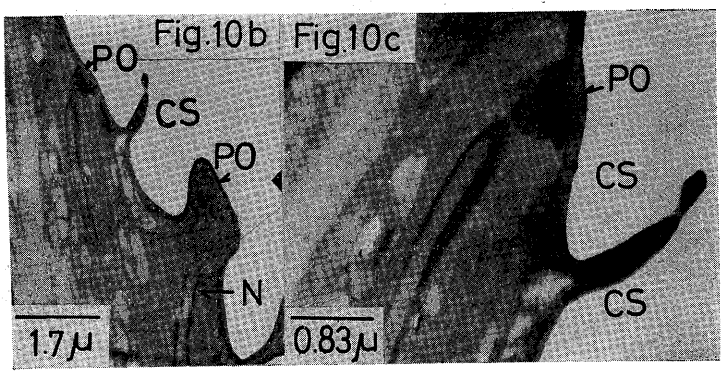


Fig. 9. a. and b. are electron micrograph of a longitudinal section of subsegment IV showing the relationships of some sensory neurons with primary rhinaria and the central antennal nerve.
c, sponge like cavity; N, antennal nerve; SCI, sensory cell of type I; D, dendrite; SCII, sensory cell of type II.
c. Electron micrograph of a sensory cell type I (SCI). The distal end of these cells go directly to the sense organ. PR, primary rhinaria.



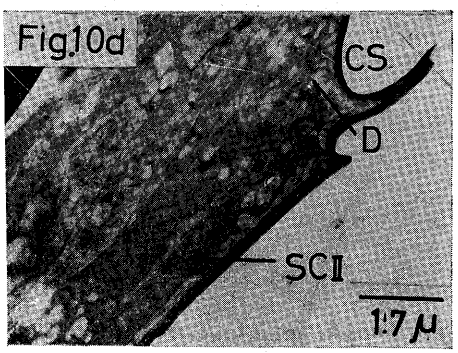


Fig. 10. Electron micrograph of longitudinal sections of subsegment IV.

a. A cluster of sensory cells type II located on the inner surface of the cuticle.
b. Section through the plate organ of primary rhinaria showing the relation of nerves to the plate.
c. High magnification of Fig. 10b.
d. A bundle of branched dendrites of SCII innervates just beneath the cavity of sensilla.

CS, cavity of sensilla; PO, plate organ; N, nerve; SCII, sensory cell of type II; D, dendrite.

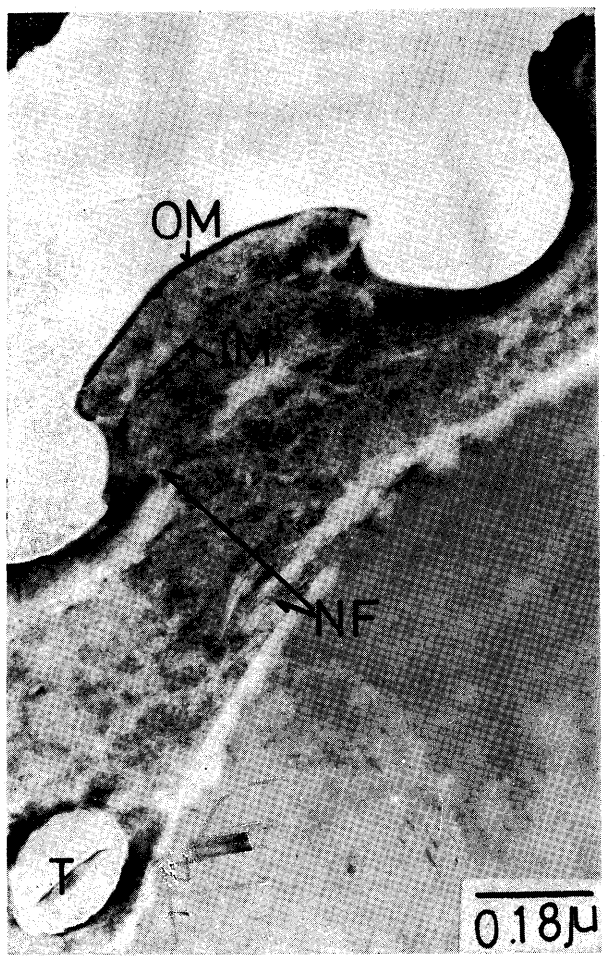


Fig. 11. Electron micrograph of a cross section of secondary rhinaria showing a plate with outer and inner membrane. Many branched nerve fibers are distributed below the inner membrane.
NF. nerve fiber; IM, inner membrane; OM, outer membrane; T, tracheole.

do not lie just beneath the sensilla. They often form clusters at the lower part of the 4th subsegment, along the inner surface of the cuticle. Each primary sensillum is innervated by the dendrites of many clusters of sensory neurons. Sometimes, the sensory neurons may be seen on the central lumen of the antennae instead along the inner surface of the cuticle.

Not far from the distal end of the 3rd subsegment, there is a large, circular plate sensillum. It is about 17 μ in diameter. It is also a primary rhinarium. The structure of this plat organ is similar to the one of the 4th subsegment just described. A flat sensillum is located in the invagination of the cuticula. A ring of branched hairs encircles it.

On the 1st and 2nd subsegments there is another kind of plate-organs. They are secondary rhinaria which appear only in the winged aphid (Fig. 6). The number is not constant; usually there are 4 to 11 in the 1st subsegment and 0 to 5 in the 2nd subsegment. Sometimes, the

number of secondary rhinaria differs between two antennae of the same specimen. The secondary rhinaria are smaller than the primary rhinaria. The diameter of the plates varies. The range is from 9 μ to 12 μ. They are located in a line that runs along the dorsal surface of the antenna. Usually the 1st subsegment has many more plate-organs than the others.

The structures of all secondary rhinaria are quite similar. There is a thin cuticular plate, round in form, set over a large invagination in a deep groove (Fig. 7). At the bottom of this groove is a narrow membrane ring. No branched hairs appear on the margin of the invagination. It has been reported by Pettersson (1970) that the principal morphological difference between the male and the winged female aphid is the far greater number of secondary rhinaria of the former located on the antennae[5]. He also says that the real function of these organs is unknown though they are suspected of being receptors for chemical signals. Unfortunately, we have not found the winged male in our 200 specimens. We do not know whether there is the same condition or not in *A. nerri* B. Thin cross sections of this plate were observed. It consists of an outer and inner membrane. The space between these two membranes is filled with non-cellular material. They are transparent when observed with the light microscope. Many branched nerve fibers are distributed underneath the inner membrane (Fig. 11).

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蚜蟲 (*Aphis nerri* Boyer) 觸角鞭毛上感覺器之構造

王 重 雄　　扈 伯 爾

本研究係以掃描式和穿透式電子顯微鏡觀察蚜蟲 (*Aphis nerri* B.) 觸角霜毛上之感覺器構造。其中感覺毛，初級感覺器及次級感覺器等三種感覺器之外部形態及內部構造和神經分佈皆在本文中曾予描述。