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Structure of Sensilla on the Antenna and Mouthparts of the Oriental Tobacco Budworm(*Heliothis assulta* Guenee) Larvae

담배나방 유충의 촉각 및 구기 감각기의 구조

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ABSTRACT Studies were carried out to describe the structure and distribution of various sensilla on the antenna and mouthparts of the Oriental tobacco budworm (*H. assulta*) larvae by light and scanning electron microscopy. The larval antenna has 3 segments. The second segment has 2 hairs and 3 pegs, while the third segment shows 3 regular pegs and a segmented peg (styloconicum type). Each mandible bears 2 aporous hairs on the lateral surface. The labrum bears 12 aporous hairs on its external surface, and 6 aporous hairs, 4 coeloconica-like sensilla and 2 campaniformia-like sensilla on its epipharynx. The stipes has 3 hairs, and the galea has 3 pegs, 2 papillae and 2 domes. The maxillary palpus has only a digitiform sensillum on its 1st segment but 11 sensilla of 4 different types on its 2nd segment. Maxillary sensilla represent almost 70% of total number of larval sensilla on the mouthparts. Labial palpus has a single segment bearing a large segmented uniporous peg and a small peg. Finally their possible functions were suggested.

KER WORDS Oriental tobacco budworm larva, *Heliothis assulta* larva, sensilla structure, antennal sensilla, mouthparts sensilla

抄 錄 주사전자현미경 및 광학현미경을 이용하여 밝혀낸 담배나방(*Heliothis assulta* Guenee) 유충의 촉각 및 구기의 감각기 구조는 다음과 같다. 촉각은 세마디로 되어있지만 마지막 두마디에만 감각기가 분포하고, 기절은 단순히 촉각을 머리에 부착시킨다. 병절은 2개의 털 감각기와 3개의 방망이형 감각기를 가지며, 편절은 3개의 방망이형 감각기와 1개의 2마디로된 방망이형 감각기를 갖는다. 큰턱은 측면에 2개의 털감각기를 가지며, 작은턱의 외엽에는 2개의 털, 3개의 방망이형 및 2개의 종상형 감각기가 있다. 작은턱 수염의 2마디중 첫째마디는 1개의 digitiform 감각기만을 갖는다. 그러나 둘째마디는 11개의 감각기를 갖는데, 1개의 digitiform과 2개의 종상형 감각기는 측면에, 8개의 방망이형 감각기는 마디끝에 위치한다. 윗입술은 외표면에 12개의 털, 내표면에 6개의 털, 2쌍의 함몰형과 1쌍의 종상형 감각기를 갖는다. 퇴화된 아랫입술은 작은턱과 융합되어서, 하인두, spinneret, 수염을 지지하며, 이들중 아랫입술수염에만 2개의 방망이형 감각기가 있다. 구조적 측면에서 감각기의 기능을 추정해보았으며 구기 전체 감각기의 70%를 차지하는 작은턱 감각기가 먹이 선택 행동에 중요한 기능을 할 것으로 보인다.

檢索語 담배나방 유충, 감각기 구조, 촉각 감각기, 구기 감각기

In selecting a host plant, insect must find out a potential host from a distance. This is usually mediated by chemicals acting as an attractant. These chemicals are a part of the secondary products in plants. Such secondary plant chemicals serve as token stimuli, indicating a suitable host to insects. These chemicals have been demonstrated as olfactory attractants for a various phytophagous insects (Hsiao 1985). After insects arrive at a potential host, they again tend to select a particular tissue or part of the host. This final behavior of insect before feeding would depend on combined information in the brain through their chemical sensilla to phagostimulants and phagodeter-

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rents as well as mechanical sensilla to physical texture.

The Oriental tobacco budworm (*Heliothis assulta*) larvae preferred the hot pepper to other possible host plants (solanum uk kwang, the sweet pepper and tobacco leaf), and also fruits to other tissues of the hot pepper, such as flowers or leaves (Choi 1988). For understanding the relationship of these host selection behavior and phagostimulants and/or phagodeterrents from plants, electrophysiological technique is the most precise method of bioassay currently available for use. However, knowledge of sensory receptors is a prerequisite to using this technique (Hatifield & Frazier 1976).

Therefore, the present study was carried out to describe the structure of sensilla on the antenna and mouthparts of the Oriental tobacco budworm larvae.

MATERIALS AND METHODS

Head capsules of the final or penultimate larvae were fixed in cold (4°C) 2.5% Karnovsky's fixative (Karnovsky 1965) and critical-point dried after dehydration. Specimens were mounted on stubs with double-sided tape or conductive silver paint, and coated (ca. 20nm) with gold for observation in a Cambridge SEM (S250 MK2) at 5—10kV.

Whole mounts were prepared by intravital staining (Behan & Ryan 1978). For histology, the heads of the Oriental tobacco budworm larvae were fixed with the same fixative for scanning electron microscopy, postfixed with buffered 1% osmium tetroxide (12—16hrs), and followed by dehydration in acetone and embedding in Epon 812. Sections (1μm) were stained with a solution of 1% toluidine or methylene blue in 1% borax and mounted with Canada balsam.

RESULTS AND DISCUSSION

Sensory receptors in the larval head of *H. assulta* are located on a pair of the three-segmented antenna oriented antero-laterally and mouthparts (Fig. 1). Around the antenna six lateral stemmata were found in a circular arc on each side. But the stemmata were not studied in the present report.

Antenna

The sensilla were observed only in the 2nd and 3rd antennal segment. The 2nd segment bears 2 hairs (trichodea-like) and 3 peg (basiconica-like) sensilla (Fig. 2). One of the hairs is long (355μm long and 16μm wide at the base), but the other is short (66μm long and 6μm wide at the base). Both hairs have no terminal pore and innervated by a single sense cell terminating at its base. Two of the 3 pegs are of similar size (15μm long and 13μm wide at the base) with a terminal pore and have rough surface textures (Fig. 2, 3). But the other peg is aporous and of a small spike-shape.

The 3rd segment measures 20μm long and 25μm wide at the base, and again bears 3 pegs (basiconica-like) and a segmented peg (styloconica-like) (Fig. 4). One of the 3 pegs is a large multiporous peg (10μm long and 7μm wide at the base) and has rough surface textures (Fig. 5). There are 2 other small pegs in 3rd antennal segment. But one is a cone, the other is of bell shape (Fig. 6). The styloconicum-like sensillum is two-segmented peg, showing 20μm long and 5μm wide at the base of the first bulbous base. Its 2nd segment is again divided into 2 branches with a pore at each terminal (Fig. 7).

The general picture of the antennal sensilla in *H. assulta* larvae is quite similar to that reported from larvae of other lepidopterans (Schoonhoven & Dethier 1966, Schoonhoven 1967). However, the 2-segmented peg on the flagellum of *H. assulta* larvae seems to be innervated by 4—5 sense cells. While a similar peg was reported to have only 3 sensory cells in other lepidopterans (Schoonhoven 1967). But coleopteran larvae tend to have more number of sensilla on their segmented antennae than lepidopterans (Bloom et al. 1981).

Mouthparts

The mouthparts of *H. assulta* larvae consist of a pair of the heavily sclerotised mandible, a labrum, a pair of the maxilla located antero-ventrally, a labium and a hypopharynx heavily sclerotised (Fig. 8). The labrum bears externally 12 socketed, aporous hairs and internally 6 hairs of similar type, 2 pairs of coeloconica-like sensilla and a pair of campaniformium-like sensilla (Fig. 9, 11). Cuticular spicules are scattered throughout the surface of the clypeo-labrum.

The maxilla is composed of a stipes, a galea and a 2-segmented palpus. The elongated stipes with 3 long hair sensilla narrows to a 2-segmented palpus and a stout galea (Fig. 8, 10). The galea with 7 sensilla, has protuberant base (Fig. 10). Two of 7 sensilla are unsocketed and uniporous 2-segmented pegs (styloconica-like) measuring 40—45μm long. Another two are socketed aporous papillae measuring 50—55μm long. Two others are campaniformia-like sensilla. The last one is short, aporous peg (basiconicum-like) sensillum. The 1st segment of palpus is 53μm long and 39μm wide bearing

Table 1. Location, appearance, number and suggested function of sensilla on the antenna and mouthparts of larval *Heliothis assulta*

Location	Appearance	Number	Function suggested
Antenna			
Pedicel	uniporous pegs	2	chemosensory
	aporous peg	1	mechanosensory
	hairs	2	mechanosensory
Flagellum	multiporous peg	1	chemosensory
	two-segmented peg	1	chemosensory
	aporous pegs (?)	2	?
Labrum			
Outer surface	aporous hairs	12	?
Inner surface	aporous hairs	6	?
	coeloconica-like	4	chemosensory
	campaniformia-like	2	mechanosensory
Mandible	aporous hairs	2	mechanosensory
Maxilla			
	aporous hairs	3	mechanosensory
Palp(1st)	digitiformium-like	1	?
Palp(2nd)	uniporous pegs	5	chemosensory
	multiporous pegs	3	chemosensory
	digitiformium	1	mechanosensory
	campaniformia-like	2	mechanosensory
Galea	aporous papillae	2	mechanosensory
	uniporous pegs	2	chemosensory
	aporous peg	1	mechanosensory
	campaniformia-like	2	mechanosensory
Labial palp	uniporous pegs	2	mechanosensory
Total		94	

only a digitiform-like sensillum in its distal wall (Fig. 15). The 2nd segment of palpus, 37μm long and 35μm wide, carries a digitiform and 2 campaniformia-like sensilla located on its lateral side (Fig. 13). The digitiform sensillum is 12μm long and 8μm wide at the base and innervated by a single neuron reaching its tip (Fig. 18). The 2nd palpal segment also shows 8 pegs (basiconica-like), 3—4μm long, at its apex (Fig. 12, 14). Five of 8 pegs are uniporous, but 3 others are multiporous.

Among the head sensilla (except for photoreceptors) of the Oriental tobacco budworm larval maxillae have the most number of the sensilla (Table 1), showing 44 sensilla belonging to 7 different types. This is almost half of the total number of sensilla on the antennae and mouthparts in *H. assulta* larvae. This ratio is similar to that of *Euxoa messoria* (Devitt & Smith 1982). In the number of sensilla the labrum is followed among the mouthparts of *H. assulta* larvae. It carries 12 sensilla each on the external and internal surface. Most of them are of hair type. However, the mandible has only 2 hairs. The labium is remarkably reduced in size, having only a segmented palp, and fused with the maxillae. This complex supports the hypopharynx, the spinneret and labial palps (Fig. 8, 10, 16). The number of its sensilla is also a few with only 2 pegs (Fig. 17, 19, 20).

It seems to be general that lepidopteran larvae have many number of chemoreceptors in their antenna and mouthparts (Reese & Carlson 1974, Albert 1980, Devitt & Smith 1982). The larvae of *H. assulta* appears to be along the same line, showing many number of possible chemoreceptors on the antenna (Table 1). But all sensilla on the mandible and labial palp of *H. assulta* seem to be mechanoreceptors from their structure. This contrasts to the coleopterans which show relatively numerous mechanoreceptors on their antenna (Hatfield & Frazier 1976, Behan & Ryan 1978, Bloom et al. 1982).

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EXPLANATION OF FIGURES

PLATE I

Fig. 1. Anterior view of the larval head in *Heliothis assulta* (A : antenna, H : hypopharynx, L : lateral stemmata, LA : labrum, * : mandible, + : maxilla, s : spinneret) (scale=400μm).

Fig. 2. Antenna of *H. assulta* larva (2ND : pedicel, B : basiconicum-like peg, H : hair, 3RD : flagellum) (scale=40μm).

Fig. 3. Higher magnification picture of a basiconicum-like peg on the pedicel of *H. assulta* larval antenna (↵ : terminal pore)(scale=1μm).

PLATE II

Fig. 4. Flagellum of *H. assulta* larval antenna (B : basiconicum-like peg, S : styloconicum-like peg)(scale=20μm).

Fig. 5. Higher magnification picture of the large multiporous peg on the flagellum of *H. assulta* larval antenna(scale=2μm).

Fig. 6. A smaller peg on the flagellum of *H. assulta* larval antenna(scale=1.9μm).

Fig. 7. Distal part of the styloconicum-like peg, showing 2 uniporous branched tips, on the flagellum of *H. assulta* larval antenna(scale=0.8μm).

Fig. 8. Various sensilla on the mouthparts of *H. assulta* larva (A : maxillary palp, B : labial palp, G : galea, H : hypopharynx, LA : labrum, S : spinneret, T : mandibular tooth, ** : mandible)(scale=200 μm).

PLATE III

Fig. 9. Inner view of the labrum of *H. assulta* larva (c : campaniform-like, H : hair, o : coeloconicum-like) (scale=200μm).

Fig. 10. Maxilla of *H. assulta* larva (B : basiconicum-like peg, c : campaniform-like, GL : galea, H : hair, #1 : 1st segment of maxillary palp, #2 : 2nd segment of maxillary palp, ST : stipes, U : uniporous peg)(scale=100μm).

Fig. 11. Higher magnification picture of coeloconicum-like sensillum on the epipharynx of *H. assulta* larval labrum(scale=10μm).

Fig. 12. Second segment of the maxillary palp of *H. assulta* larva (2nd : second segment of the maxillary palp, ↑ : digitiform sensillum, ▲ : campaniformium-like sensillum)(scale=20μm).

Fig. 13. A digitiform sensillum on the second segment of the maxillary palp(scale=10μm).

PLATE IV

Fig. 14. Eight basiconica-like pegs on the second palpal segment of *H. assulta* larva (M : multiporous peg, U : uniporous peg)(scale=4μm).

Fig. 15. The first segment (1st) of the maxillary palp, showing a digitiform-like sensillum (D), in *H. assulta* larva(scale=10μm).

Fig. 16. Labium of *H. assalta* larva (b : labial palp, 1 : labium, s : spinneret)(scale=100μm).

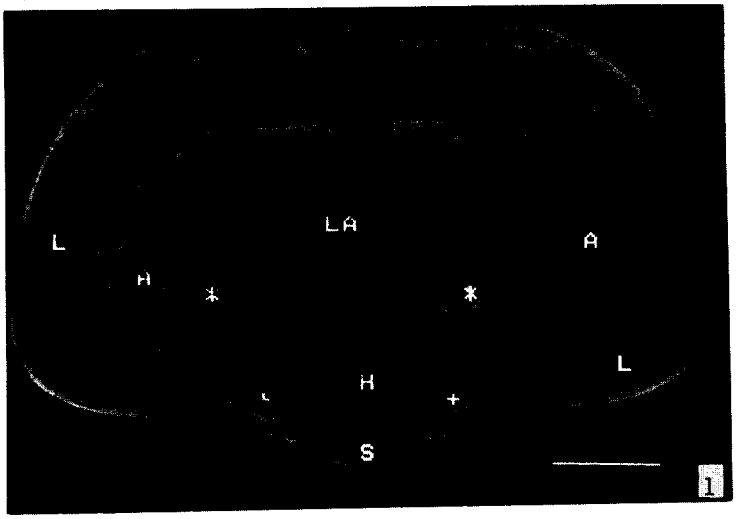
Fig. 17. Oblique cross section through the labial palp, showing a single sensillum(↵), of *H. assulta* larva (×1,000).

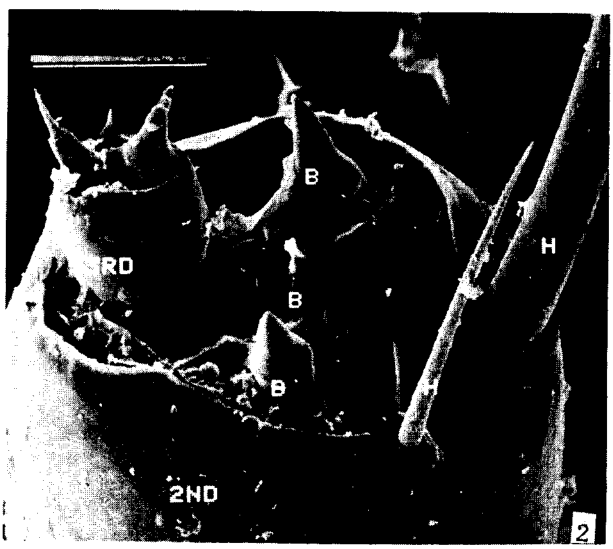
Fig. 18. Longitudinal section through the second segment of the maxillary palp in *H. assulta* larva, showing a singly innervated digitiform sensillum (D)(×1,000).

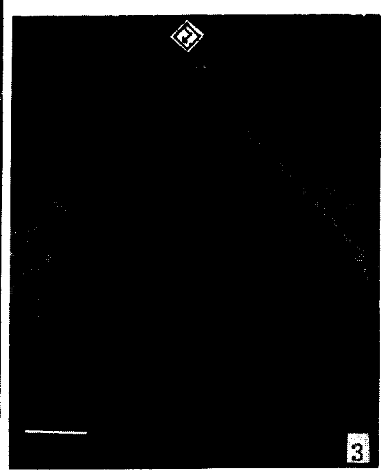
Fig. 19. Labial palp, showing two pegs, of *H. assulta* larva (L : large peg, s : small peg)(scale=10μm).

Fig. 20. Whole mounts of spinneret (×100) and labial palp (×400) of *H. assulta* larva(l : large peg, lp : labial palp, s : small peg, sp : spinneret).

PLATE I







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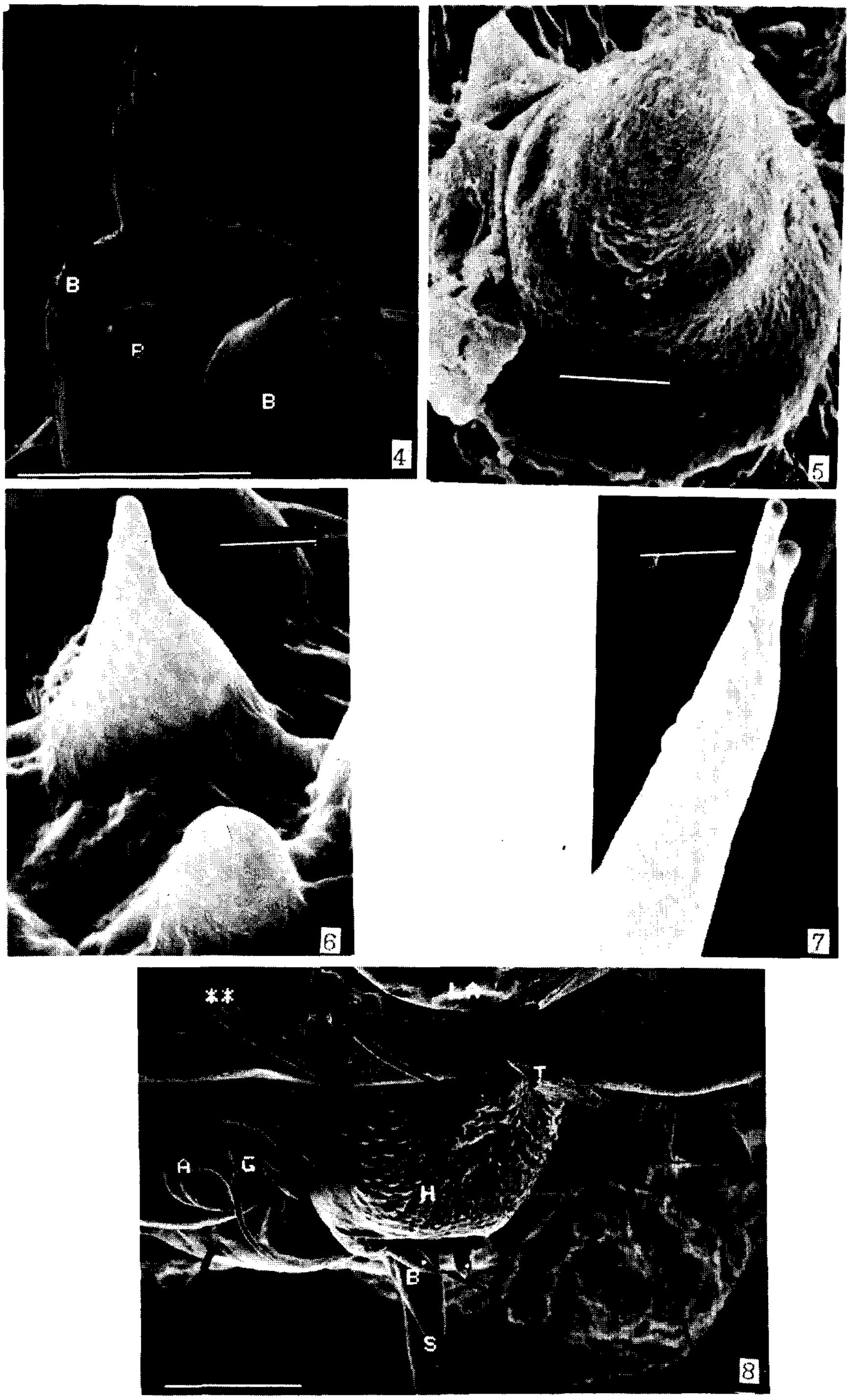

PLATE Ⅲ

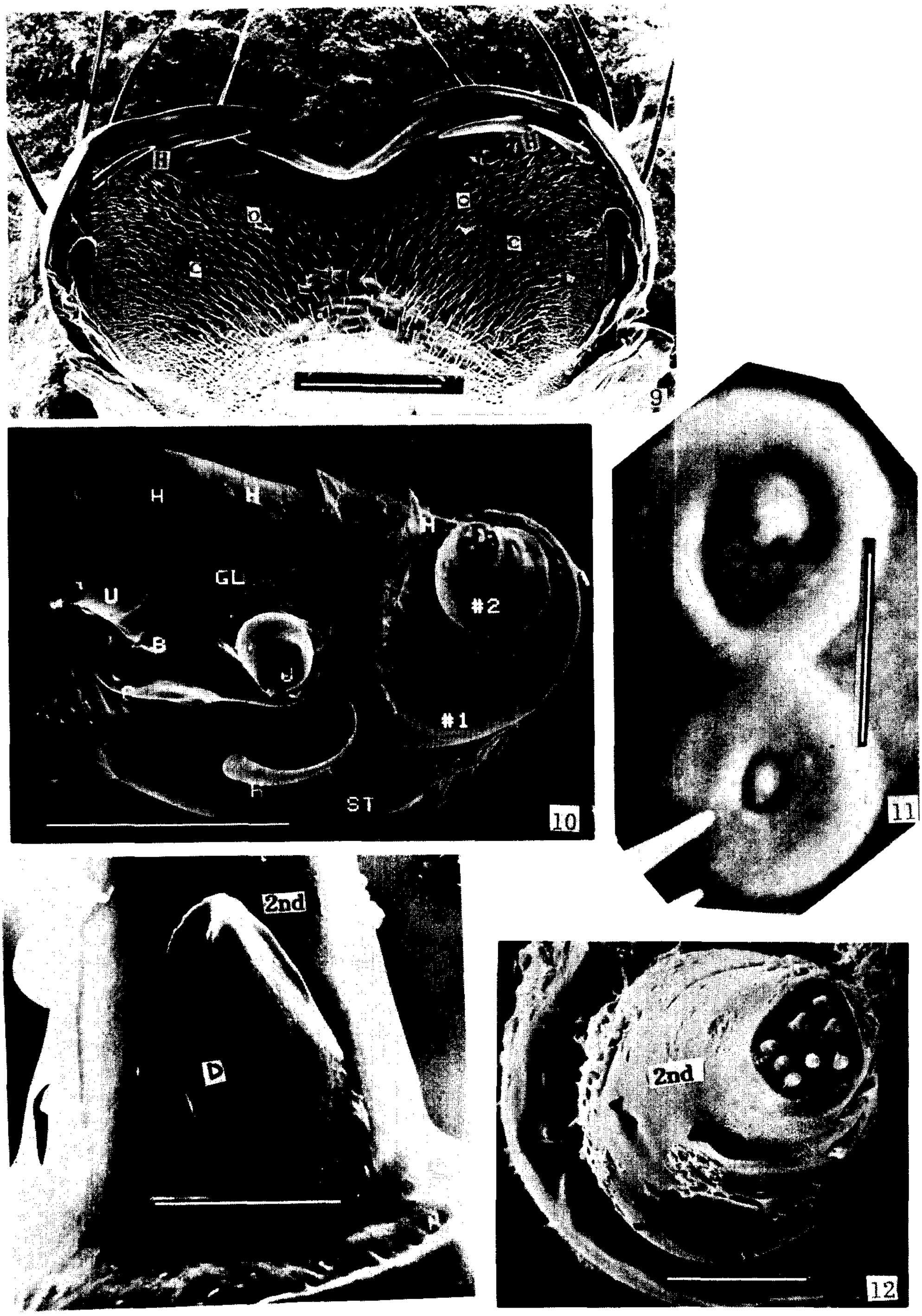

PLATE Ⅳ