Scanning Electron Microscopy of Antennal Sense Organs in *Prosapia bicincta* (Say) (Hemiptera: Cercopidae)[1]

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Abstract The external morphology of the sensilla on the antennae of the adult spittlebug, *Prosapia bicincta* (Say) (Hemiptera: Cercopidae), is described for the first time, using scanning electron microscope observations. The sensilla include one peg-like basiconic sensillum (about 65.05 to 65.90 µm in length and 13.33 to 14.08 µm in width at base), 18 to 23 porous coeloconic sensilla (mostly 7.38 to 8.94 µm in diam), one campaniform sensillum and a cluster of trichoid sensilla (about 45 to 55 µm long). The first two types of sensilla are located on the expanded flagellar base, while the latter two sensilla are on the pedicel.

Key Words *Prosapia bicincta,* Cercopidae, antennal sensilla, ultrastructure, scanning electron microscopy

Prosapia bicincta (Say) is one of the two known cercopid species of the genus *Prosapia* Fennah occurring in North America north of Mexico (Doering 1930, Hamilton 1982). This species is abundant in the southern and eastern U.S., ranging north to Pennsylvania, Indiana, Massachusetts, New Jersey, and Maine and south to Florida, Kansas and Texas (Say 1831, Morse 1921, Mead 1962, Hamilton 1982). It is recognized by the following combination of characters: male 7.9 to 10.8 mm, female 7.7 to 9.8 mm; color dark brown to black, mottled with deep crimson on underside, including legs, marked with three narrow transverse bands of scarlet, orange or yellow on upper side, one across humeral angles of pronotum, and two across forewings (Mead 1962, Hamilton 1982).

Adults of *P. bicincta* are general feeders on deciduous trees, bushes, and broad-leaved herbaceous plants as well as grasses. They have been reported on sugarcane (*Saccharum officinarum* L.) (Doering 1942), Pangola grass (*Digitaria decumbens* Stent.) (Genung 1955), coastal Bermudagrass (*Cynodon dactylon* Pers.) (Tombes and Pass 1961, Beck 1961) and holly (*Ilex* sp.) (Baker 1972) in Florida, Georgia and South Carolina. Nymphs feed on the subterranean stems and roots of grasses (Ball 1928).

This paper contains observations on the antennal sensilla of *P. bicincta* that expands the knowledge of the morphology of the Nearctic Cercopidae. A description of the external morphology, number, and distribution of the antennal sensilla that are found on the antenna of this species is presented herein.

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Materials and Methods

Dry, pinned museum specimens of two adult males, collected at Gulfport, FL and one adult male, collected at Paterson, NJ were studied with scanning electron microscopy. They were obtained from the American Museum of Natural History in New York.

The head was removed from the body of each specimen, examined and transferred to 10% KOH for 1 to 2 min, cleaned with a fine brush, then washed in distilled water. These were mounted individually on aluminium stubs using double-sided sticky tape. They were air-dried at room temperature and coated with gold-palladium using a sputter coater. Observations were made with a JEOL JSM-6301F (Japanese Electronic and Optical Ltd., Tokyo, Japan) scanning electron microscope, operated at accelerating voltages of 5 kV.

Morphological terminology largely follows that of Snodgrass (1926), Kramer (1950), Schneider (1964) and Zacharuk (1985).

Results and Discussion

Gross morphology of the antenna. As in other cicadomorphan insects, the antennae of *P. bicincta* are inserted in an antennal fovea of the vertex at the side of the postclypeus below the antennal ledges (Fig. 1) (Kramer 1950). Each antenna consists of three segments: a basal scape (sc), a pedicel (pe) and an apical long bristle-like flagellum (fl) (Fig. 1). Both the scape and the pedicel are cylindrical with a concave apex (Figs. 1-3). The inner wall of the apical concave pedicel is provided with radular cuticular protuberances (Figs. 1-3, 5, 6). The flagellum is composed of two distinct portions, an expanded, somewhat conical base and a long, slender, apical extension (Figs. 1, 3, 5). The expanded flagellar base (fb) is inserted in the concave apex of the pedicel (Figs. 1-3, 5, 6).

The cuticular surface of both the pedicel and the swollen flagellar base (excluding the area where the sensilla are located) is characterized by many transverse imbrications (Figs. 1-3, 5, 6). The apical flagellar extension is provided with very small, bud-like cuticular processes (Fig. 4). These processes appear homologous with the cuticular transverse imbrications in the expanded flagellar base and are possibly formed by reduction development during the course of the extension of the flagellum.

The scape is without special characters, but the pedicel and the expanded flagellar base are distinctive in possessing sensory sensilla. The expanded flagellar base is provided with a field of sensilla mainly on the ventrolateral side (Figs. 1-3, 5, 6). It consists of a long and slender basiconic sensillum and about 18 to 23 porous coeloconic sensilla (Figs. 3, 5, 6).

Antennal sensilla types and distribution. Four types of sense organs were observed. These were trichoid sensilla (tr), campaniform sensilla (ca), basiconic sensilla (ba) and coeloconic sensilla (co). The former two types of sensilla are found on the pedicel, and the latter two types of sensilla are seen on the expanded flagellar base (Figs. 1-8).

Basiconic sensillum. This elongate, slender, peg-like sensillum (Figs. 1-6) has a smooth cuticle surface. It is located in a large, shallow, nearly rounded pit at the apex of the expanded flagellar base, ventrally below the flagellum. It is long and slender, about 65.05 to 65.90 μm in length and 13.33 to 14.08 μm in width basally, tapering from base to blunt apex, pointing in parallel with the flagellar extension. The apex of the basiconic sensillum is sometimes slightly curved downward (Fig. 3).

Basiconic sensilla are widely present in Cercopidae, Machaerotidae, and in the relatively primitive members of Aphrophoridae (e.g., Cloviini, Philaenini) at the apex of the expanded flagellar base. Their number varies between 1 and 4 among different taxa. In the relatively advanced members of the Aphrophoridae (e.g., Aphrophorini), basiconic sensilla are replaced by placoid sensilla. The number, length, size, and shape of these pegs vary among the taxa and are phylogenetically informative (Liang, unpubl. data). Fennah (1949, 1953a-b, 1966, 1968, 1979, 1985) used the length of the basiconic sensilla (= his aristae) in separating Neotropical cercopid taxa.

The basiconic sensillum seen in *P. bicincta* is similar to that found in the African *Locris maculata* (F.) (Boulard and Boulard 1979) and the Oriental *Sounama (Stenaulophrys) borneensis* Liang & Webb (Liang and Webb 2001) in its number and position but differs from the latter two species in having the basiconic sensillum being very elongate and slender. The main function of the basiconic sensilla is chemosensory and olfactory (Zacharuk 1980, Keil and Steinbrecht 1984).

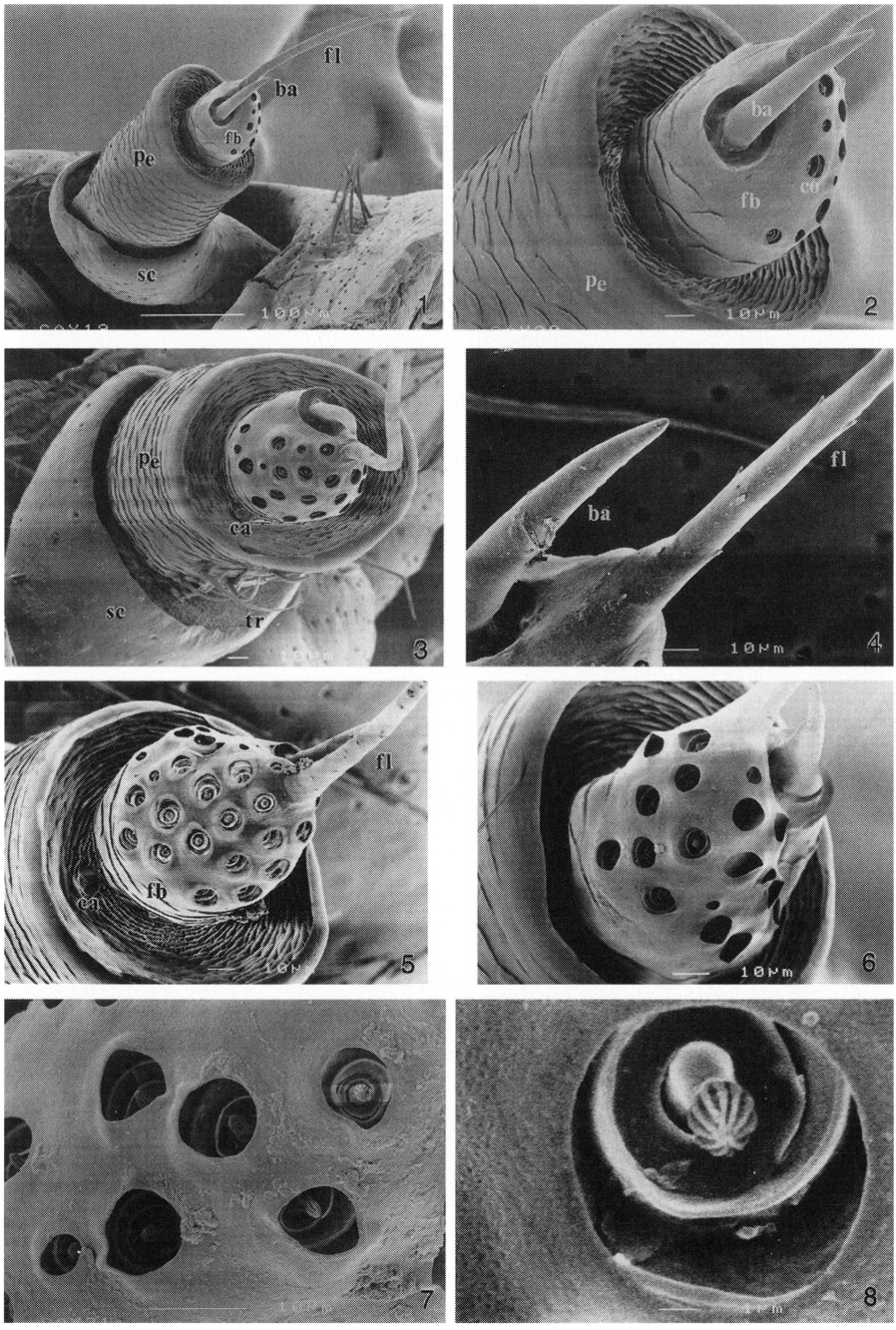
Coeloconic sensilla. These are porous sensory structures widely located on the surface of the expanded flagellar base, excluding the anterior area and the basal area in dorsal aspect (Figs. 1-3, 5-8). In *P. bicincta,* there are about 18 to 23 porous coeloconic sensilla, approximately 7.38 to 8.94 µm in diam. Two or three are distinctly smaller in size with a diameter of 3.62 to 4.13 µm. There is a significant association between the body size and the number of the coeloconic sensilla. Specimens from Florida are noticeably larger than other specimens from New Jersey. The former has about 23 porous coeloconic sensilla (Figs. 3, 5), while the latter has only about 18 coeloconic sensilla (Fig. 6).

Each coeloconic sensillum is composed of a deep cavity with an opening in which one central grooved peg is set on the bottom wall of the cavity (Figs. 1-3, 5-8). The porous cavity has two inner rims with smooth margins (outer rim diam ≈ 6.36 µm, inner rim diam ≈ 5.06 µm). The central peg has a broad basal stem and a pistil-like apex with 10 to 12 longitudinal valves (cap diam 1.82 to 2.55 µm). The apex of the central peg does not reach the level of the apical opening of the coeloconic sensilla (Figs. 7, 8). The cuticular surface of the expanded flagellar base where the porous coeloconic sensilla are located is smooth (Figs. 2, 3, 5-7).

Coeloconic sensilla are widely present in the spittlebug families (e.g., Cercopidae, Aphrophoridae, Machaerotidae and Clastopteridae) (Boulard and Boulard 1979, Liang and Webb 2001, Liang unpubl. data) and in the Cicadoidea (Klein et al. 1988a,b). Most members of Cercopidae have numerous, large porous coeloconic sensilla, but few and relatively small, porous coeloconic sensilla are seen in the Aphrophoridae, Machaerotidae and Clastopteridae. The number, size, distribution, and the number of the apical valves of the central grooved peg of these porous coeloconic sensilla vary among different taxa and are phylogenetically informative (Liang, unpubl. data).

The number and location of the coeloconic sensilla in *P. bicincta* are very similar to those observed in the African *L. maculata* (Boulard and Boulard 1979). However, differences exist in the shape of the coeloconic sensilla between the two species. In *P. bicincta,* the inner rim of the porous cavity of the coeloconic sensilla is smooth (Figs. 7, 8), while in *L. maculata,* the inner rim of the porous cavity of the coeloconic sensilla has numerous spinous processes extending concentrically (Boulard and Boulard 1979).

Prosapia bicincta possesses a greater total number of coeloconic sensilla than Oriental *S. borneensis* (Liang and Webb 2001). The arrangement and location of the



Figs. 1–8. Scanning electron micrographs of antennal sensilla of *Prosapia bicincta* (Florida: Gulfport, except where indicated): 1. antenna, ventral view, showing scape, pedicel, and flagellum (including expanded flagellar base and apical flagellar extension); 2. apex of pedicel and expanded flagellar base, ventral view; 3. antenna, showing campaniform sensillum and trichoid sensilla on pedicel; 4. flagellar extension, showing bud-like cuticular protuberances; 5. apex of pedicel and expanded flagellar base, showing arrangement of coeloconic sensilla on expanded flagellar base and campaniform sensillum on pedicel; 6. apex of pedicel and expanded flagellar base (New Jersey: Paterson); 7. surface of expanded flagellar base; 8. one coeloconic sensillum on surface of expanded flagellar base.

coeloconic sensilla are also different between the two species. In *P. bicincta,* the coeloconic sensilla are widely distributed over the surface of the expanded flagellar base (excluding the anterior area and the basal area). But in *S. borneensis,* the coeloconic sensilla (8 to 9 total) are concentrated in a large, deep pit at the upper, ventrolateral side of the expanded flagellar base (Liang and Webb 2001).

The coeloconic sensillum can function either as olfactory and chemosensory receptors or thermo/hygroreceptors (Kellogg 1970, Loftus 1976, Altner et al. 1977, Zacharuk 1980). The numerous porous coeloconic sensilla in *P. bicincta* appear to be the main olfactory receptors for host selection.

Campaniform sensillum. The campaniform sensillum is a very small, nearly dome-shaped sensory structure positioned at the apical radular bottom surface of the pedicel dorsally near the expanded flagellar base (Figs. 3, 5). Only one campaniform sensillum is found in *P. bicincta.* Although campaniform sensilla are found in many insects, they are usually few in number and are usually located near segmental joints. They are considered mechanoreceptors (Schneider 1964, McIver 1985, Zacharuk 1985).

Trichoid sensilla. These sensilla are a cluster of about 45 to 55 μm long hairs with straight or slightly curved longitudinal grooves. They are nearly straight or curved toward the antennal shaft (Fig. 3). They are present near the base of the pedicel dorsally (Fig. 3). The hair bases (2.8 to 3.2 μm in diam) are inserted tightly into a small cuticular socket and protrude dorsolaterally between 30 and 40° from the antenna. Similar trichoid sensilla have been observed on the antenna of many other cercopid spittlebug species (Liang, unpubl. data). Trichoid sensilla are common in insects' antennae and are considered gustatory (Whitehead 1981, Whitehead and Larsen 1976) and mechanoreceptive (Slifer 1970, Zacharuk 1980).

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