MORPHOLOGY, HISTOLOGY, AND FINE STRUCTURE

Sense Organs on the Antennal Flagellum of *Leptoglossus zonatus* (Heteroptera: Coreidae)

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ABSTRACT For the first time, antennal sensorial organs of *Leptoglossus zonatus* (Dallas) (Heteroptera: Coreidae) are described through scanning electron microscopy. The antennae are formed by a scape, pedicel, and a flagellum that is composed of two flagellomeres and is the main bearer of sensorial organs. Five types of sensory structures were identified: Trichoid sensilla, basiconic sensilla, coeloconic sensilla, campaniform sensilla, and placoid sensilla. Trichoid sensilla were divided into five subtypes. The large striated trichoid sensilla have almost straight longitudinally striated cuticles and were present throughout the antenna. Flattened trichoid sensilla were variable-sized curved hairs distributed from the base of the scape to the distal end of the first flagellomere. Small striated trichoid sensilla were found mainly on the antenna distal flagellomeres. Smooth trichoid sensilla were located at the distal end of the scape and along the entire length of the pedicel, and are the least abundant type on the antenna. Small smooth trichoid sensilla were found precisely on the joints between the pedicel and scape. Based on size and shape, the basiconic sensilla were also divided into five subtypes (Bs1, Bs2, Bs3, Bs4, and Bs5). These all are rod-shaped. Coeloconic sensilla were found exclusively on the second flagellomere of the flagellum. Just one campaniform sensilla on each antenna was located on the second flagellomere of the flagellum. Finally, a group of 10 oval placoid organs were found at the scape base, in proximity to the joint connecting the antenna to the insect’s head.

KEY WORDS leaf-footed bug, *Jatropha curcas*, pest, biofuel, antennal sensillum

The majority of information regarding antennal sensilla in Heteroptera is based mainly on hematophagous species, particularly of the family Reduviidae (Slu 1980, Catalá 1997, Gracco and Catalá 2000, Guerenstein and Guerin 2001, Carbajal de la Fuente and Guerin 2005), Pentatomidae (Bretraitura and Panizzi 2005), Lygaeidae (Rani and Madhavendra 2005, Venin 1997), Alydidae (Rani and Madhavendra 2005, Venin 1997, Gracco and Catalá 2000, Guerenstein and Guerin 2005), and Coreidae (Akent’eva 2008). Antennal sensilla have also been studied in phytophagous families such as Miridae (Chinta et al. 1997), Alydidae (Rani and Madhavendra 2005, Ventura and Panizzi 2005), Lygaeidae (Rani and Madhavendra 2005), Pentatomidae (Brézot et al. 1997, Sinitsina and Chaika 1998, Rani and Madhavendra 2005), and Coreidae (Akent’eva 2008). The sensilla identified in the order of Heteroptera consist of trichoid, basiconic, coeloconic, styloconic, campaniform, and chaetica sensilla (Slu 1980, Sinitsina and Chaika 1998, Guerenstein and Guerin 2001, Carbajal de la Fuente and Catalá 2002, Rani and Madhavendra 2005). Few studies have been carried out on species belonging to the Coreidae family.

The leaf-footed bug *Leptoglossus zonatus* (Dallas) (Heteroptera: Coreidae) was described in Mexico by Allen (1969). Currently, this species is distributed throughout the American continent (Matrangolo and Waquil 1994). This bug is considered a polyphagous pest because it has multiple hosts, including the species cited by Schaefer and Panizzi (2000), guava (Souza Filho and Costa 2003), and Satsuma tangerine (Xiao and Fadamiro 2010). Furthermore, it is one of the most frequent pests of *Jatropha curcas* L. (Malphighiales: Euphorbiaceae), a species that has become important in the production of biodiesel (Grimm and Maes 1997, Grimm and Fuhrer 1998, Morales–Morales et al. 2011, Tepole–García et al. 2012). Knowledge regarding sensilla type and morphology contributes to a better understanding of the role these structures play in intra- and interspecific communication, as well as the selection of the host plant. Regarding *L. zonatus*, there are no studies related to the morphological description of its antennal sensory organs. Consequently, the aim of this study was to describe the morphology and types of antennal sensilla for both sexes of this species.

Materials and Methods

Insects. *L. zonatus* adults were obtained from a breeding batch maintained in the Centro de Desarrollo de Productos Bióticos (Center for the Develop-
ment of Biotic Products at the Instituto Politécnico Nacional) (CeProBi-IPN). Twenty-five-d-old male and female adults were decapitated, and the heads were stored in 70% alcohol until required. Both sexes were always managed separately.

**Light Microscopy.** The study was carried out in the Microscopy and Imagenology laboratory of CeProBi-IPN. Measurements of the antenna (scape, pedicel, and flagellum) of 10 male and 10 female adults were made by using a stereoscopic microscope (Nikon L2M 1500, Nikon, Tokyo, Japan). Measurements were made by means of an Image Tool for Windows Version 3.0 image analyzer (Wilcox et al. 2002). The image was calibrated according to the scale established in each photograph of the antenna. The length and basal width of each flagellum were measured for both sexes. A Student t-test with $P < 0.05$ was carried out on the antenna data to compare between sexes, measurements for each previously mentioned structure.

**Scanning Electron Microscopy.** As in the preceding case, same-aged adults conserved in 70% alcohol were used. The antennas of males and females were separated from the rest of the body under a dissection microscope and were placed separately into a solution of 70% ethanol and 2% formaldehyde for 24 h at room temperature. The antennae were washed with 70% ethanol and then dehydrated by incubation (2 by 1 h) in 80, 90, and 100% ethanol. The dehydrated samples were fixed to metallic microscope slides with carbon conduct tape and covered with a 70-nm gold layer in a metal ionizer (JEOL Fine Coat JFC-1100). The study was conducted in the microscopy unit of the Colegio de Posgraduados (Postgraduate College) by using a scanning electron microscope (JEOL JSM-6390/LGS) at 5 kV to create micrographs of different types of sensilla from each part of the antenna of *L. zonatus*. The antennal sensilla were classified according to the characteristics proposed by Zacharuk (1980) and Frazier (1985).

**Results**

**Morphological Characterization of the Antenna of *L. zonatus*.** They are formed of three parts: Scape, pedicel, and flagellum (Fig. 1A), the latter composed of two flagellomeres. The relative position of these parts is almost straight, in normal position, but can assume a pronounced angle at the joint between the scape and the pedicel. The scape is curved and significantly longer in female than in male antennae ($t = -3.22; df = 18; P = 0.005$) (Table 1), and its smallest diameter is at the base, where it forms a joint with the cephalic capsule. Its maximum diameter is in the middle of the segment. The pedicel is significantly longer in female than in male antennae ($t = -3.32; df = 18; P = 0.004$). This structure has the shape of a straight tube that maintains a constant diameter almost along its entire length, apart from at the distal end adjacent to the flagellum joint, where it is a little wider. The flagellum is composed of two flagellomeres. The first flagellomere is almost straight, slightly wider at the distal end, and has an area of cuticle free of setae and lined with longitudinal striae at its base. This flagellomere is significantly wider in female than in male antennae ($t = -2.52; df = 18; P = 0.02$). Between first and second flagellomere, there is a small intercalary segment. It presents sensory organs and presents a surface that displays irregular fine ornamentations. The distal edge forms a groove on the ventral side to allow movement of the second flagellomere in this direction. The second flagellomere carries the majority of sensory organs. It presents a barely perceptible curved shape, a uniform diameter that is slightly narrower at its base, and a rounded distal end (Fig. 1A). No statistical differences between sexes were found in antenna or flagellum total longitude and width (Table 1).

**Morphological Description of Sensilla of *L. zonatus*.** Observations made with the scanning electron microscope revealed the presence of five types of sensilla in both sexes of *L. zonatus*: Trichoid, basiconic, coeloconic, campaniform, and placoid. Based on size and striae presence, trichoid sensilla were classified into five subtypes: Large striated trichoids (Lst), flattened trichoids (Ft), small striated trichoids (Sst), smooth trichoids (St), and small smooth trichoids (Ssm).

Lst sensilla are the only dark cuticle sensorial organs and because of their size and color, stand out from the rest of the sensilla on the antenna surface. They are virtually straight setae with a longitudinally striated cuticle, with joints positioned in round alveolus (Figs. 1B and 2F). With the exception of the second flagellomere, they are present on every part of the antenna. These setae are wider toward the base of the antenna and become thinner toward the distal end. Mean length and base width is 111 μm and 13 μm, respectively (64–181 μm; $N = 30$ sensilla).

The Ft sensilla are distributed from the scape base, where they are most abundant, to the distal end of the first flagellomere, where they are found in fewer numbers. They are variable-sized setae with a mean length of 41 μm and base width of 5 μm (48–89 μm; $N = 30$ sensilla). They are curved hairs distinguished by their transversal section, rounded at the base and gradually flattening out toward the apex. Width increases upwards until reaching its maximum toward the end, where it narrows to form a fine hooked-shaped tip. The setae joint is found on socket surrounding base (Fig. 1B).

The Sst sensilla are very similar in form to large trichoids; however, they display significant differences regarding size (Figs. 1C and 2F). These sensilla present a mean length and base width of 57 μm and 6 μm, respectively (50–64 μm; $N = 30$ sensilla) and are mainly found on the distal flagellomeres of the antenna, inserted between the chemoreceptors. They present slightly inclined longitudinal striae and because of their short setae, give the impression of being robust (Fig. 2F). The joint is pronounced at the base of the sensilla and is situated in a much less distinct depression than in Lst. Another difference between Sst and Lst is that the former display a rounded tip (Fig. 2F).
The St sensilla, which owe their name to the fact that their surface is not lined with striae, present a mean length and base width of 64 and 4 \( \mu m \), respectively (56–68 \( \mu m \); \( N \) = 20 sensilla) and are fully curved in all cases (Fig. 1B and C). These setae are less abundant on the antenna. They are found on the scape, principally at the distal edge and along the entire length of the pedicel.

The Ssm sensilla are straight, conic, very short, and robust. They present a mean length and base width of 28 and 5 \( \mu m \), respectively (23–32 \( \mu m \); \( N \) = 20 sensilla). They are found precisely on the joint between the scape and pedicel (Fig. 1D). The base rests on the edge nearest to the pedicel in such a way that when it moves, the sensilla tip strikes the distal edge of the scape. The sensilla joints are found in pronounced rounded protuberances.

The basiconic sensilla are also classified into five subtypes, based on size and shape (Bs1, Bs2, Bs3, Bs4, and Bs5). Subtype 1 (Bs1) basiconic sensilla are rod-

Fig. 1. Scanning electron micrographs (SEM) of antennal sensilla of *Leptoglossus zonatus*. (A) General view of the antenna of a male showing the scape, pedicel, and flagellum. (B) Dorsal view of first flagellomere of a female. (C) Ventral view of the second flagellomere of a male. (D) Lateral view of the articulation of the scape with pedicel in a male. (E) Type 3 basiconic sensilla showing longitudinal striae in the antenna of *L. zonatus* female. (F) Type 1 basiconic sensilla in the second flagellomere of the antenna of *L. zonatus* female. (G) Type 4 basiconic sensilla in the second flagellomere of the antenna of *Leptoglossus zonatus* female. Sc = scape, P = pedicel, F = flagellum, a = first flagellomere, b = second flagellomere, Lst = large striated trichoid sensilla, Ft = flattened trichoid sensilla, St = smooth trichoid sensilla, Sst = small striated trichoid sensilla, Bs1 = type 1 basiconic sensilla, Bs2 = type 2 basiconic sensilla, Bs3 = type 3 basiconic sensilla, Bs4 = type 4 basiconic sensilla, Co = coeloconic sensilla, Ssm = small smooth trichoid sensilla.

The basiconic sensilla are also classified into five subtypes, based on size and shape (Bs1, Bs2, Bs3, Bs4, and Bs5). Subtype 1 (Bs1) basiconic sensilla are rod-

Table 1. Measurements of antennae of both sexes of *L. zonatus*

| Measurements (mm) | Male (mean ± SE) | Female (mean ± SE) |
|------------------|------------------|-------------------|
| Length escape    | 2.14 ± 0.065a    | 2.42 ± 0.056b     |
| Width escape     | 0.39 ± 0.021a    | 0.41 ± 0.022a     |
| Length pedicel   | 3.26 ± 0.079a    | 3.63 ± 0.006b     |
| Width pedicel    | 0.19 ± 0.021a    | 0.22 ± 0.009a     |
| Length flagellum | 0.83 ± 0.16a     | 1.07 ± 0.16a      |
| Width flagellum  | 0.31 ± 0.01a     | 0.33 ± 0.01a      |
| Length flagellomerea | 2.56 ± 0.071a | 2.69 ± 0.050a |
| Width flagellomerea | 0.17 ± 0.006a | 0.20 ± 0.005b |
| Length flagellomereb | 4.54 ± 0.055a | 4.52 ± 0.14a |
| Width flagellomereb | 0.26 ± 0.006a | 0.29 ± 0.006a |
| Antenna total length | 12.35 ± 0.20a | 12.33 ± 0.26a |
| Antenna total width | 0.23 ± 0.01a | 0.23 ± 0.011a |

Presented values are median ± SE, \( n \) = 10 antennae of 10 specimens different in each case.

*a* First flagellomere.

*b* Second flagellomere.

Different letters in each row signify significant statistical difference (Student t-test; \( P < 0.05 \)).
shaped sensilla and are the largest basiconic sensilla with a mean length and base width of 68 and 5 μm, respectively (65–71 μm; N = 20 sensilla). The base is directly joined to the smooth cuticle of the last flagellomere. These sensilla are always curved and are wider at the base than at the tip, which is rounded (Figs. 1C and F and 2A and F).

Subtype 2 (Bs2) basiconic sensilla are similar to Bs1, apart from being much smaller; with a mean length and base width of 43 and 5 μm, respectively (38–51 μm; N = 20 sensilla). Some are virtually straight, but majority are very slightly curved. Their surface displays a degree of roughness, and they are always accompanied by microtrichia at the distal flagellomere (Figs. 1C and F and 2A and F). Distribution is uniform, almost equidistant.

Subtype 3 (Bs3) basiconic sensilla are notably smaller than the previously mentioned basiconic sensilla, with a mean length and base width of 12 and 3 μm, respectively (10–16 μm; N = 15 sensilla). They are characterized by 20 parallel longitudinal striae that run from the base to the apex. In contrast to the striae found on previously described Lst sensilla, these coincide with the longitudinal axis. The rod diameter does not change from the base to the middle section, resulting in a cylindrical form, whereas the upper section gradually decreases in thickness until ending in a rounded tip where the longitudinal striae converge (Figs. 1C and E and 2A and F). They are abundant and distributed over the whole surface of the distal flagellomere.

Subtype 4 (Bs4) basiconic sensilla have the smallest antennal rods. They are few in number and observed mostly on the ventral face of the second flagellomere. Their structure is different from the other basiconic sensilla, specifically the relationship between the base width and length of the organ (Fig. 1G). Above the base, the diameter narrows abruptly (4 μm) and ends in a rounded tip at a height of just 7 μm (N = 5 sensilla). They are lined by a dozen striae, which converge at the distal end of the sensilla. Between the

Fig. 2. SEM of antennal sensilla of *L. zonatus*. (A) Dorsal view of second flagellomere of antenna of *L. zonatus* male. (B) Ventral view of the second flagellomere of the antenna of *L. zonatus* male showing type 5 basiconic sensilla. (C) Ventral view of the second flagellomere of the antenna of *L. zonatus* male showing coeloconic sensilla. (D) Ventral view of the second flagellomere of the antenna of *L. zonatus* male showing campaniform sensilla. (E) Lateral view of scape of the antenna of female showing placoid sensilla. (F) Dorsal view of second flagellomere of antenna of *L. zonatus* female showing different sensilla. Bs1 = type 1 basiconic sensilla, Bs2 = type 2 basiconic sensilla, Bs3 = type 3 basiconic sensilla, Bs4 = type 4 basiconic sensilla, Co = coeloconic sensilla, M = microtrichia, Ca = campaniform sensilla, Pl = placoid sensilla, Sst = small striated trichoid sensilla, Lst = large striated trichoid sensilla.
striae, the cuticle is not flat but crest-shaped. The base is found in a shallow but prominent depression.

Subtype 5 (Bs5) basiconic sensilla, which are also only present at the distal flagellomere, are very scarce with extremely few observed on the ventral face of the flagellomere. They present a mean length and base width of 23 and 6 µm, respectively (17–31 µm; N = 5 sensilla), are noticeably curved and placed in round spacious cuticular cavities (Fig. 2B).

The coeloconic sensilla (Co) are found exclusively on the second flagellomere of the flagellum, and although present in other areas, are mainly located on the ventral side, accompanied by basiconic sensilla and immersed between microtrichia. The cuticular cavities are deep and have a mean aperture diameter of 6 µm (N = 15 sensilla). At the bottom of the coeloconic cavity is a rod with a tip that slightly protrudes above the cavity opening. (Figs. 1C and 2A, C, and F).

Only a few campaniform sensilla (Ca) were observed for each antenna. They are characterized by a rounded cupular with a diameter approximately of 5 µm, placed within a cuticular concavity. These features were observed on the second flagellomere of the flagellum. Their structure is bell-shaped (Fig. 2D).

At the scape base, very close to the joint between the antenna and head, a group of 10 oval placoid organs (Pl) were observed (Fig. 2E). Each had a slightly convex plate, measuring 7 µm on the lesser axis and 10 µm on the major axis (N = 10 sensilla), and aligned with the longitudinal axis of the scape. The edge is discernible because of a pronounced canal, and each organ is surrounded by a wide rim of elevated cuticle.

Finally, fine hairs known as microtrichia (M) were observed in all antennal surfaces. These M are cuticular ornamentations of the antenna and are unjointed in general. They are slightly curved hairs, although some are almost straight. They are uniformly distributed exclusively on the second flagellomere (Fig. 2A and F).

Discussion

Both male and female L. zonatus did not present differences in antenna size or type of antenna sensilla. Similar results were reported for Eurygaster maura (L.) (Scutelleridae) (Romani and Rossi 2009) and Nezara viridula (L.) (Pentatomidae) (Brézot et al. 1997). In contrast, in Neomegalotomus parvus (Westwood) (Alydidae) and Lygus lineolaris (Palisot de Beauvois) (Miridae), male antennae were larger than female antennae (Chinta et al. 1997) (Ventura and Panizzi 2005). Typically, antennae in Heteroptera are formed by a scape, pedicel, and a flagellum with two flagellomeres. However, in Aufidius trifasciatus (Stal), Euryaulax carnifex (F.), Puttigla deprivata (Walker), and Tomnoiria tasmaniae (Lambley) (Cercopidae), the flagellum consists of a large apical hair inserted into an expanded conical base (Liang and Fletcher 2002). The flagellum of L. zonatus is formed by two flagellomeres that hold the largest number of sensilla. Similarly, two flagellomeres were observed in N. parvus (Ventura and Panizzi 2005), Paurostrongylus megistus (Burmeister) (Reduviidae) (Villela et al. 2005), Coreus marginatus (L.) (Coreidae), Ne. viridula (Pentatomidae) (Brézot et al. 1997), and Rhodnius prolixus (Stal) (Reduviidae) (Akent'eva 2008). Like in L. zonatus, the greatest number of sensilla are found on the final flagellomere (Ventura and Panizzi 2005, Akent'eva 2008). This could be an adaptation to improve olfaction, as identified in Oncopeltus fasciatus (Dallas) (Lygaeidae) (Yersen and Ball 1959) and Oxycarenus laetus Kirby (Lygaeidae) (Raman 1988). The antennal flagellum of Hyalesthes obsoletus, formed by a bulb and arista (in itself considered as a sensilla or an antennal segment bearing other sensilla), functions as a sound receptor (Romani et al. 2009).

The different types of identified sensilla in L. zonatus, such as trichoid, basiconic, coeloconic, campaniform, and placoid, have also been indentified in other species of Heteroptera. For example, in C. marginatus, Coreus lectularius, and R. prolixus, the first three types of sensilla were identified (Akent'eva 2008). The same author also subdivided the trichoid sensilla from these three species into large pointed trichoids and short blunt trichoids. Whereas in P. megistus, the trichoid sensillum was subdivided in thin-walled trichoid and thick-walled trichoid (Villela et al. 2005). The basiconic sensilla found in P. megistus (Villela et al. 2005) and those in N. parvus described by Ventura and Panizzi (2005) are similar in both size and shape to the Lst identified in L. zonatus.

In both sexes of L. zonatus, trichoids were the most abundant sensilla. Similar results were reported in species from different families such as Pentatomidae: Euschistus heros (F.), Pieszodorus guldinii (Westwood), Edessa meditabunda (F.) (Silva et al. 2010), Cyclopedia sicifolia (Westwood), and Chrysoecoris purpureus (Westwood) (Rani and Madhavendra 2005); Alydidae: Riporttus pedestris (F.); and Lygaeidae: Elasmomolomus sordidus (F.) (Rani and Madhavendra 2005). Like in C. marginatus, C. lectularius, and R. prolixus (Akent'eva 2008), in L. zonatus, these sensilla were distributed over the entire antenna. The majority were located on the scape and decreased in number toward the apical end of the antenna. In the four species of Cercopidae studied by Liang and Fletcher (2002), trichoid sensilla were clustered laterally close to the pedicel base. Most trichoid sensilla found on N. parvus were located on the last segment of the antenna (Ventura and Panizzi 2005). Poreless striated trichoid sensilla were identified on L. lineolaris (Chinta et al. 1997). An apical pore was identified on the trichoid sensilla of N. parvus (Ventura and Panizzi 2005). Zacharuk (1985) suggested that these sensilla may have a mecanano- and chemosensory function, whereas Elizarov (1978) and Chinta et al. (1997) reported that they may have a olfactory and gustatory function. In species studied by Liang and Fletcher (2002), trichoid sensilla were classified as mechanoreceptors, as the sensilla base was inserted into a cuticular base (Zacharuk 1980; Frazier 1985) and taste
receptors in Coleoptera (Whitehead 1981). However, Chinta et al. (1997) found multiporous trichoid sensilla with a thin cuticle on *L. lineolaris*, suggesting an olfactory role. The fact that trichoid sensilla are most abundant on the antenna confirms their importance in adults for food perception, intraspecific recognition, and pheromone detection (Akent’eva 2008).

Small smooth trichoid sensilla identified on *L. zonatus* between the scape and pedicel appear to detect antenna movement, functioning as proprioceptors. The role of this type of sensilla is contradictory, as other authors such as Zacharuk (1980) describe them as mechanoreceptors, whereas Ventura and Panizzi (2005) state that they are chemoreceptors. However, the true role of these sensilla is probably related to the particular insect species on which they are found. Regarding *L. zonatus*, corresponding Single Cell Recording studies would have to be conducted to identify the role of this particular type of sensilla.

The basiconic sensilla identified in *L. zonatus* are short rods with joints at their base and rounded tips. Basiconic sensilla on *N. parvus* (Ventura and Panizzi 2005) and three species studied by Akent’eva (2008) were described as small staves lacking a flexible base or inserted into a hole. A basiconic sensillum was also identified on the four species of Cercopidae studied by Liang and Fletcher (2002). They are the most abundant sensilla in several species of Heteroptera (Akent’eva 2008); however, Liang and Fletcher (2002) reported only one type of sensilla per antenna in each species. In species studied by Liang and Fletcher (2002), the basiconic sensilla were identified on the extended conic base of the flagellum, whereas in *L. zonatus*, they were identified mainly on the distal flagellomere. Similarly, in *C. marginatus*, *C. lectularius* (Akent’eva 2008), and *E. maura* (Romani and Rossi 2009), this type of sensilla was observed on the apical segments of the flagellum. The fact that they have just one apical pore suggests that they play a mechanoochemical sensory role. However, Frazier (1985) and Zacharuk (1980) suggested a chemoreceptor role, whereas Silva et al. (2010) consider that the role of this type of sensilla is to detect specific sexual pheromones. Basiconic sensilla without a flexible base play an olfactory role in female hematophagous mosquitoes (Bowen 1995). There are no studies for *L. zonatus* in relation to the particular role of basiconic sensilla.

Unlike *L. zonatus*, whose coeloconic sensilla are on the second flagellomere, 8–9 of this type of sensilla were identified clustered on the extended base of the flagellum in species studied by Liang and Fletcher (2002). Two different types of coeloconic sensilla were identified on *H. obsoletus*, situated in internal cavities of the flagellum bulb (Romani et al. 2009). It has been mentioned that in species not belonging to the Heteroptera order, the role of this type of sensilla is olfactory, chemosensory, or thermo-hygro receptor (Kellogg 1970; Loftus 1976; Altner et al. 1977, 1981; Zacharuk 1990; Ruchty et al. 2009). Liang and Fletcher (2002) suggest a receptor role, used for the detection of host plant volatiles.

Coeloconic sensilla on *L. zonatus* were found on the last flagellomere. In other species of Heteroptera such as *E. heros*, *P. guildinii* (Silva et al. 2010), *E. maura* (Romani and Rossi 2009), *C. marginatus*, *C. lectularius*, and *R. prolixus*, these sensilla have been detected on the distal segment of the flagellum (Akent’eva 2008). Although coeloconic sensilla are also characteristic of other insects, they play different roles in these species. For example, in *E. maura*, they assume a thermo-hygro receptor role (Romani and Rossi 2009); in *R. prolixus*, they are considered as chemoreceptors (Shu 1980), whereas Frazier (1985) and Zacharuk (1980) define them as olfactory sensors or mechanoreceptors.

Just one campaniform sensillum was identified in both sexes of *L. zonatus*, located on the apical segment. However, in species of different families not belonging to Heteroptera, such as *Diaphorina citri* (Kuwayama) (Homoptera: Psyllidae), an unidentified uniporous sensillum (perhaps a campaniform sensillum) similar to that described for *L. zonatus* was located on the antennal pedicel (Onagbola et al. 2008). In species studied by Liang and Fletcher (2002), this sensillum was detected in the apex of the pedicel, close to the extended conic base of the flagellum. According to Frazier (1985) and Zacharuk (1980), campaniform sensilla are mechanoreceptors. In some species from other orders such as Coleoptera, these sensilla play a thermo-hygro receptor role, detecting changes in environmental humidity and temperature (Merivee et al. 2002, Ploomi et al. 2003). The role of campaniform sensilla in *L. zonatus* is not clear, as their location differs from that reported in the previously mentioned species.

The placoid sensilla are located at the base of the scape. The fact that they always display a clustered arrangement, suggests they could be mechanoreceptors. Presently, there is a lack of information on this type of sensilla for Heteroptera and depending on the species, different roles have been attributed. According to the classification presented by Frazier (1985) and Zacharuk (1980), these sensilla are olfactory receptors. However, in species of Coleoptera, they play a chemoreceptor role, detecting sexual pheromones (Leal and Mochizuki 1993).

Nonjointed fine microscopic hairs are found on the antennae of the majority of insects, formed by a direct continuation of the antennal cuticle but not connected to any sensory neurons. Therefore, we are not dealing with sensory organs but ornamentations known as microtrichia that protect the sensilla. In *L. zonatus*, the microtrichia are observed exclusively on the second flagellomere and are slightly curved, although some are practically straight. The shape of these organs, and in particular their location, suggests they act as mechanoreceptors, informing the insect of complete antenna movements; these plates are capable of detecting small deformations of the cuticle on the scape base.

Of all the sensory organs present in insects, the antennae are probably the most important for signal perception, especially because they are characterized by the highest concentration of sensilla in comparison...
with other parts of the body (Zacharuk 1985). This is the first study on antennal morphological characterization of *L. zonatus*. It is important to point out that there was no evidence of sexual dimorphism; male and female individuals of *L. zonatus* presented the same five types of antennal sensilla. According to Schneider (1964), this type of insect may have a gregarious behavior; therefore, these have the same type of sensilla to perceive the aggregation pheromone of conspecifics. Studies of the sensory organs of *L. zonatus* increase and enhance our comprehension of the sensory receptor process. However, further electrophysiological and ultrastructure studies are essential to characterize and classify the antennal sensilla according to their roles and thus improve our understanding of the sexual behavior and chemical communication of this particular insect.

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