# Occurrence of the Latero-subapical Labial Sensillum in *Borysthenes maculata* and *Andes marmorata* (Hemiptera: Fulgoromorpha: Cixiidae)[1]

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J. Entomol. Sci. 40(4): 428-437 (October 2005)

**Abstract** A peg-like structure, found on each lateral side of the distal segment of the labium, close to the labial apex, in two cixiid planthopper species *Borysthenes maculata* (Matsumura) and *Andes marmorata* (Uhler) (Hemiptera: Fulgoromorpha: Cixiidae), is reported for the first time with scanning electron micrograph. It is an elongate, peg-like structure hidden in an elongate, narrow, shallow cavity parallel to the longitudinal axis of the labium. In *B. maculata*, the peg, being about 82 µm proximal to the labial tip, is about 27.6-29.4 µm long and 6.8-7.6 µm wide with a blunt apex. The peg in *A. marmorata*, being about 60 µm proximal to the labial tip, is distinctly short and narrow and is about 10.2-12.0 µm long, tapering gradually from a basal width of about 2.7 µm to a blunt apex of 0.88 µm wide. The structure, being two in number (one at each lateral side of the labium), is present in both male and female adults. Light microscopic survey shows that this structure is common in cixiid species. It also is present in species of the relatively primitive fulgoromorphan families, e.g., Achilixiidae, Delphacidae and Achilidae, but it is absent in other relatively advanced fulgoromorphan families, e.g., Fulgoridae, Dictyopharidae, Lophopidae and Eurybrachidae. It is regarded as a homologous structure with the previously described 'multi-lobed sensillum' in Delphacidae and is herein named 'latero-subapical labial sensillum'. The function of the structure is not clear but it seems likely that it is a sensory structure. The phylogenetic significance of this structure is briefly discussed.

**Key Words** Labium, sensillum, morphology, ultrastructure, SEM, Cixiidae, Fulgoromorpha, Hemiptera

The Cixiidae, containing almost 2200 described species in about 146 genera (Metcalf 1936, Holzinger et al. 2002), is one of the 16-20 families currently recognized in the planthopper infraorder Fulgoromorpha (Hemiptera: Auchenorrhyncha). The group is cosmopolitan, but most species occur in temperate and tropical regions. Cixiids are all phytophagous. Both adults and nymphs suck juices from the phloem of their host plants with the piercing and sucking mouthparts. The cixiid adults usually feed on the leaves and stems of a variety of plants whereas their nymphs feed on roots, at or below ground level.

The cixiids, like other hemipteran insects, have a highly modified piercing and sucking labium or rostrum. The labium is a modified stout sheath structure that holds

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and guides the two mandibulary and two maxillary stylets (piercing and sucking tubular organs). Previous studies of various hemipteran insects (Hansen 1890, Cobben 1978) have shown that the tip of the labium is armed with many external sensory structures, which have dual contact chemosensory and mechanosensory functions, thus aiding in host plant selection and feeding (Cobben 1978, Hatfield and Frazier 1980, Foster et al. 1983a,b, Backus 1985, 1988). Investigations on the structure and function of the labial tip sensilla are of interest, because their location places them in direct contact with the food source during the events of host location and feeding (Hatfield and Frazier 1980). Unfortunately, there are very few studies on the sensory organs at the tip of the labium of cixiid species (Cobben 1978).

In the course of a general study on Cixiidae morphology, I encountered a previously-undetected, peg-like structure on the lateral surface near the tip of the labium in *Borysthenes maculata* (Matsumura), *Andes marmorata* (Uhler), and other cixiid species. This structure has never been previously reported in any cixiid species. A broad survey of some selected representative species from other fulgoromorphan families showed that this structure is also present in some relatively primitive fulgoromorphan groups, e.g., Achilixiidae, Delphacidae and Achilidae, but it is absent in the relatively advanced families, e.g., Fulgoridae, Dictyopharidae, Tropiduchidae, Flatidae, Lophopidae and Eurybrachidae (see Asche 1988, Emeljanov 1990). Herein, I provide a description of the ultrastructural morphology, number and distribution of this labial structure in *B. maculata* and *A. marmorata*, document its distribution in Cixiidae and other fulgoromorphan families, and provide a brief discussion on its phylogenetic significance.

## Materials and Methods

**Specimens studied.** Dry, pinned museum specimens were examined from the American Museum of Natural History, NY, USA (AMNH); Bernice P. Bishop Museum, Honolulu, HI, USA (BPBM); The Natural History Museum, London, UK (BMNH); California Academy of Sciences, San Francisco, CA, USA (CAS); Institute of Zoology, Chinese Academy of Sciences, Beijing, China (IZCAS); Department of Entomology Insect Collection, NC State University, Raleigh, NC, USA (NCSU); and [US National Museum] National Museum of Natural History, Smithsonian Institution, WA, DC, USA (USNM).

Specimens of the following species were examined at higher magnifications with scanning electron microscopy (SEM): *B. maculata* (Matsumura) (2M, 3F, China: Fujian, Chong'An, XingCun, SanGang; IZCAS), *A. marmorata* (Uhler) (2F, China: Beijing, Sanbao; IZCAS), and *Betacixius obliquus* Matsumura (2M, 2F, China: Sichuan; IZCAS). Specimens of the following species were examined under light microscopy: Cixiidae, Borystheninae: *Borysthenes strigipennis* Distant (1M, 1F, NE India; BMNH); Cixiidae, Bothriocerinae: *Bothriocera* sp. (1F, Mexico; AMNH); Cixiidae, Cixiinae: *Betacixius* sp. (2M, 2F, China: Fujian; IZCAS); *Kuvera* sp. (2F, China: Beijing; IZCAS); *Myndus* sp. (2F, USA: New York; AMNH); *Oecleopsis sinicus* (Jacobi) (1M, 2F, China: Fukien; CAS, IZCAS); *Oliarus horishanus* Matsumura (1F, China: Taiwan; IZCAS); *O. kurseongensis* Distant (1M, 1F, China; IZCAS); *O. nigronervatus* Fennah (1F, China: Fujian; IZCAS); *Macrocixius giganteus* Matsumura (1M, Japan; IZCAS); *Pentastiridius apicalis* (Uhler) (2M, 2F, China: Beijing; IZCAS); *Reptalus quadricinctus* (Matsumura) (2M, 2F, China: Hebei; IZCAS). Achilixiidae: *Benna* sp. (2F, [Philippines]: Luzon, Mt. Makiling; USNM). Delphacidae: *Nilaparvata lugens* (Stål) (2M, 2F, China: Jiangsu; IZCAS); *Ugyops zoe* Fennah (1M, 1F, China: Hainan; NCSU). Achilidae: *Rhotala formosana* Matsumura (1F, Taiwan; NCSU); *Rhotala* sp. (1M, 4F, NE New Guinea; BPBM). Derbidae: *Diostrombus politus* Uhler (2M, 2F, China: Sichuan; IZCAS); *Zoraida pterophoroides* (Westwood) (2M, 2F, China: Sichuan; IZCAS). Fulgoridae: *Limois kikuchii* Kato (4M, 4F, China: Beijing; IZCAS); *Penthicodes atomaria* (Walker) (1M, 1F China: Yunnan; IZCAS); *Zanna chinensis* (Distant) (2M, 4F, China: Yunnan; IZCAS). Dictyopharidae: *Dichoptera hyalinata* (F.) (1M, 1F, China: Hainan, Guangxi; IZCAS); *Saigona fulgoroides* (Walker) (4M, 4F, China: Fujian; IZCAS). Tropiduchidae: *Mesepora onukii* (Matsumura) (2M, 2F, China: Guangdong; IZCAS); *Padanda gressitti* Fennah (2M, 2F, China: Sichuan; IZCAS). Flatidae: *Cryptoflata guttularis* (Walker) (1M, 1F, China: Fujian; IZCAS); *Phromnia intacta* (Walker) (2M, 2F, China: Yunnan; IZCAS). Lophopidae: *Lacusa fuscofasciata* (Stål) (1M, 1F, China: Yunnan; IZCAS); *Pyrilla perpusilla* (Walker) (1M, 1F, India; CAS). Eurybrachidae: *Eurybrachys tomentosa* (F.) (2M, 2F, S. India; BPBM); *Guentheria formosa* Lallemand (1M, 3F, China: Fujian; IZCAS); *Thessitus insignis* (Westwood) (2M, 2F, S. India; BPBM).

**SEM preparation.** For scanning electron microscopy (SEM) study, the labium of the female adults was first removed from the body, cleaned with 10% KOH, then washed with distilled water, mounted on aluminum stubs with double-sided sticky tape, air-dried at room temperature, and coated with gold-palladium using a sputter coater. Observations and photographs were made with a JEOL JSM-6301F (Japanese Electronic and Optical Ltd., Tokyo, Japan) scanning electron microscope, operated at accelerating voltage of 15 kV.

**Terminology.** Morphological terminology largely follows that of Kramer (1950) and O'Brien and Wilson (1985).

## Results and Discussion

**Gross morphology of mouthparts.** The mouthpart morphology of *B. maculata* and *A. marmorata* is generally similar to that of other hemipteran insects (Snodgrass 1935). The mouthpart includes the labrum, labium and a stylet fascicle consisting of two mandibulary and two maxillary stylets. The mouthpart complex is recognized as a tubular structure, the labium (also known as rostrum, proboscis or beak). The labium is three-segmented. The proximal segment is shortest and is partially obscured by the overlapping clypellus. The distal and middle segments are distinctly elongate with the distal segment being slightly shorter than the middle segment.

The total length of the labium of *B. maculata* and *A. marmorata* is about 2625 μm and 2500 μm, respectively. The entire labium is relatively and evenly broad with the distal segment narrowing to a circular tip apically (Figs. 1A, 2A). The labial tip is heavily sclerotized and forms a hemispherical, terminal, tripartite plate consisting of 2 lateral lobes separated by the dorsal stylet groove, and an apical plate; each lateral lobe possessing a terminal field of about 10 basiconic sensilla (Fig. 2A, also see Liang 2001a). The main functions of these basiconic sensilla are chemosensory and mechanosensory (Zacharuk 1980, Keil and Steinbrecht 1984).

**Description of the latero-subapical labial sensillum.** In *B. maculata* and *A. marmorata*, the surface of the lateral side of the labium is sparsely covered with moderately long hair-like setae (Fig. 1A,B). When carefully examined under light microscopy, a very small, slender, elongate pit area can be seen on the surface of the each lateral side of the distal segment of the labium close to the labial apex (Fig.

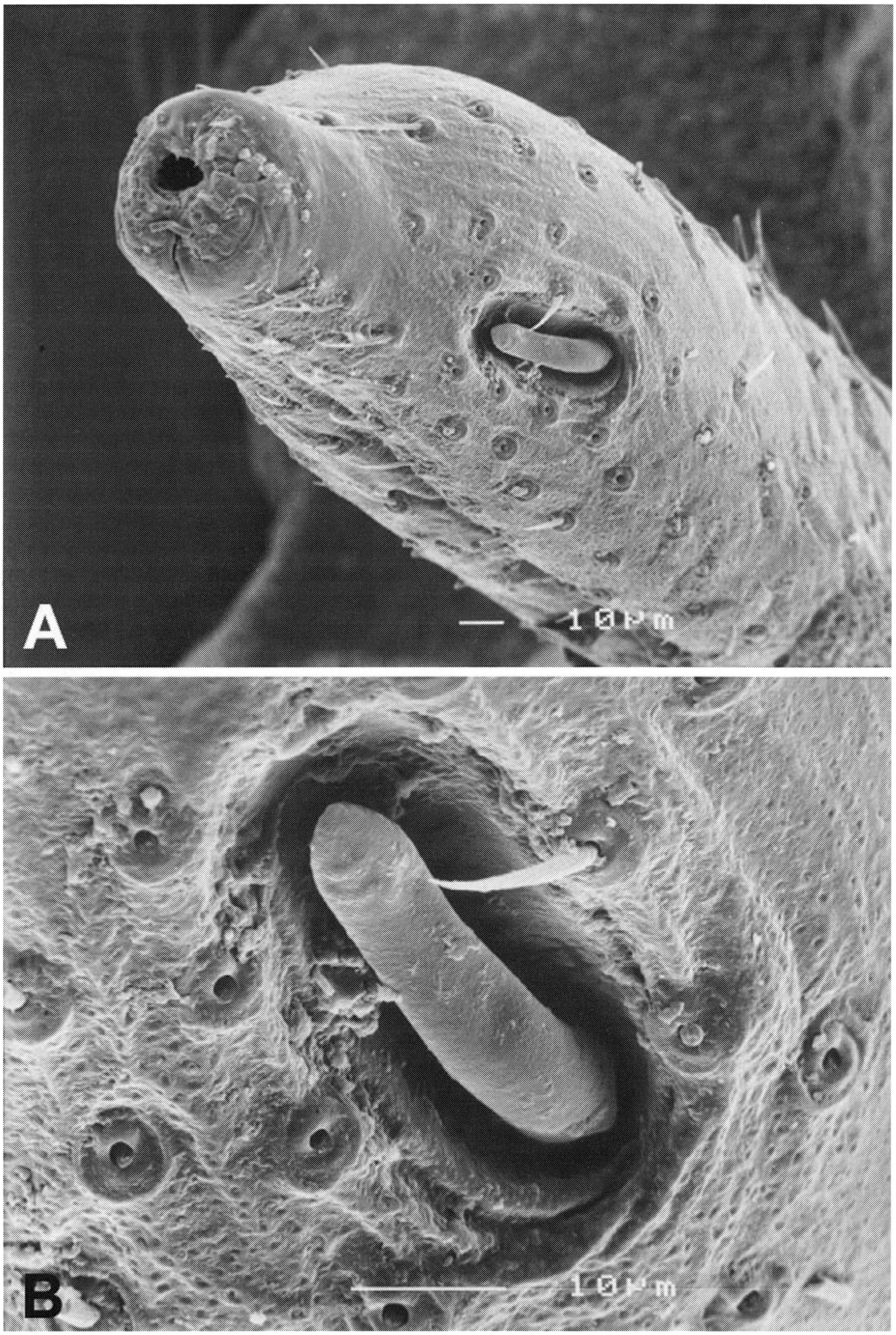

Fig. 1. Scanning electron micrographs of *Borysthenes maculata* (Matsumura) (SE China: Fujian: Chongan): A, distal tip of labium, lateral view, showing the position of the latero-subapical labial sensillum; B, latero-subapical labial sensillum.

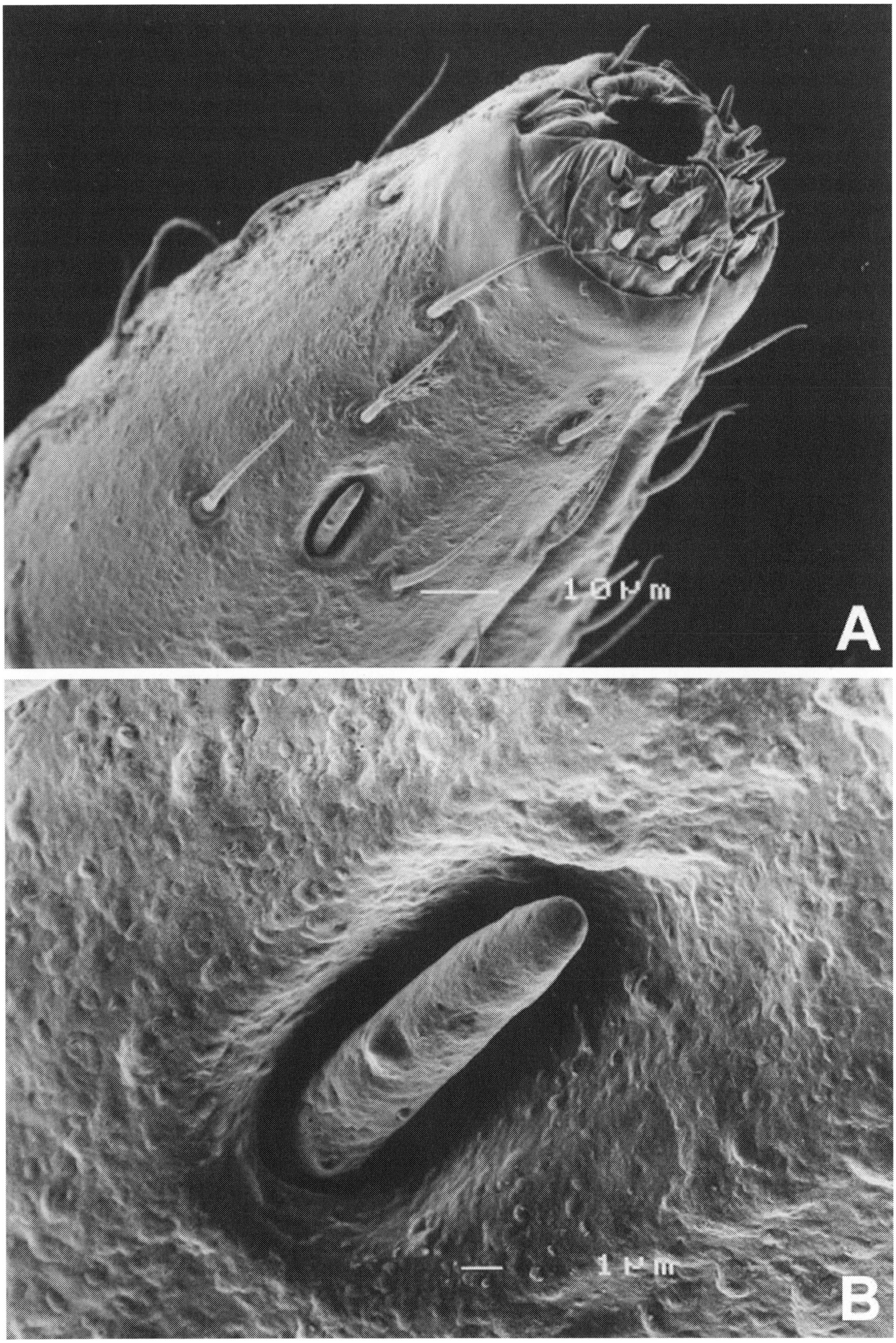

Fig. 2. Scanning electron micrographs of *Andes marmorata* (Uhler) (China: Beijing): A, distal tip of labium, lateral view, showing the latero-subapical labial sensillum; B, latero-subapical labial sensillum.

1A,B). The pit area is present in both male and female adults with one at each lateral side of the labium.

Scanning electron microscopic examination of the pit area showed that it is composed of an elongate, shallow cavity in which a slender, elongate, peg-like structure is set (Fig. 1A,B). The cavity and the enclosed peg-like structure are parallel to the longitudinal axis of the labium. The peg, being in a prostrate position, is attached proximally and extends toward the apex of the labium.

In *B. maculata*, the peg is relatively broad, flat, and somewhat depressed. It is approximately 27.6-29.4 μm long and 6.8-7.6 μm wide with a blunt apex and is about 82 μm from the labial tip (Fig. 1A,B). In *A. marmorata*, the peg is distinctly short and narrow and is about 10.2-12.0 μm long. It tapers gradually from a basal width of about 2.7 μm to a blunt apex of about 0.88 μm in width, and is about 60 μm from the labial tip (Fig. 2A,B). There are no variations in the peg morphology between the males and the females.

Light microscopy showed that the peg-like structure occurs in many cixiid species (see Table 1). In my literature search I was unable to locate references for such a structure or a similar structure on the labium in any cixiid species. It is obviously an overlooked structure in Cixiidae.

A light microscopy survey of the infraorder Fulgoromorpha showed that this structure is also present in species of some relatively primitive fulgoromorphan families, e.g., Delphacidae, Achilixiidae and Achilidae, but it is not seen in the selected representative species from the relatively advanced fulgoromorphan families, e.g., Fulgoridae, Dictyopharidae, Tropiduchidae, Flatidae, Lophopidae and Eurybrachidae (see Table 1; see also Asche 1988, Emeljanov 1990).

## Discussion

Sōgawa (1977) reported a pair of labial palpus-like structures on the lateral surface of the labium near labial tip in rice brown planthopper, *Nilaparvata lugens* (Stål) (Fulgoromorpha: Delphacidae), based on a light microscopy study. He described and illustrated the structure and called it the "labial palpi". Later Sōgawa (1981) published the scanning electron microscopic micrographs of this structure. It showed that the structure has two major and 8-10 minor porous branches. Foster et al. (1983a) redescribed the ultrastructural morphology of this structure and called it a 'multi-lobed sensillum' as he believed that it is a sensory receptor. Based on his unpublished observation, Foster et al. (1983) noted that this structure is also present on the labium of other delphacid species. Since the work of Sōgawa (1977, 1981) and Foster et al. (1983a,b), this structure has never been mentioned in the literature.

The peg-like structure found here in *B. maculate, A. marmorata,* many other cixiids and other fulgoromorphan species as well as the "multi-lobed sensillum" found in *N. lugens* (Sōgawa 1977, 1981; Foster et al. 1983a) are similar in external gross morphology, number and position, and they seem very likely a homologous structure. To unify the morphological terminology within the Fulgoromorpha, I here tentatively name this structure in Fulgoromorpha the latero-subapical labial sensillum (see the discussion on the possible function of this structure below).

It is necessary to note that a similar structure was reported on the lateral area of distal-most tip of labium of the bed-bug *Cimex hemipterus* (Hemiptera: Cimicidae) (see Singh et al. 1996, Figs. 3B, 3E). Singh et al. (1996) called the structure in *C. hemipterus* a baton-shaped structure. Whether this baton-shaped structure is ho-

**Table 1. The occurrence of the latero-subapical labial sensillum within the Fulgoromorpha**

| Taxa (species) | Origin | Latero-subapical labial sensillum |
|---|---|---|
| Cixiidae | | |
| Borystheninae | | |
| *Borysthenes maculata* | China | Present |
| *Borysthenes strigipennis* | NE India | Present |
| Bothriocerinae | | |
| *Bothriocera* sp. | Mexico | Present |
| Cixiinae | | |
| *Andes marmorata* | China | Present |
| *Betacixius obliquus* | China | Present |
| *Betacixius* sp. | China | Present |
| *Kuvea* sp. | China | Present |
| *Macrocixius giganteus* | China | Present |
| *Myndus* sp. | United States | Present |
| *Oecleopsis sinicus* | China | Present |
| *Oliarus horishanus* | China | Present |
| *O. kurseongensis* | China | Present |
| *O. nigronervatus* | China | Present |
| *Pentastiridius apicalis* | China | Present |
| *Reptalus quadricinctus* | China | Present |
| Axchilixiidae | | |
| *Benna* sp. | Philippines | Present |
| Delphacidae | | |
| *Nilaparvata lugens* | China | Present |
| *Ugyops zoe* | China | Present |
| Achilidae | | |
| *Rhotala formosana* | China | Present |

mologous with the latero-subapical labial sensillum in the Fulgoromorpha or whether they are convergent developments is not clear and needs further future investigation.

The function of the peg-like structure found here on labium in *B. maculata* and *A. marmorata* and other fulgoromorphan species is not known. Possible hypotheses concerning its functional significance are olfactory or mechanoreceptive because the peg-like basiconic sensilla are mainly chemosensory and mechanosensory (Zacharuk 1980, Keil and Steinbrecht 1984). Sōgawa (1977, 1981) believed that the multilobed sensillum in *N. lugens* is a sensory receptor. Foster et al. (1983a,b) suggested two possible functions, olfaction or hygroreception, for the multilobed sensillum in *N. lugens*. He noted that the multilobed sensilla in *N. lugens* may serve as humidity detectors because experiments by Saxena et al. (1974) have shown that the rice brown planthopper is attracted toward regions of high humidity, and because the gross morphology of the multilobed sensilla resembles that of the branched humidity detectors found on the antennae of some coleopteran beetles (Roth and Willis 1951).

Although the Cixiidae is generally assumed to be a monophyletic group, few synapomorphies of the group are known (Asche 1988). In addition, the phylogenetic relationships of Cixiidae to other families within Fulgoromorpha are also still not settled. Asche (1988) considered that Cixiidae and Delphacidae are a pair of sister family group within Fulgoromorpha. However, Emeljanov (1990) believed that Cixiidae is the sister group of other fulgoromorphan families except Tettigometridae. Investigations on new morphological character systems and more robust cladistic analyses are needed to solve these problems.

The latero-subapical labial sensillum in Cixiidae, Delphacidae, Achilixiidae and Achilidae species may represent an apomorphic character as this structure has not been found in the species of many other fulgoromorphan families, including Derbidae, Fulgoridae, Dictyopharidae, Tropiduchidae, Flatidae, Lophopidae and Eurybrachidae. If this structure proves to be a real apomorphy, it will support the monophyly of a clade comprising Cixiidae, Delphacidae, Achilixiidae and Achilidae. This is compatible with Asche's (1988) conclusion that the Cixiidae and Delphacidae are a pair of sister family group within the Fulgoromorpha and also supports Liang's (2001b) suggestion to include Achilixiidae within Cixiidae based on the presence of the antennal flagellar process in the two groups. There is also an alternative possibility that the structure is actually a symplesiomorphy which is retained by the "primitive" fulgoroids and was lost in the "advanced" fulgoroids. Further investigations would be interesting and necessary to examine the labia of some "advanced" fulgoroids under SEM to determine whether vestiges of the sensillum are present (not detectable by light microscopy).

It is hoped that by describing the latero-subapical sensillum, the present paper has helped provide one valuable diagnostic feature for adults of the Cixiidae. A more extensive survey of the integumental fine structure of Cixiidae and other fulgoromorphan families is needed to determine whether this previously overlooked character system supports current taxonomic classifications of the group. Furthermore, elucidation of the functions of the structure described herein may provide valuable information concerning the evolution and ecology of the fulgoromorphan taxa in which they occur.

## Acknowledgments

I am grateful to L.L. Deitz and R.L. Blinn (NCSU), R.C. Froeschner and T.J. Henry (USNM), N. Penny (CAS), D.J. Preston and S.E. Miller (BPBM), R.T. Schuh (AMNH) and M.D. Webb (BMNH), for providing the specimens used in this study, Y.-J. Yan and L.-F. Fu (Advanced Materials Laboratory, Ministry of Education of China, Beijing) for providing technical assistance with the scanning electron microscopy, K. Sōgawa (Independent Administrative Institute, Japan International Research Center for Agricultural Sciences, Ibaraki, Japan) for providing his earlier publications and for several useful discussions, and L.B. O'Brien (Florida A & M University, Tallahassee, FL), S.W. Wilson (Central Missouri State University, Warrensburg, MO), L.L. Deitz (North Carolina State University, Raleigh, NC), and W.A. Gardner (University of Georgia, Griffin, GA), for giving welcome support and comment on the manuscript. The work on which this paper is based was supported by the following sources: the Hundred Talent Program from the Chinese Academy of Sciences (grant number A2903077), the National Natural Science Foundation of China (grant number 30370187), a CAS Presidential Research Fellowship, and the National Science Fund for Fostering Talents in Basic Research (NSFC-J0030092).

## References Cited

**Asche, M. 1988.** Preliminary thoughts on the phylogeny of Fulgoromorpha (Homoptera, Auchenorrhyncha), Pp. 47-53. *In* C. Vidano and A. Arzone (eds.), Proc. 6th Auchen. Meeting, Turin, Italy, 7-11 Sept., 1987.

**Backus, E. A. 1985.** Anatomical and sensory mechanisms of leafhopper and planthopper feeding behavior, Pp. 163-194. *In* L. R. Nault and J. G. Rodriguez (eds.), The leafhoppers and planthoppers. John Wiley and Sons, New York.

**1988.** Sensory systems and behaviours which mediate hemipteran plant-feeding: a taxonomic overview. J. Insect Physiol. 34: 151-165.

**Cobben, R. H. 1978.** Evolutionary trends in Heteroptera. Part II. Mouthpart-structures and feeding strategies. Mededeling No. 289: 1-407. Laboratorium voor Entomologie, Wageningen, Nederland.

**Emeljanov, A. F. 1990.** An attempt to construct a phylogenetic tree for planthoppers (Homoptera, Cicadina). Entomol. Obozr. 69: 353-356. [In Russian]. [English translation in Entomol. Rev. 90: 24-28.]

**Foster, S., L. J. Goodman and J. G. Duckett. 1983a.** Ultrastructure of sensory receptors on the labium of the rice brown plant hopper. Cell Tissue Res. 230: 353-366.

**1983b.** Sensory receptors associated with the stylet and cibarium of the rice brown planthopper *Nilaparvata lugens*. [sic]. Cell Tissue Res. 232: 111-119.

**Hansen, H. J. 1890.** Gamle og nye hovedmomenter til Cicadariernes morphologi og systematik. Entomol. Tidskr. 11: 19-76 (pls. 1-2). [In Danish-English translations in Entomologist 33 (1900): 116-120, 169-172, 334-337; 34 (1901): 149-154; 35 (1902): 214-217, 234-236, 260-263; 36 (1903): 42-44.]

**Hatfield, L. D. and J. L. Frazier. 1980.** Ultrastructure of the labial tip sensilla of the tarnished plant bug *Lygus lineolaris* (P. de Beauvois) (Hemiptera: Miridae). Int. J. Insect Morphol. Embryol. 9: 59-66.

**Holzinger, W. E., A. F. Emeljanov and I. Kammerlander. 2002.** The family Cixiidae Spinola 1839 (Hemiptera: Fulgoromorpha) - a Review. Denisia 4: 113-138.

**Keil, T. A. and R. A. Steinbrecht. 1984.** Mechanosensitive and olfactory sensilla of insects, Pp. 477-516. *In* R. C. King and H. Akai (eds.), Insect Ultrastructure, Vol. 2. Plenum, New York.

**Kramer, S. 1950.** The morphology and phylogeny of auchenorrhynchous Homoptera (Insecta). Illinois Biological Monographs 20: 1-109 (pls. 1-15).

**Liang, A.-P. 2001a.** First record of the genus *Adolenda* Distant (Hemiptera: Fulgoroidea: Kinnaridae) from China, with description of one new species. Zool. Stu. 40(4): 365-370.

**2001b.** Morphology of antennal sensilla in *Achilixius sandakanensis* (Hemiptera: Fulgoromorpha: Achilixiidae) with comments on the phylogenetic position of the Achilixiidae. Raffles Bull. Zool. 49: 221-225.

**Metcalf, Z. P. 1936.** General catalogue of the Hemiptera. Fascicle IV, Fulgoroidea. Part 2, Cixiidae. Smith College, Northampton. 269 pp.

**O'Brien, L. B. and S. W. Wilson. 1985.** Planthopper systematics and external morphology, Pp. 61-102. *In* L. R. Nault and J. G. Rodrigues (eds.), The Leafhoppers and Planthoppers. Wiley and Sons, Inc., New York.

**Roth, C. M. and E. T. Willis. 1951.** Hygroreceptors in Coleoptera. J. Exp. Zool. 117: 451-488.

**Saxena, K. N., J. R. Gandhi and R. C. Saxena. 1974.** Patterns of relationships between certain leafhoppers and plants. I. Responses to plants. Entomol. Exp. Appl. 17: 303-313.

**Singh, R. N., K. Singh, S. Prakash, M. J. Mendki and K. M. Rao. 1996.** Sensory organs on the body parts of the bed-bug *Cimex hemipterus* Fabricius (Hemiptera: Cimicidae) and the anatomy of its central nervous system. Int. J. Insect Morphol. Embryol. 25(1-2): 183-204.

**Snodgrass, R.** E. 1935. Principles of insect morphology. McGraw-Hill, New York.

**Sōgawa, K. 1977.** Feeding physiology of the brown planthopper, Pp. 95-114. *In* The Rice Brown Planthopper, Food Fert. Technol. Cent. Asian Pac. Reg., Taipei.

**1981.** Scanning electron microscopy of the labial tip, feeding mark, and stylet sheath of the brown planthopper. Proc. Assoc. Plant Prot. Hokuriku 29: 32-35. (In Japanese with English Summary at p. 22.)

**Zacharuk, R. Y. 1980.** Ultrastructure and function of insect chemosensilla. Annu. Rev. Entomol. 25: 27-47.