Formosan Entomologist
Journal Homepage: entsocjournal.yabee.com.tw

Sensilla on the Larval Antennae and Mouthparts of Pentateucha inouei Owada et Brechlin (Lepidoptera: Sphingidae)【Research report】

絨毛天蛾幼蟲觸角及口器之感覺毛【研究報告】

Cheng-Shing Lin*
林政行*

*通訊作者E-mail : cslin@mail.nmns.edu.tw

Received: 2001/12/31 Accepted: 2002/04/09 Available online: 2002/06/01

Abstract

Sensilla on the larval antennae and mouthparts of Pentateucha inouei Owada et Brechlin were examined with a scanning electron microscope. Sensilla on the antennae and mouthparts are characterized, and their distribution is described. An attempt has been made to identify the function of the sensilla by comparing them with those of other larvae in order to understand the sensory basis of the feeding behavior of this insect.

摘要

利用掃描電子顯微鏡檢視絨毛天蛾幼蟲觸角及口器感覺毛之結構。詳細描述觸角及口器之感覺毛之特性和分佈。並與其他鱗翅目幼蟲觸角及口器之感覺毛比較，推測感覺毛之功能，以瞭解絨毛天蛾幼蟲取食行為之感應基礎。

Key words: sensilla, labium, maxilla, SEM.

關鍵詞: 感覺毛、上唇、小顎、掃描電子顯微鏡

Full Text: PDF(0.21 MB)

下載其它卷期全文 Browse all articles in archive: http://entsocjournal.yabee.com.tw

台灣昆蟲 22: 115-124 (2002)
Formosan Entomol. 22: 115-124 (2002)

Sensilla on the Larval Antennae and Mouthparts of *Pentateucha inouei* Owada et Brechlin (Lepidoptera: Sphingidae)

Cheng-Shing Lin* Department of Zoology, National Museum Natural Science, 1 Kuan-Chien Rd., Taichung, Taiwan 404, R.O.C.

ABSTRACT

Sensilla on the larval antennae and mouthparts of *Pentateucha inouei* Owada et Brechlin were examined with a scanning electron microscope. Sensilla on the antennae and mouthparts are characterized, and their distribution is described. An attempt has been made to identify the function of the sensilla by comparing them with those of other larvae in order to understand the sensory basis of the feeding behavior of this insect.

Key words: sensilla, labium, maxilla, SEM

Introduction

The sphingid genus *Pentateucha* Swinhoe was revised by Kitching *et al*. (1997). *Pentateucha curiosa* Swinhoe is distributed from eastern Nepel, northeastern India, northern Thailand and northern Vietnam. *Pentateucha stueningi* Owada et Kitching is found in southeastern China, and *P. inouei* Owada et Brechlin is distributed in Taiwan. The biology, morphology, and host plants of immature stages of *P. inouei* were reported by Lin (2000).

Numerous papers on the types of sensilla found on the cephalic appendages of various lepidopterous larvae have been published, especially focusing on the olfactory sensilla on the antennae, the maxillary palpi and galeae (Morita and Yamashita, 1961; Schoonhoven and Dethier, 1966; Stadler and Hansan, 1975; Devitt and Smith, 1982; Grimes and Neunzig, 1986a, b), the gustatory sensilla on the galeae, and palpi of the maxillae and epipharynx (Dethier, 1937; Ishikawa, 1963; Schoonhoven and Dethier, 1966; Ma, 1972; Stadler and Hanson, 1975; DeBoer *et al.*, 1977). In addition, the mechanosensory senillla found on the antennae as well as on all mouthparts have been studied (Faucheux, 1995).

So far, no available information about the sensory organs of the larva of *P. inouei* has been reported. Thus, the present study was undertaken to observe and localize the sensilla on the antennae and mouthparts of *P. inouei* in an attempt to understand the sensory basis of feeding behavior of this insect.

Materials and Methods

Female of *P. inouei* (Lepidoptera: Sphingidae) were collected from Sunken, Nantou on March 11, 1999. Eggs were

*Correspondence address
e-mail:cslin@mail.nmns.edu.tw

laid by the female and larvae were reared in the laboratory with their host plants (*Ilex formosana* Maxin). The egg, the first instar, and last instar larvae were used for SEM observations. The larvae were killed by immersing in hot water (70-80 ℃) and immediately fixed and stored in Kahle's solution (120 ml 95% ethanol, 48 ml formaldehyde, 16 ml acetic acid, 240 ml water). The mouthparts were dissected and superficially cleaned by gentle stroking with a soft brush. The tissues were sonicated briefly in a 50% ethanol solution.

The mouthparts of the insects were dehydrated in a ethanolic gradient series from 50 % to absolute. Drying was accomplished in a CO_2 critical point dryer (Hitachi CPD HCP-2). Dried tissue were then dissected and coated with gold by using a Hitachi E-1010. The coated mouthparts were examined and photographed in a scanning electron microscope (Hitachi S-3000N) at accelerating voltages of 15 kV.

Results

The head of the first instar larva is oval, smooth and hairy. It has many simple hairlike setae including long tactile setae (Fig. 1; A1, A2, A3, S1, S2, S3, SS1, SS2, SS3, L1, P1, P2, AF1, AF2, C1, and C2) and minute proprioceptor setae (Fig. 1; MD1 and MD2). Both dorsal and lateral thoracic and abdominal segments have verrucae with about 5-25 simple setae on it (Fig. 2). The epidermic surface encircling the verruca has a rugulose, rough structure consisting of numerous minute tubercles (Fig. 3).

Antennae

The antennae of the first instar larvae of *P. inouei* are short and consist of three segments. Except for the basal segment, the other segments bear sensilla (Figs. 4, 5). The medial segment bears two sensilla chaetica, C1, and C2, and three sensilla basiconia, B1, B2, and B3. Sensillum C1 is located externally, with C2 is located ventrally and close to sensillum basiconium B3 (Fig. 5). The sensilla chaetica are aporous with a socket at the base and are of various lengths. These sensilla basiconia B1 and B2 are located dorsally, sensillum basiconicum B2 is slender; both sensilla basiconia B2 and B3 are stout pegs, which have enlarged basal portions. These sensilla basiconia are multiporous.

The distal segment possesses three sensilla basiconia, B4, and B5, and B6, and one sensillum styloconicum, S1. The sensillum basiconisum B4 is a stout peg and is located dorsally. Both sensilla basiconia B5 and B6 are shorter and are located laterally. The sensillum styloconicum S1 is located ventrally and is aporous. All sensilla basconia are thick-walled, multiporous pitted sensilla. The type, number, and distribution of sensilla on the antenna of the last instar larva are similar to those of the first instar larva.

Labrum

The labrum of the first instar larva has 12 aporous socketed sensilla chaetica (K1-K12) distributed over the dorsal surface of the labrum (Fig. 4). The labrum of the last instar has a similar number of sensilla chaetica as the first instar larva. The labrum of the first instar larva covers most of the mandible, but in the last instar larvae, the mandible is almost completely exposed.

Maxilla

Each maxilla comprises two appendages; the maxillary palpus (MP) and galea (G) arise from the basal segment, cardo (CA). The base of the cardo is connected to the stipes (ST). The

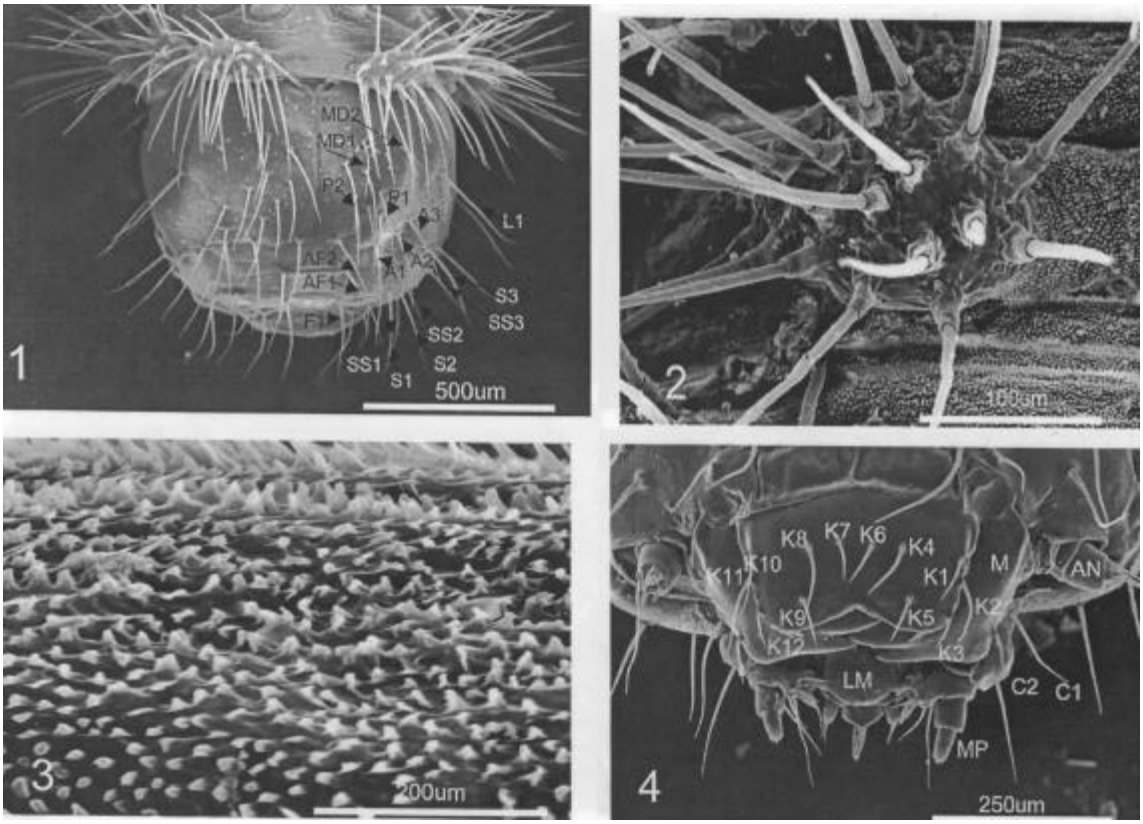

Fig. 1. Dorsal view of head of the first instar larva of *Pentateucha inouei* showing tactile setae (A1, A2, A3, S1, S2, S3, S1, S2, S3, SS1, SS2, SS3, L1, P1, P2, AF1, AF2, C1, and C2) and minute proprioceptor setae (MD1 and MD2).

Fig. 2. Dorsal view of verruca of the first instar larva of *Pentateucha inouei*.

Fig. 3. Dorsal view of the rugulose structure of the epidemic surface encircling the verruca of *Pentateucha inouei*.

Fig. 4. Ventroanterior view of the first instar larva head of *Pentateucha inouei* showing the labrum (L), sensilla chaetica (K1-12), mandible (M), labium (LM), maxillary palpus (MP), and sensilla chaetica (C1-2).

galea of the first instar larva possesses six sensilla on its distal surface: three sensilla chaetica (C1-C3) and three sensilla syloconica (S1–S3) (Figs. 6, 7). Both cardo and stipes possess one sensillum chaeticum (C4 and C5). Sensilla styloconica S1 and S2 consist of a small uniporous unsocketed peg on top of a bulbous base. Sensillum styloconium S3 is located medially and is shorter. Sensilla chaetica C4, C5, and C6 are three large-socketed, with sharply pointed pegs, and are located midventrally. All sensilla chaetica are aporous.

The maxillar palpus (MP) is two-segmented. The apical segment is long and carries eight sensilla basiconica on its distal end, one sensillum digitiformium (D) and two multiporous sensillia placodea (PM) laterally (Figs. 8, 9). The eight sensilla basiconica can be divided into three morphological groups: three apical sensilla (A), three lateral sensilla (L) and two medial sensilla (M). All these sensilla possess an apical pore. The type, number, and distribution of sensilla on the maxilla of the last instar

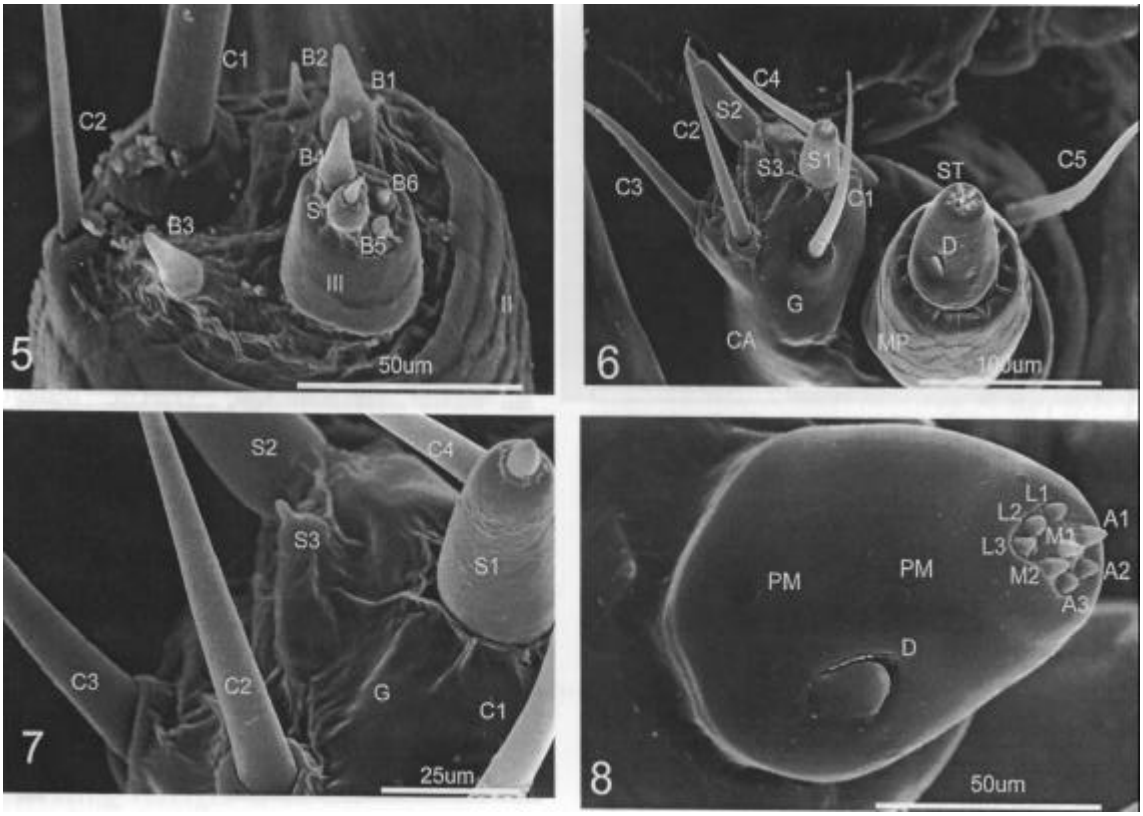

Fig. 5. Ventral view of antennal segments II and III of the first instar larva of *Pentateucha inouei* showing the sensilla chaetica (C1-3), sensillum styloconicum (S1), and sensilla basiconica (B1-6).

Fig. 6. Dorsal view of left maxilla of the first instar larva of *Pentateucha inouei* showing the galea (G), cardo (CA), stipes (ST), maxillary palpus (MP), sensilla chaetica (C1-5), and sensilla styloconica (S1-3).

Fig. 7. Enlarged dorsal view of the left maxilla of the first instar larva of *Pentateucha inouei* showing the galea (G), maxillary palpus (MP), sensilla chaetica (C1-4), and sensilla styloconica (S1-3).

Fig. 8. Dorsoposterior view of the third segment of a maxillary palpus of the first instar larva of *Pentateucha inouei* showing the apical sensilla basiconica (A1-3), medial sensilla basiconica (M1-2), lateral sensilla basiconica (L1-3), sensillum digitiformium (D), and sensilla placodea (PM).

larva are similar to those of the first instar larva.

Labium

The labial region (LM) of the first instar larva consists of two palpi and a long spinneret (S) from which silk is secreted by larvae (Fig. 10). The palpus bears two sensilla, a sensillum styloconicum (S) and a sensillum chaeticum (C). The sensillum styloconicum has a bulbous base and a pointed apical portion. The type, number, and distribution of sensilla of the labial region of the last instar larva are similar to those of the first instar larva. The shape of labial palpus is broad and flat, and the spinneret is broad and short. The prementum is granulated (Figs. 11, 12).

Mandible

The mandible (M) of the first instar

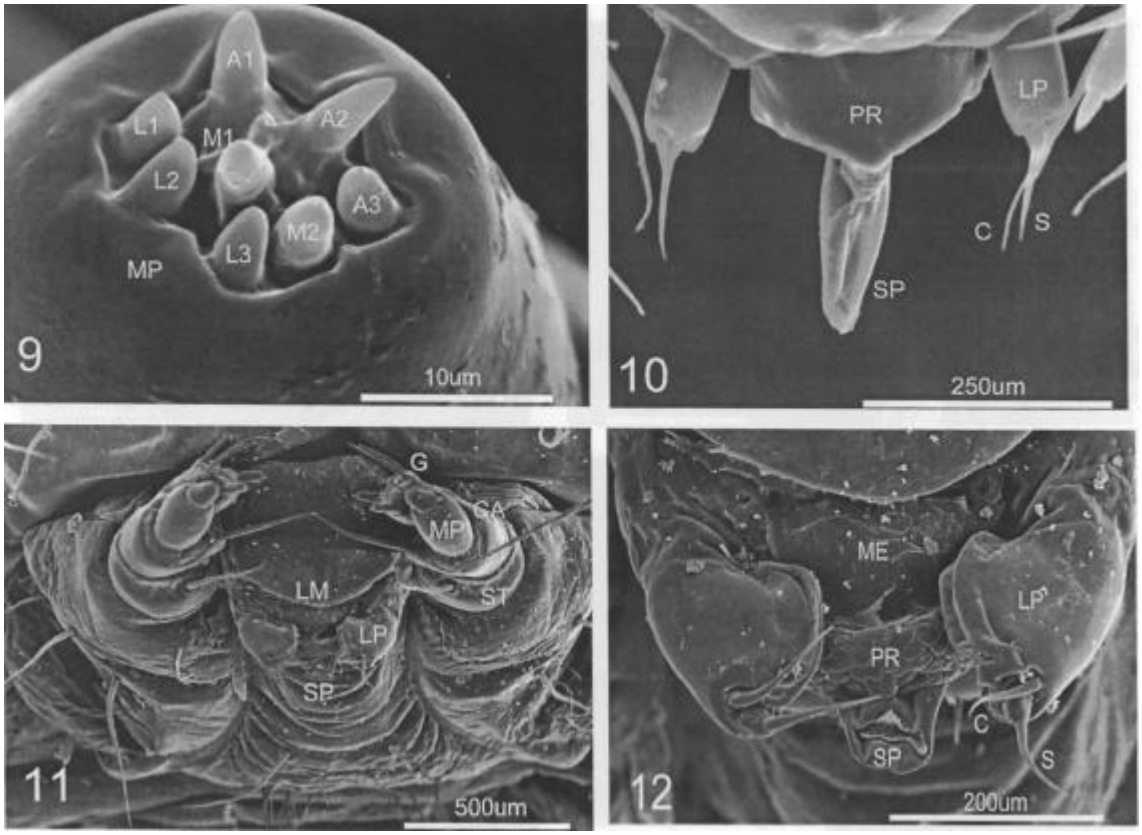

Fig. 9. Close dorsal view of the third segment of a maxillary palpus of *Pentateucha inouei* showing the apical sensilla basiconica (A1-3), medial sensilla basiconica (M1-2), and lateral sensilla basiconica (L1-3).

Fig. 10. Dorsal view of the labium of the first instar larva of *Pentateucha inouei* showing the spinneret (SP), labial palpus (LP), sensillum chaeticum (LP), and sensillum styloconicum (S).

Fig. 11. Dorsal view of the labium of the last instar larva of *Pentateucha inouei* showing the spinneret (SP), labium (LM), labial palpus (LP), maxillary palpus (MP), galea (G), cardo (CA), and stipes (ST).

Fig. 12. Close dorsal view of the labium of the last instar larva of *Pentateucha inouei* showing the spinneret (SP), prementum (PR), mentum (ME), labial palp (LP), sensillum chaeticum (C), and sensillum styloconicum (S).

larva contains two aporous sensilla chaetica (Figs. 5, 13, 14). These sensilla are present at the tips of or between the molar cusps. The type, number, and distribution of the mandible of the last instar larva is similar to those of the first instar larva. The mandible incisor region of the first instar larva is pointed and sharp. The molar region of the first instar larva is less developed than those of the intermediate and last instar larvae. The molar region of the last instar larvae is well developed and has two pointed teeth (Fig. 15)

Discussion

The first instar larva of *P. inouei* is rather hairier than the other instar larva or other species of sphingids. The sphingid larva has a relatively naked appearance and some have short or stubby setae (Stehr, 1987). It is an exposed feeder and is heavily parasitized and preyed on. A hairy rugulose appearance and simple cryptic coloration

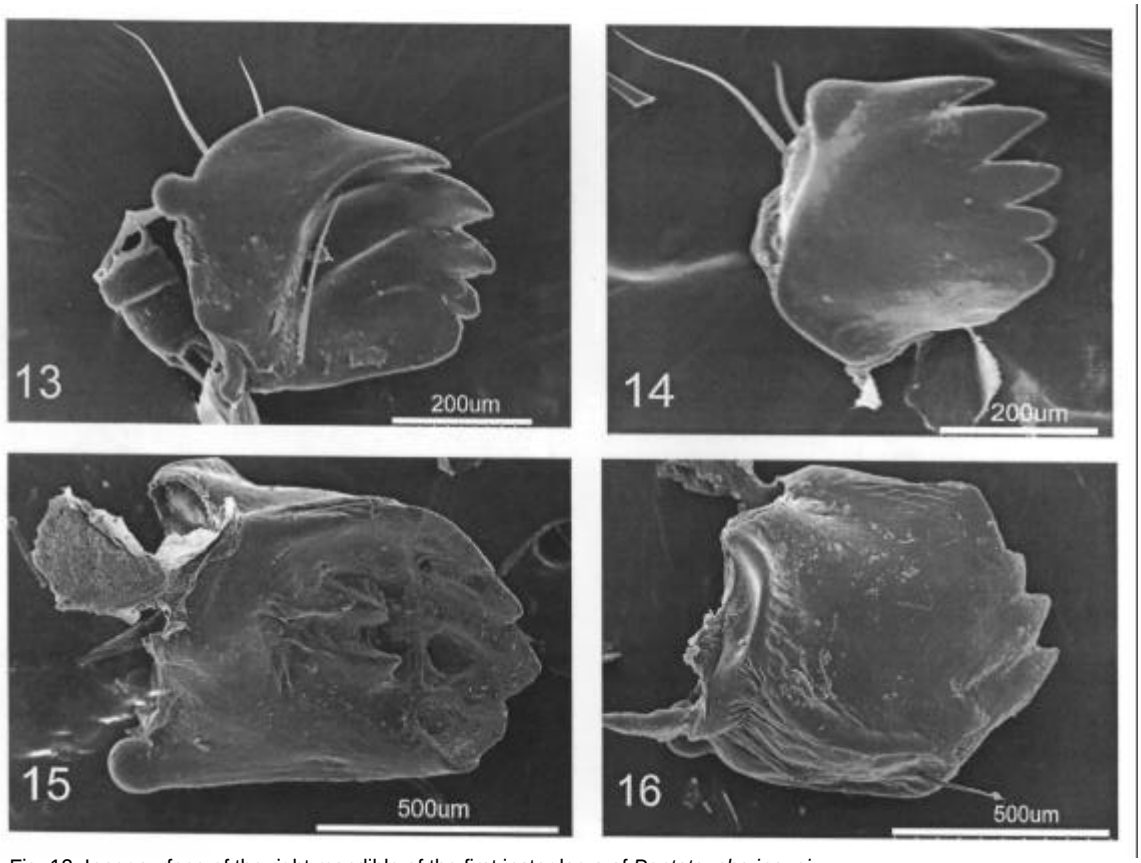

Fig. 13. Inner surface of the right mandible of the first instar larva of *Pentateucha inouei*.
Fig. 14. Outer surface of the left mandible of the first instar larva of *Pentateucha inouei*.
Fig. 15. Inner surface of the right mandible of the last instar larva of *Pentateucha inouei*.
Fig. 16. Outer surface of the left mandible of the last instar larva *Pentateucha inouei*.

that matches the background are means of adaptation. According to collection records of *P. inouei*, the adults emerge in alpine forests at middle elevations (about 2000 to 3000 m) during February and March. Larvae are exposed in the rather cold environment. Dense hairs may reduce evaporative water loss and prevent heat loss during cold weather in the mountains. Sensilla provide temperature, humidity, and tactile monitoring for orientation and protection (Stehr, 1987).

The types, numbers, and distribution of sensilla on the larval antennae of *P. inouei* are similar to those of other lepidopterous larvae. The two aporous sensilla chaetica are on the second segment. Sensilla chaetica of *P inouei* larvae are longer but fewer in number than in the leaf roller (Lin, 1997). These sensilla are innervated by one mechanosensory cell and are adapted for the reception of tactile stimuli including air currents, vibrations of the substrate, and shocks sensed by the sensilla from exploratory movements of the antennae (Kent and Hildebrand, 1987; Faucheux, 1999).

Pentateucha inouei larva feed specifically on leaves of *Ilex formosana* Maxin in the family Aguifoliaceae. The

olfactory and taste cues for food selection are very important for this insect. Three multiporous sensilla basiconica of the antennae are olfactory receptors (Schoonhoven and Dethier, 1966; Hanson and Dethier, 1973; Dethier, 1980). In the Lepidoptera, the antennal sensilla basiconica play a very important role in olfactory discrimination between different plants. One aporous sensillum styloconicum may be innervated by cold sensitive receptors (Faucheux, 1999).

Sensilla on the larval mouthparts of *P. inouei* are similar to those of other lepidopterous larvae, with several differences in external appearance, location, and number of these sensilla. The location of the labral sensilla chaetica is unique for certain species of sphingids and used for species identification (Zhu and Wang, 1997). The labral sensilla consist of two aporous types. The outer surface of the labrum has 12 aporous sensilla chaetica whose function is mechanosensory. The labral sensilla are innervated by a single bipolar neuron in *Choristoneura fumiferana* (Albert, 1980) and *M. sexta* (Kent and Hildebrand, 1987).

Aporous sensilla chaetica are on the distal part of galea of *P. inouei* larvae are adapted for reception of tactile stimuli. Sensilla chaetica on the distal part of the cardo and on the lateral part of stipes are proprioceptors in response to the movement of the mandible (Faucheux, 1999). The uniporous sensilla styloconica are tasete-tactile sensilla. During feeding, they are in contact with plant sap from the host plant. They respond to mechanical stimuli, water, glycosides, sugars, and other feeding stimulants. The medial and lateral sensilla styloconica have different response patterns. In all lepidopterous larvae, the sensilla styloconica play the major role in discriminating between plant constituents in the biting response (Faucheux, 1999). These sensilla styloconia play an important function in food recognition (Ishikawa *et al*., 1969).

The uniporous sensilla basiconica are on the tip of the terminal maxillary palpus of *P. inouei* larvae have a gustatory function in perceiving specific phagostimulants and feeding deterrents. A long finger like sensillum digiformium on the side of the apical segment is either sensitive to mechanical forces such as contact or vibratory stimuli or hygro- and thermo-sensitive. Two multiporous sensilla placodea consist of shallow depressions of the cuticle, located near the sensillum digiformium are probably olfactory receptors.

An aporous sensillum styloconicum and aporous sensillum chaeticum, located at the tip of the labial palpus of *P. inouei*, may be mechanosensory, and sensitive to distortions over the entire length of the sensillum.

Two aporous sensilla chaetica of different lengths located on they lateral surface of each mandible of *P. inouei* larvae are mechanoreceptors. These sensilla are innervated by a pair of dendrites extending through a canal in the sensillum and ending close beneath the surface in *Haritlodes derogatus* and are mechanoreceptors (Lin, 1997). These sensilla are present at the tips of the incisor cusps or between molar cusps. These receptors help to monitor the hardness of food and modulate the power output of the adductor muscles (Zacharuk and Albert, 1978).

Acknowledgments

Thanks are given to W. T. Yang, a technician, and L. H. Chang, the former project assistant of the Department of Zoology, National Museum of Natural Science for assistance with rearing insects. Dr. C. Chang, Departmernt of Botany, National Museum of Natural Science assisted with taking the SEM

photo- graphs. Sincere thanks are given to the two anonymous reviewers who provided valuable comments on this manuscript.

References

Albert, P. J. 1980. Morphology and innervation of mouthpart sensilla in larvae of the spruce budworm, *Choristoneua fumiferana* (Clem.) (Lepidoptera: Tortricidae). Can. J. Zool. 58: 842-51.

Baker, G. T. 1990. Morphology of eyes and sensory receptors of larval and adult stages of *Thyridopteryx sphemerae-formis* Haworth (Lepidoptera: Hypo-nomeutoidea). Ann. Soc. Entomol. Fr. (N. S.) 25: 163-70.

De Boer, G. V., G. Dethier, and L. M. Schoonhover. 1977. Chemoreceptors in the peroral cavity of the tobacco hornworm, *Manduca sexta* and their possible function in feeding behavior. Entomol. Exp. Appl. 21: 287-298.

Dethier, V. G. 1987. Gustation and olfaction in lepidopterous larvae. Biol. Bull. 72: 7-23.

Dethier, V. G. 1941. The function of the antennal receptors in lepidopterous larvae. Biol. Bull. 80: 403-14.

Devitt, B. D., and J.J.B. Smith. 1982. Morphology and fine structure of mouthpart sensilla in the dark-sided cutworm *Euxoa messoria* (Harris) (Lepidoptera: Noctuidae). Int. J. Insect Morphol. Embryol. 11: 255-70.

Faucheux, M. J. 1995. Sensilla on the larval antennae and mouthparts of the European sunflower moth, *Homoeosoma nebulella* Den and Schiff. (Lepidotpera: Pyralidae). Int. J. Insect Morphol. Embryol. 24: 391-403.

Faucheux, M. J. 1999. Biodiversité et unité des organs sensoriels des insects Lépidoptères. Supp. Hors Serie1999-Bulletin de la Société des Sciences Naturelles de l'Ouest de la France. 294 pp.

Grimes, L. R., and H. H. Neunzig. 1968a. Morphological survey of the maxillae in last stage larvae of the suborder Ditrysia (Lepidoptera) Palp. Ann. Entomol. Soc. Am. 79: 491-509.

Grimes, L. R., and H. H. Neunzig. 1968b. Morphological survey of the maxillae in last stage larvae of the suborder Ditrysia (Lepidoptera) Mesal lobes (Laciniogaleae). Ann. Entomol. Soc. Am. 79: 510-26.

Ishikawa, S. 1963. Response of maxillary chemoreceptors in the larva of the silkworm, *Bombyx mori*, to stimulation of carbohydrates. J. Cell. Comp. Physiol. 61: 99-107.

Kent, K. S., and J. G. Hildebrand. 1987. Cephalic sensory pathways in the central nervous system of larval *Manduca sexta* (Lepidoptera: Shingidae). Philos. Trans. R. Soc. Lond. B. 315: 1-36.

Kitching, I. J., M. Owada, and R. Brechlin. 1997. A revision of the genus *Pentateucha* (Lepidoptera: Sphingidae), with the description of two new species from eastern China and Taiwan. Tinea 15: 79-93.

Kitching, I. J., and J. M. Cadiou. 2000. Hawkmoths of the World – An Annotated and Illustrated Revisionary Checklist (Lepidoptera: Sphingidae). The Natural History Museum, London. 226 pp.

Lin, C. S. 1997. Sensilla on the larval antennae and mouthparts of cotton leaf-roller, *Haritalodes derogatus* Fabricius (Lepidoptera: Pyralidae). Chinese J. Entomol. 17: 92-99.

Lin, C. S. 2000. Larval morphology and life history of three sphingid moths (Lepidoptera: Sphingidae) of Taiwan. Chinese J. Entomol. 20: 89-95.

Ma, W. C. 1972. Dynamics of feeding responses in *Piereis brassicae* Linn. As a function of chemosensory input: a behavioral, ultrastructural and electrophysiological study. Meded.

Landbouwhogesch Wageningen 72: 1-162.

Morita, H., and S. Yamashita. 1961. Receptor potentials recorded from sensilla basiconica on the antennae of the silkworm larvae, *Bombyx mori*. J. Exp. Biol. 38: 851-61.

Schoonhoven, L. M., and V. G. Dethier. 1966. Sensory aspects of host plant discrimination by lepidopterous larvae. Arch. Neerl. Zool. 16: 497-530.

Stadler, E., and F. F. Hanson. 1975. Olfactory capabilities of the "gustatory" chemoreceptors of the tobacco hornworm larvae. J. Comp. Physiol. 104: 97-102.

Stehr, F. W. 1987. Immature Insects. Kendall/Hunt Publishing Company, Dubuque, Iowa. 754 pp.

Zacharuk, R. Y., and P. J. Albert. 1987. Ultrastructure and function of scolopophorous sensilla in the mandible of an elaterid larva (Coleoptera). Can. J. Zool. 56: 246-259.

Received Dec. 31, 2001
Accepted April 9, 2002

絨毛天蛾幼蟲觸角及口器之感覺毛

林政行*　國立自然科學博物館動物組　臺中市館前路一號

摘　　要

利用掃描電子顯微鏡檢視絨毛天蛾幼蟲觸角及口器感覺毛之結構。詳細描述觸角及口器之感覺毛之特性和分佈。並與其他鱗翅目幼蟲觸角及口器之感覺毛比較，推測感覺毛之功能，以瞭解絨毛天蛾幼蟲取食行為之感應基礎。

關鍵詞：感覺毛、上唇、小顎、掃描電子顯微鏡。