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Source: Entomological NewsEntomological News, 120 120(2 2):137 152-152 152. 2009 2009.
Published By: The American Entomological Society
DOI: 10.3157/021.120.0203
URL: http://www.bioone.org/doi/full/10.3157/021.120.0203

ANTENNAL MORPHOLOGY AND SENSILLA OF ASIAN MULTICOLORED LADYBIRD BEETLES, *HARMONIA AXYRIDIS* PALLAS (COLEOPTERA: COCCINELLIDAE)[1]

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ABSTRACT: We investigated the antennal morphology, sensillar types, and sensillar distribution in the dark ("melanic") and the light ("*succinea*") forms of Asian multicolored ladybirds, *H. axyridis*, using scanning electron microscopy (SEM). Antennae of both sexes of *H. axyridis* consist of the scape, pedicel, and nine flagellomeres. Seven sensillar types are distinguished: four types of sensilla trichodeae (s.tr), four types of sensilla basiconicae (s.ba), four types of sensilla chaetica, and one type each of sensilla coeloconica (s.co), sensilla sporangium (s.sp), sensilla placoidea (s.pl), and Böhm bristle (s.bm). Sensilla trichodea are the most numerous; sensilla chaetica are the next most abundant. The number of other sensillar types is greatly reduced. On the tip of the 9th flagellomere, various types of sensilla are densely packed, except for s.bm and s.pl. No remarkable differences are found in the antennal size, shape, and sensillar types between the melanic and *succinea* forms of *H. axyridis*, but there is a difference in the total number of s.tr.2 between the two forms. No differences are found in the antennal size and the total number of sensillae between males and females of each form. According to the distribution of sensillae and sensillar functions reported in the past, s.tr are presumed to be pheromone receptors in *H. axyridis*, s.ch may function as mechanoreceptors and chemoreceptors, s.ba and s.co are postulated as plant volatiles receptors and chemo-, thermo-, or hygroreceptions, respectively, and s.bm may be related to perceiving the antennal position and movement.

KEYWORDS: *Harmonia axyridis*, antennal morphology, sensilla, SEM

Harmonia axyridis Pallas (Coleoptera: Coccinellidae) is a natural enemy of various pests, especially of arboreal aphids (Brown and Miller, 1998; Brown, 2004; Wang and Shen, 2002). Insects depend on olfactory sensilla situated on the antennae to perceive semiochemicals in the environment. The coccinellid beetle, *Harmonia axyridis*, relies on olfaction to detect semiochemicals released by pests plant volatiles induced by damage from different aphids for directional searching as food source (Han and Chen, 2000; Wang et al., 2001; Lü et al., 2006). Osawa (2000) indicated that, in *H. axyridis*, visual and chemical cues are important to find habitat. The behavioral mechanisms of *H. axyridis* in biological control have been reported (Cottrell, 2005; Lee and Kang, 2004). Recently, Verheggen et al (2007) pointed that two semiochemicals, (E)-ß-farnesene and (-)-ß-caryophyllene were implied as having potential usefulness in push-pull strategies, which repelling target pest from a protected host, while luring them toward an attractive trap, using *H. axyridis* as a biological control agent in aphid-infested sites or to control new urban pests in residential structures. Seldom have any studies of the antennal olfactory sensillae been reported for *H. axyridis* (Han et al., 2000). At the same time, the main bases for classification of *H. axyridis* are elytra background color, as well as spots quantity and shape. Currently,

[1] Received on April 18, 2008. Accepted on July 28, 2008.

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Mailed on August 14, 2009

H. axyridis is generally divided into two categories based on the elytra background color: the dark, or melanic, form and the light, or *succinea* form. The melanic form has a black background with red or yellow spots and *succinea* form has a light reddish and brownish background color. We explore whether there are differences in antennal morphology and behavior between the two forms. This paper provides a description of the antennal sensilla types, and their numbers and distribution on *H. axyridis* adults belonging to both the melanic and light forms.

METHODS

Insects

Harmonia axyridis are collected in September 2006, from the Maoershan Forestry Centre of Northeast Forestry University, Harbin, Heilongjiang Province, China. According to the pattern and color, adult beetles are separated into melanic forms, which are characterized by a black background with two to four red or yellow spots, sometimes these spots formed a ribbon, and the *succinea* group, which is characterized by a light reddish and brownish background color with zero to nineteen small dark spots. Sixteen specimens are examined in both groups, eight of both sexes are included in each group which possesses four different types of *H. axyridis*, one male and female are selected for each type, and the male and female are identified by dissection under microscope. The terminology of Yuan Rongcai (1994) is followed for classification of the different types of *H. axyridis*.

Melanic forms: *H. axyridis* ab. *conspicua* Fald; *H. axyridis* ab. *circumscripta* Hem; *H. axyridis* var. *spectabilis* Fald; *H. axyridis* ab. *lunata* Hem; s*uccinea* group: *H. axyridis* ab. *succinea* Hope; *H. axyridis* ab.1347-*octosignata* Yuan; *H. axyridis* ab.12345678- *sedecimsignata* (Mls.) Yuan; *H. axyridis* ab.½12345 6789-*undevigintisignata* Fald.

Scanning Electron Microscopy (*SEM*)

Antennae are prepared for SEM following Srivastava and Omkar (2003). The types, number, and location of sensillae situated on the ventral side of the antennae are identified using SEM (FEI-QUANTA-200) at an accelerating voltage of 10Kv at different magnifications. In classifying sensillae, the terminology of Schneider (1964) and Zacharuk (1985) is used.

RESULTS

Morphology of antennae

Female and male antennae of *H. axyridis* consist of the scape, pedicel, and nine flagellomeres (fl1-fl9) (Fig. 1A). The tip of the ninth flagellomere is almost round and has a gentle transverse ridge; olfactory sensilla are concentrated on both sides of this ridge (Figs. 1B and 1C). The length of antennae in the melanic forms ranges from 1.16-1.22mm and 1.06-1.29mm for the *succinea* group. In the melanic forms, female and male antennae range from 1.17-1.22mm long and 1.16-1.21mm, respectively, while in the *succinea* group, they range from 1.14-1.29mm and 1.06-1.20mm, respectively. There are no obvious differences be-

tween the antennal lengths in these two groups. Various types of sensillae are densely distributed on the apical flagellomere; a few sensillae are present on the other flagellomeres. Most of the sensillae situated on the other flagellomeres are sensilla chaetica (s.ch) except for the second flagellomere (Figs. 1E and 1F, Fig. 2A) that has sensilla trichodea (s.tr) and sensilla basiconica (s.ba). S.ch and Böhm bristle (s.bm) are located on the scape and pedicel (Figs. 2B-2F).

Sensilla types on the antennae

Seven kinds of antennal sensillae are found in the melanic forms and *succinea* groups, which include sensilla chaetica (s.ch), sensilla trichodea (s.tr), sensilla basiconica (s.ba), sensilla coeloconica (s.co), sensilla sporangium (s.sp), sensilla placoidea (s.pl) and Böhm bristle (s.bm). Moreover, sensilla sporangia (s.sp) and sensilla placoidea (s.pl) are found uniquely in either the *succinea* or melanic groups, respectively. According to the external shape, dimensions, and location, four types of s.ch, four types of s.tr, and four types of sensilla basiconica are distinguished.

Sensilla chaetica (s.ch)

Sensilla chaetica (s.ch) are bristles distinguished by a specialized and flexible circular membrane at the base. This type of sensilla has a thick wall, no foramen, and is marked longitudinally by arranged furrows (Figs. 1D and 1E). Sensilla chaetica are found on the surface of the entire antennae and four types are distinguished.

Sensilla chaetica 1 (s.ch1) are straight bristles and stand almost perpendicular to the antennal axis. This type of sensilla ranges from 150-220 μm long and has the longest bristles among the s.ch with the basal diameter ranging from 5-8 μm. Few s.ch1 were observed and these are only distributed on the protuberance of the scape (Fig. 2B).

Sensilla chaetica 2 (s.ch2) range from 70-90 μm long and are bristles with a blunt tip. They stand an angle of 50-70° to the antennal surface. S.ch2 are only situated on the edge of the apical flagellomere. The length and basal width are 70-90 μm and 4.0-5.2μm, respectively (Figs. 1B and 1C).

Sensilla chaetica 3 (s.ch3) are straight bristles with a light curving tip. These are the main sensilla type on each flagellomere of the antennae. These sensilla vary greatly in length, ranging from 40-100 μm. The diameter of the base ranges from 2.0-4.5 μm (Figs. 1B and 1F, Figs. 2A and 2B). S.ch3 resemble the sensilla chaetica observed in *Psylliodes chrysocephala* (Coleoptera: Chrysomelidae) (Isidoro et al., 1998).

Sensilla chaetica 4 (s.ch4) prominently are straight bristles with a pointed tip, the length and diameter of which are shorter than those of s.ch 3. These sensilla are situated only on the scape and pedicel (Fig. 2B).

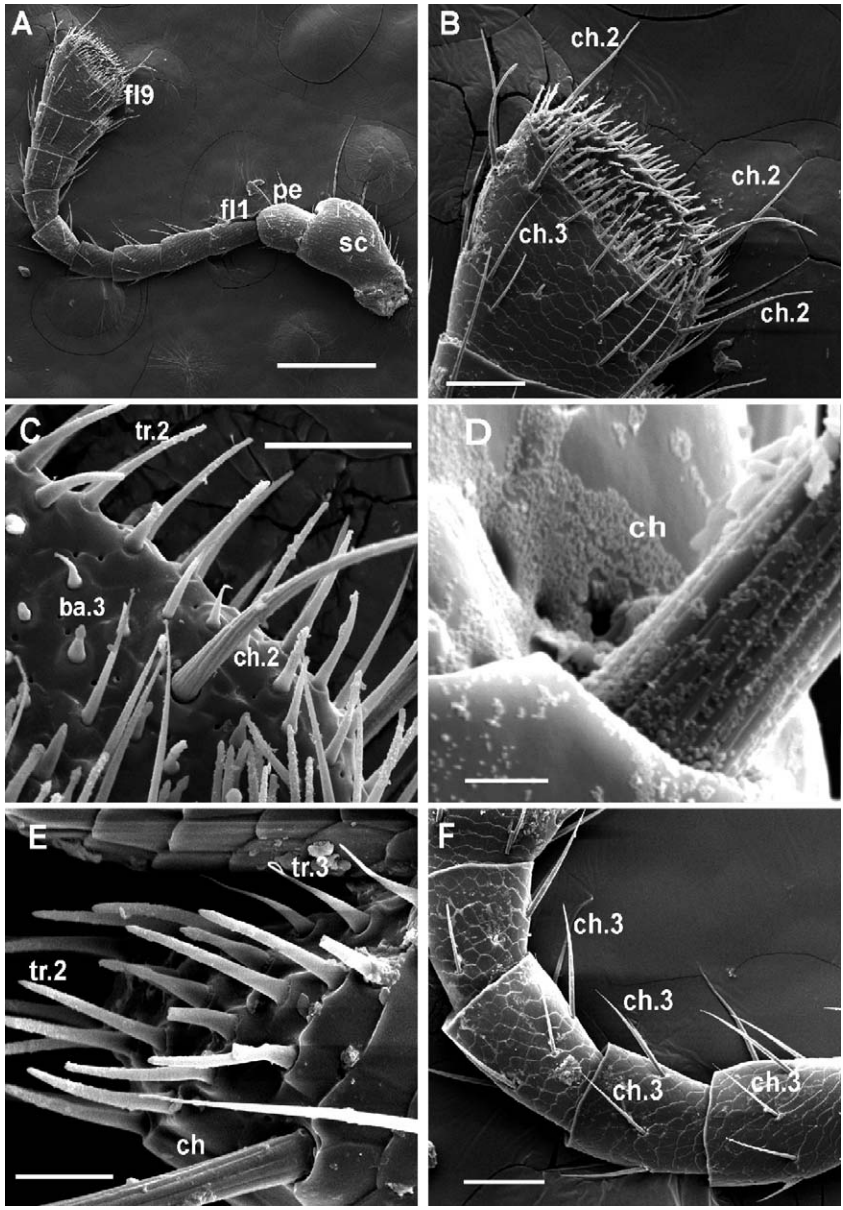

Fig. 1. The entire antennae and antennal sensillae of *H. axyridis.* (A) the antennae of both sexes of *H. axyridis* consist of the scape (sc), pedicel (pe), and nine flagellomeres (fl1-fl9). Bar=200µm. (B) apical segment of antennae (9th flagellomere) and its various types of sensillae. Bar=50µm. (C) sensillae situated on the apical segment of antennae (close up). Bar=20µm. (D) sensilla chaetica (s.ch). Bar=2µm. (E) profile of 2nd flagellomere of the apical antennal segment, s.ch, sensilla chaetica. Bar=10µm. (F) sensilla chaetica type III (s.ch.3) located on flagellomeres 5-8th. Bar=50µm.

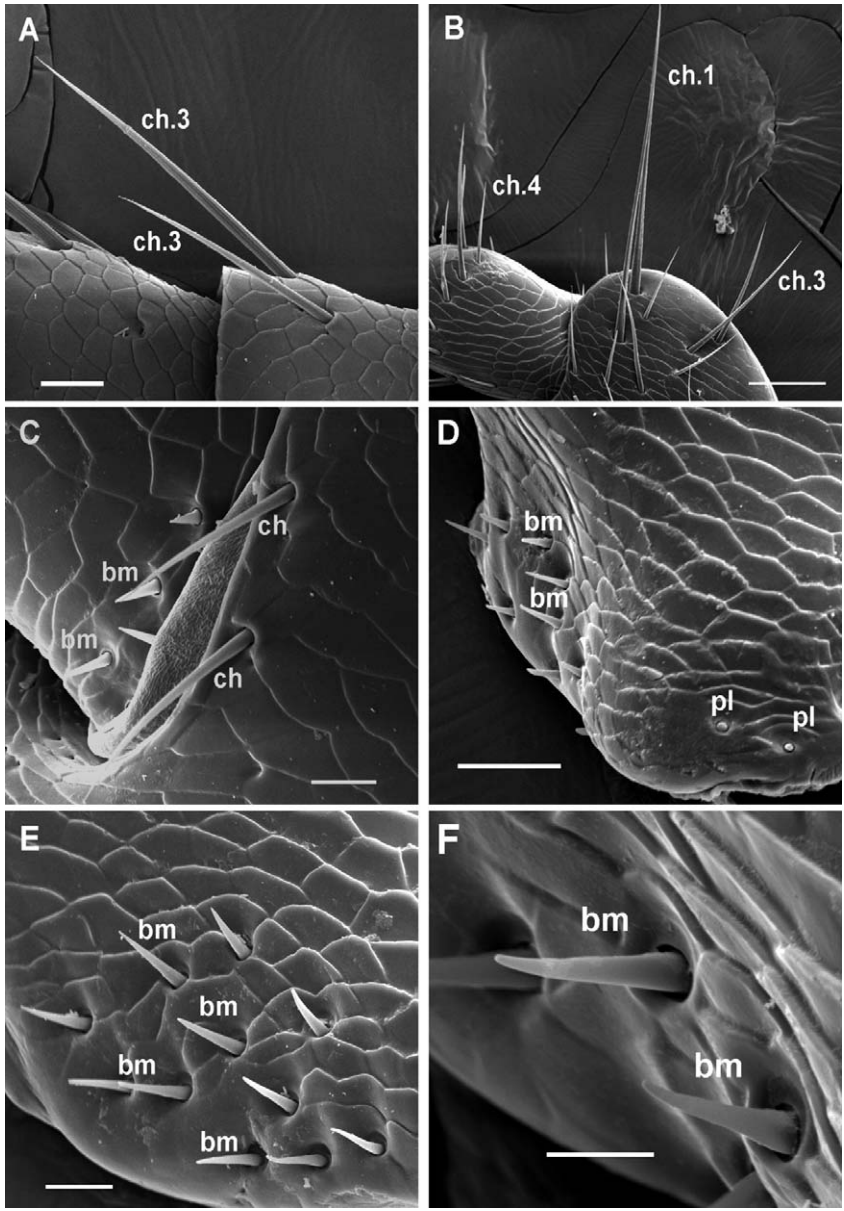

Fig. 2. Sensilla chaetica type III l (s.ch.3) located on the flagellomere and sensillae situated on the scape and pedicel of antennae in both sexes of *H. axyridis. (*A) sensilla chaetica type III (s.ch.3) on the flagellomere. Bar=20µm. (B) sensilla chaetica type I, III and IV (s.ch.1, s.ch.3, s.ch.4) located on the scape and pedicel. Bar=50µm. (C) Böhm bristle (s.bm) and sensilla chaetica (s.ch) located on the joint of the scape and the pedicel. Bar=10µm. (D) Böhm bristles (s.bm) and sensilla placoidea (s.pl) located on the scape. Bar=10µm. (E-F) the amplification of Böhm bristles (s.bm). Bar=5µm.

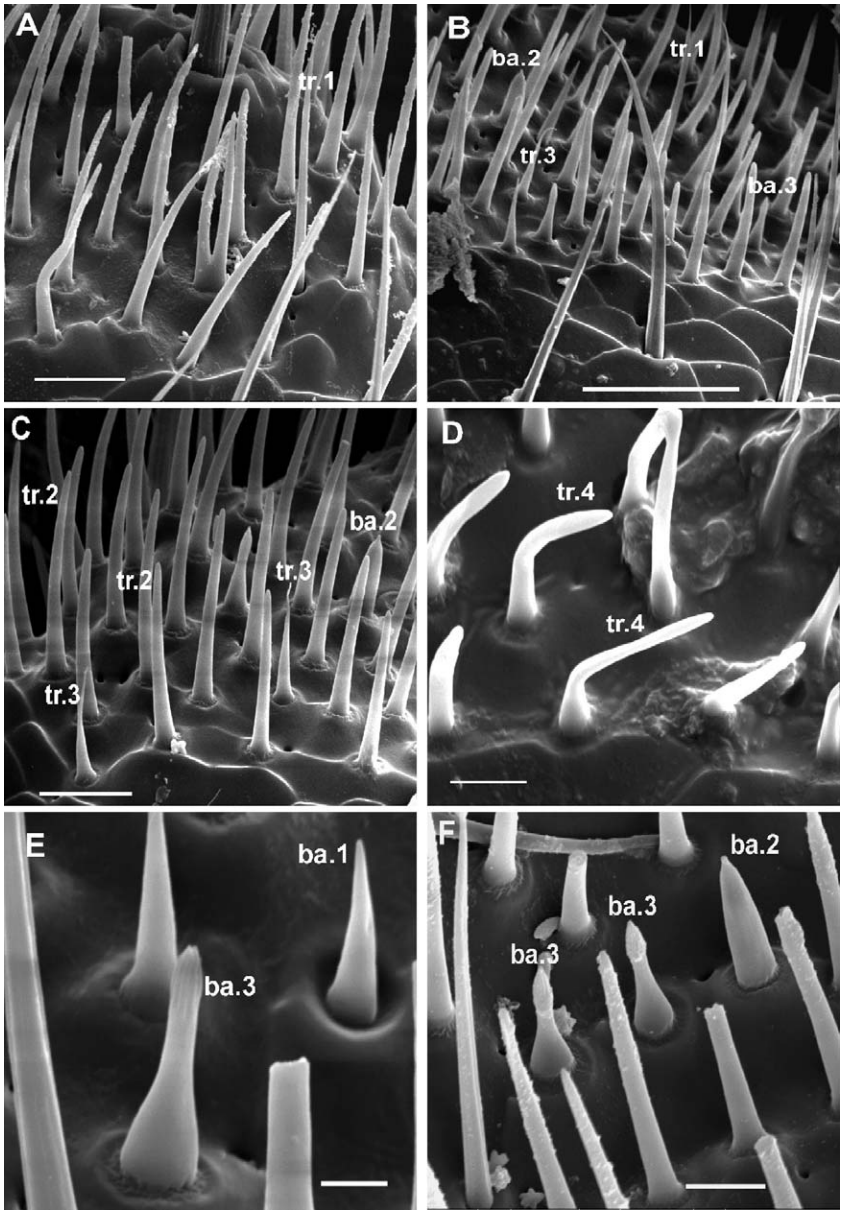

Fig. 3. Sensilla types located on the apical segment of antennae in both sexes of *H. axyridis*. (A) sensilla trichoidea type I (s.tr.1). Bar=10µm. (B) sensilla trichoidea type I and III (s.tr.1, s.tr.3), sensilla basiconica type II and III (s.ba.2, s.ba.3). Bar=20µm. (C) sensilla trichoidea type II and III (s.tr.2, s.tr.3), sensilla basiconica type II (s.ba.2). Bar=10µm. (D) sensilla trichoidea type IV (s.tr.4). Bar=5µm. (E) sensilla basiconica type I and III (s.ba.1, s.ba.3). Bar=2µm. (F) sensilla basiconia type II and III (s.ba.2, s.ba.3). Bar=2µm.

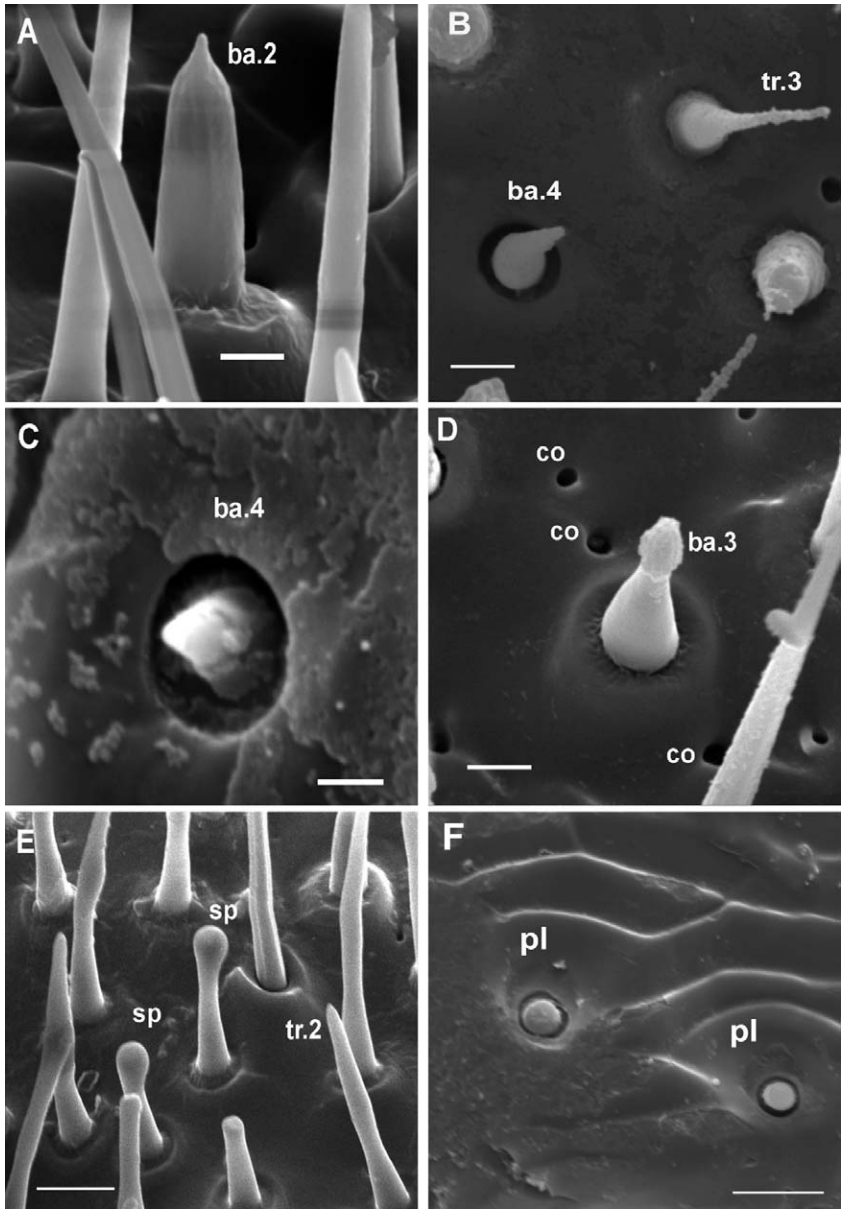

Fig. 4. Sensillae situated on the antennal apical segment and pedicel of both sexes of *H. axyridis*. (A) sensilla basiconica type II (s.ba.2). Bar=2µm. (B) sensilla trichoidea type III (s.tr.3), sensilla basiconica type IV (s.ba.4). Bar=2µm. (C) sensilla basiconica type IV (s.ba.4). Bar=1µm. (D) sensilla coeloconica (s.co), sensilla basiconica type III (s.ba.3). Bar=2µm. (E) sensilla sporangia (s.sp), sensilla trichoidea type II (s.tr.2). Bar=5µm. (F) sensilla placoidea (s.pl). Bar=5µm.

Sensilla trichodea (s.tr)

Sensilla trichodea (s.tr) are trichoid, with a smooth wall, and without a specialized basal cuticular ring serving as an articulating membrane. S.tr are located on the tip of the ninth flagellomere, their basal diameter ranging from 1-3µm. According to the shape and length, four types of sensilla trichodea are distinguished.

Type 1 (s.tr1) have long hairs that ranged from 20-36µm and have a sharp tip (Figs 3A and 3B).

Type 2 (s.tr2) are the most numerous sensilla type on the antennae, the entire length ranging from 13-20µm. These setae have a blunt tip (Figs 1C and 1E; Fig 3C).

Type 3 (s.tr3) are relatively shorter hairs (6-12µm) with sharp tips, tapering rapidly from the base to the distal end (Fig 1E; Figs 3B and 3C, 3H).

Type 4 (s.tr4) resembles s.tr2 in length, but are slightly curved hairs with blunt tips, forming an angle of 50-80° in relation to the surface of the flagellomeres (Fig. 3D).

Sensilla basiconica (s.ba)

Sensilla basiconica (s.ba) are blunt tipped, smooth walled, relatively stout pegged sensillae, gently curved toward the antennal shaft fitted tightly in their sockets. We distinguish four types of s.ba, as follows:

Sensilla basiconica 1 (s.ba1) are 5-6µm long pegs with basal diameters ranging from 1-2µm (Fig. 3E).

Sensilla basiconica 2 (s.ba2) are 6-9µm long thick, with basal diameters of ranging from 2-3µm. They are smooth-walled conical pegs with apical nipples (Figs. 3B and 3C, 3F; Fig. 4A). Sensillae of this shape are similar to s.b5 observed in small numbers in the distal area of the apical flagellomere in both sexes of the click beetle *Limonius aeruginosus* (Olivier) (Merivee et al.,1998), and the spiniform basiconic sensilla located on the antennae of the millipede *Orthomorphella pekuensis* (Polydesmida: Paradoxosomatidae) (Chung and Moon, 2006).

Sensilla basiconica 3 (s.ba3) are found mainly in the distal area of the apical flagellomere and are rare. They are 5-10µm long with sharp-tipped pegs, distal longitudinal grooves, and basal diameters ranging from 2-3µm (Fig. 1C; Fig. 3B, 3E, and 3F; and Fig. 4D). S.ba3 of *H. axyridis* looks identical to the basiconica type II in the ladybird beetle *Semiadalia undecimnotata* (Coccinellidae) (Jourdan et al., 1995).

Sensilla basiconica 4 (s.ba4) are the least common sensilla. They are found in a pit surrounded by a cuticular collar (20-25µm diameter) where a distinct cone is observable at the bottom of the pit (Figs. 4B and 4C).

Sensilla coeloconica (*s.co*)

Sensilla coeloconica (s.co) are small pit-organs resembling pores. They have no visible cones and are surrounded by a cuticular collar in the center of the opening (Fig. 4D).

Sensilla sporangium (*s.sp*)

Sensilla sporangium (s.sp) are found only on the distal area of the ninth antennal flagellomere in the *succinea* group of *H. axyridis* ab.1347-*octosigna* ta Yuan, approximately perpendicular to the antennal surface. S.sp looks like a long pole, 5-9 μm long with a basal diameter ranging from 2-3μm. They have an apical protuberance similar to a sporangium and have a diameter ranging from 2-4μm (Fig. 4E). There are less sensilla sporangia than any other sensilla.

Sensilla placoidea (*s.pl*)

Sensilla placoidea (s.pl) are elliptical plates with a pit, surrounded by a narrow circular membrane. These sensillae are rare and are situated only on the scape of the antennae in the melanic form *H. axyridis* ab. *lunata* Hem. These plates have smooth surfaces and are located on sunken sockets (Fig. 4F).

Böhm bristles (*s.bm*)

Böhm bristles (s.bm) are sensory hairs that are always found in areas opposite to the intersegmental membranes, between the head and the scape, as well as the scape and the pedicel, or on the scape and the pedicel respectively (Figs. 2C-2F). These have been named Böhm bristles after L. K. Böhm, who described them in the Lepidoptera (Böhm, 1911; Schneider, 1964). They are probably present on homologous places in all insects. Sometimes, the name "sensilla chaetica" has been used for this organ, while other authors have called them "sensilla trichodea" or "sensilla basiconica."

Number and distribution of antennal sensillae

Through the statistical analysis of amounts of sensilla chaetica (s.ch), sensilla trichodea (s.tr) and sensilla basiconica (s.ba), the results show an average of 237 sensilla of female in the melanic form of *H. axyridis*, 259 sensilla in the male. In the succinea group, there is an average of 264 sensilla in the female, 257 for the male. It is obvious there are no differences in the total number of sensillae between both sexes in each form of *H. axyridis*. The Maoershan Forestry Centre of Northeast Forestry University is a region with a rich diversity of species in Heilongjiang Province, China, so we select here to collect samples in different days of September. These data are obtained by scanning electron microscopy, and the statistic analysis is completed by one person.

Sensillae trichodea (s.tr) and sensillae chaetica (s.ch) are the most abundant sensillar types on the antennae of both adult females and adult males *H. axyridis* in both the melanic and *succinea* groups. Of these, sensilla trichodea are the most numerous and sensilla chaetica are the next most numerous (Tables 1 and 2); other sensilla types are considerably less abundant. S.tr, s.ba, and s.co are situated mainly on the top of the ninth flagellomere, while s.ch can be found along the entire antenna. Böhm bristles (s.bm) are located only on the joints between the head and the scape, as well as on the scape and the pedicel. In the melanic form,

statistical differences between males and females are observed in the number of s.ch3 situated on the pedicel and ninth flagellomere, and s.tr3 located on the eighth and ninth flagellomeres (Table 1). In the *succinea* form, the number of s.ch4 located on the pedicel of the antennae in the male is evidently more than that of the female (Table 2). On the other hand, there is a statistical difference in the number of s.ch4 located on the pedicel of the antennae between male and female antennae in the *succinea* form of *H. axyridis* (Table 2). Also, there are differences in the number of s.tr1, s.tr2 and s.ba1 between both sexes in the melanic form; in the *succinea* form this difference is only found in the number of s.tr3.

Table 1. Mean number and distribution of different sensillae on male (M) and female (F) antenna of melanic forms adult of *H. axyridis*. "*" represents the presence of significant differences (1 tails, independent samples, equal scadascity t-test) between both sexes of the melanic form of *H. axyridis*. f_1 to f_9 represents first to ninth flagellomeres. The number of Böhm bristles and few sensilla coeloconica, sensilla sporangium and sensilla placoidea is not counted. Ch, tr and ba represents sensilla chaetica, sensilla trichodea and sensilla basiconica respectively.

Sensilla types sex	**ch.1 M/F**	**ch.2 M/F**	**ch.3 M/F**	**ch.4 M/F**	**tr.1 M/F**	**tr.2 M/F**	**tr.3 M/F**	**ba.1 M/F**	**ba.2 M/F**
scape	3/3	—	—	16/16	—	—	—	—	—
pedicel	—	—	3/5*	6/8	—	—	—	—	—
f_1	—	—	6/8	—	—	—	—	—	—
f_2	—	—	6/8	—	—	—	—	—	—
f_3	—	—	6/6	—	—	—	—	—	—
f_4	—	—	5/4	—	—	—	—	—	—
f_5	—	—	5/5	—	—	—	—	—	—
f_6	—	—	5/5	—	—	—	—	—	—
f_7	—	—	8/7	—	—	—/1*	—	—	—
f_8	—	1/1	11/11	—	—	12/9*	—/1*	1/1	—
f_9	—	6/6	14/11*	—	9/6*	116/105*	8/5*	10/5*	2/2
total	3/3	7/7	69/68	22/24	9/6*	128/115*	8/6	11/6*	2/2

Table 2. Mean number and distribution of different sensillae on male (M) and female (F) antenna of the *succinea* group adult of *H. axyridis*. "*" represents the presence of significant differences (1 tail, independent samples, homoscadastic, t-test) between both sexes of the melanic form of *H. axyridis*. f_1 to f_9 represents first to ninth flagellomeres. Böhm bristles, sensilla coeloconica, sensilla sporangia, and sensilla placoidea were not counted. Ch, tr and ba represents sensilla chaetica, sensilla trichodea and sensilla basiconica respectively.

Sensilla types sex	**ch.1 M/F**	**ch.2 M/F**	**ch.3 M/F**	**ch.4 M/F**	**tr.1 M/F**	**tr.2 M/F**	**tr.3 M/F**	**ba.1 M/F**	**ba.2 M/F**
scape	3/3	—	—	12/13	—	—	—	—	—
pedicel	—	—	2/3	9/6*	—	—	—	—	—
f_1	—	—	6/6	—	—	—	—	—	—
f_2	—	—	6/5	—	—	—	—	—	—
f_3	—	—	6/6	—	—	—	—	—	—
f_4	—	—	5/5	—	—	—	—	—	—
f_5	—	—	6/6	—	—	—	—	—	—
f_6	—	—	6/6	—	—	—	—	—	—
f_7	—	—	7/7	—	—	—	—	—	—
f_8	—	2/2	9/10	—	—	12/14	—/1*	1/1	—
f_9	—	7/7	13/13	—	11/8	116/119	6/9*	10/12	2/2
total	3/3	9/9	66/67	21/19	11/8	128/133	6/10*	11/13	2/2

Morphological difference between melanic and succinea groups

No obvious differences are noted in the antennal size, shape, sensilla types and the total number of sensillae between the melanic and *succinea* forms of *H. axyridis*. The sensillar types, s.tr, s.ch, s.ba, s.co and s.bm are the most common sensillae in both the melanic and *succinea* groups. The s.pl and s.sp are unique to the antennae of either the melanic or *succinea* groups, respectively. However, the average of s.tr2 of both sexes in the *succinea* form is slightly more than that of the melanic form (Table 3).

Table 3. Mean number and distribution of antennal sensillae in the antennomeres of the melanic, m, and succinea, s, forms of H. axyridis. "*" represents the presence of significant differences (1 tails, independent samples, equal scadascity t-test) between both sexes of the melanic form of H. axyridis. Ch, tr, and ba represents sensilla chaetica, sensilla trichodea and sensilla basiconicae, respectively. Böhm bristles, sensilla coeloconica, sensilla sporangia, and sensilla placoidea were not counted.

sensilla types	forms	scape	pedicel	flagellomeres 1	2	3	4	5	6	7	8	9	total
ch.1	m/s	3/3	—	—	—	—	—	—	—	—	—	—	3/3
ch.2	m/s	—	—	—	—	—	—	—	—	—	1/2	6/7	7/9
ch.3	m/s	—	4/3	7/6	6/6	6/6	5/5	5/6	5/6	8/7	11/10	13/13	70/68
ch.4	m/s	16*/13	7/8	—	—	—	—	—	—	—	—	—	23/21
tr.1	m/s	—	—	—	—	—	—	—	—	—	—	8/10	8/10
tr.2	m/s	—	—	—	—	—	—	—	—	1*/—	11/13	111*/118	123*/131
tr.3	m/s	—	—	—	—	—	—	—	—	—	1/1	7/8	8/9
ba.1	m/s	—	—	—	—	—	—	—	—	—	1/1	8/11	9/12
ba.2	m/s	—	—	—	—	—	—	—	—	—	—	2/2	2/2

DISCUSSION

A widespread phenomenon in insects is sexual dimorphism in antennae. Usually, the antennae of males are more complex, as males may require relatively more sensillae to detect the sex pheromones needed to find a mate (Howse et al., 1959; Agren, 1995; Kim and Leal, 2000). However, such differences are usually not present, or are infrequent in insects that live gregariously, such as *H. axyridis*, or use auditory or visual organs as sexual cues (Schneider, 1964; Renou et al., 1998). In this study, no obvious differences are observed in the antennal size, amount and distribution of sensillae, as well as sensilla types between the melanic and *succinea* groups. Also, no differences are found in antennal size and total number of sensillae between males and females of each form. On the other

hand, the differences in the sensillar types may also result from the small random sampling of the melanic and *succinea* groups (eight beetles from each color phase or each sex). The sensilla that are unique to either the melanic form or the *succinea* group may, as well, be present on other individuals of other similar forms. The antennal sensillae of *Coccinella septempunctata* have been described by Shefali and Omkar (2003) and they include sensilla trichodea (s.tr), sensilla chaetica (s.ch), sensilla basiconica (s.ba), sensilla campaniformia (s.ca), sensilla ampucellaceous (s.am), sensilla scolopalia (s.sc), sensilla placoidea (s.pl), hook-shaped sensilla and Böhm bristles (s.bm). Despite *C. septempunctata* and *H. axyridis* belonging to the same family, there are differences in the sensilla types. For example, sensilla campaniformia, sensilla ampucellaceous, and hook-shaped sensillae were not present in *H. axyridis*, however, sensilla coeloconica and sensilla sporangium were absent in *C. septempunctata*.

Sensilla trichodea have different functional types; for instance, they are usually responsible for pheromone reception in the antennae of Lepidoptera (Kaissling, 1986; Hansson et al., 1986; Hallberg et al., 1994). In *Drosophila* (Diptera) antennae, s.tr functions as pheromone and plant volatiles receptors (Clyne et al., 1997) but in the female moth *Manduca sexta*, type-A trichoid sensilla is sensitive to three different functional types of plant-associated volatile organic compounds (Shields and Hilderbrand, 2001). S.tr are the most numerous sensilla type in the adult antennae of *H. axyridis*, and are densely distributed on the tip of the flagellum. As for the aggregative habit of *H. axyridis*, we assumed that s.tr are responsible for their aggregative behavior, they may be pheromone receptors.

Functionally, sensilla chaetica have been ascribed to mechano- and chemoreception in the coccinellids, *Semiadalia undecimnotata* and *Pseudoscymnus tsugae* (Jourdon et al., 1995; Broeckling and Salom, 2003). The sensilla chaetica of *Psylliodes chrysocephala* is suggested to be contact chemosensilla, that responds to chemicals presented in plant surface waxes when *P. chrysocephala* contacts a leaf with antennae (Isidoro et al., 1998). The sensilla chaetica herein described resembles those of other insects and are abundant in the antennae of *H. axyridis* in both groups. It is premature to assign any particular function to these sensilla. Sensilla basiconica are used for reception of plant volatiles (Kaissling, 1986; Lopes et al., 2002). Interestingly, in the cigarette beetle *Lasioderma serricorne*, sexual differences in the number of sensilla basiconica have been observed (Okada et al., 1992). Electrophysiological experiments have shown that one of two sensory cells in the sensilla basiconica of the cigarette beetle responds to a natural sex pheromone and the other responds to a behavioural inhibitor (Okada et al., 1993). There are a few sensilla basiconica on the antennae of *H. axyridis*, thus they are hypothesized as possible plant volatile receptors.

The sensilla coeloconica described in *H. axyridis* are similar to that of other beetles, such as *Bembidion lampros* Hbst. (Coleoptera: Carabidae) (Merivee et al., 2000). Moreover, sensilla coeloconica situated on the antennae of *C. septempunctata* and ground beetle, *Carabus fiduciarius saishutoicus*, are classified as

sensilla ampullaceal (Kim and Yamasaki, 1996). Sensilla coeloconica are sensitive to water vapors, carbon dioxide, and thermal changes in Orthropterans and Dipterans (Waldow, 1970; Davis and Sokolove, 1975). So far there are a few reports of sensilla coeloconica functioning in chemo-, thermo-, or hygroreception have been proven (Zacharuk, 1985). Therefore, s.co is presumed to be related to the above functions.

Sensilla placodea (s.pl) are selective to different odors, having been identified as sex pheromone receptors in *Popillia japonica* and *Anomala cuprea* (Coleoptera: Scarabaeidae) (Kim and Leal, 2000; Larsson et al., 2001). On the antennae of *Oryctes rhinoceros*, sensilla placodea function as olfactory sensilla for aggregation pheromone and plant volatiles (Renou et al., 1998). Sensilla placodea also responds to plant volatiles in the parasitoid *Microplitis croceipes* (Hymenoptera: Braconidae) (Ochieng et al., 2000). The sensilla placodea herein described is notably less abundant than sensilla trichodea, sensilla chaetica, sensilla basiconica and Böhm bristles, and is only situated on the scape of the melanic forms of *H. axyridis*. Although their functions are not clear, the role of these sensilla is considered to be related to reception of pheromone and plant volatile. Böhm bristles are located at the intersegmental joints between the head and the scape, as well as between the scape and the pedicel of *H. axyridis*. Similar distribution patterns have been found in other insects (Merivee, 1992; Merivee et al., 1998). In the honeybee, Böhm bristles were shown to be phasic-tonic mechanoreceptors (Schneider, 1964). Presumably, they may be used to perceive the antennal position and movement.

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ERRATA

The following typos were detected in Santiago-Blay [2009, *Entomological News* 120(1)] before printing, but could not be edited out in time.

Page 115 — second line in text of the *Rhopalurus* section should read, "with an elevated 'Λ'-shaped area (Fig. 10)"

Back Cover — the first word of the title should have been "Systematics."