J. Insect Biodivers. Syst. 09 (4), 663–678

https://jibs.modares.ac.ir

OPEN ACCESS

Tarbiat Modares University Press | Research Article | https://doi.org/10.61186/jibs.9.4.663 | ISSN: 2423-8112

Entomological Society of Iran | Functional Morphology | https://zoobank.org/urn:lsid:zoobank.org:D7435C53-7B30-47A3-9FF5-133E26AD7663

Morphology, ultrastructure and sexual dimorphism in antennal sensilla of *Belionota prasina* (Thunberg, 1789) (Coleoptera, Buprestidae)

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ABSTRACT. The "jewel beetle" - *Belionota prasina* (Thunberg, 1789), is a polyphagous insect pest found throughout India and its neighboring countries. To develop semiochemical-based pest control strategies, we must first comprehend the entire morphological features of the insect's antennal sensory structure. This is the first study report revealing the morphology and ultrastructure of antennal sensillae of male and female of *B. prasine* using light and scanning electron microscopy. Both antennae are serrated in appearance with 11 antennomers. In both sexes, Böhm sensilla, sensilla trichodea, sensilla basiconica, sensilla chaetica, and multiporous grooved peg sensilla are common. Sexual dimorphism is present in the case of length and width (basal and distal) of entire antenna as well as each antennomer. Male antennomeres are larger and more robust. The antenna of *B. prasina* shows a high degree of sexual dimorphism. The C4 type aporous serrated sensilla chaetica, which serves a tactile function, are highly specific to male antennae. The sensilla basiconica subtype 4 is found in female antennomeres while multigrooved are pegs present only in male antennomerers. The number and type of sensillae are greater in males than females. Apical fossae are present dorsally and ventrally on each male antennomere. The function and distribution of all types of sensilla are explained and illustrated in this paper.

Received:
20 December, 2022

Accepted:
25 July 2023

Published:
07 August, 2023

Subject Editor:
Reza Zahiri

Key words: Antennal sensilla, Buprestidae, chemical ecology, light microscopy, SEM.

Citation: Seena, S., Anand, P.P. & Shibu Vardhanan, Y. (2023) Morphology, ultrastructure and sexual dimorphism in antennal sensilla of *Belionota prasina* (Thunberg, 1789) (Coleoptera, Buprestidae). *Journal of Insect Biodiversity and Systematics*, 9 (4), 663–678.

INTRODUCTION

An insect antenna is the primary olfactory organ that plays a significant role in host plant selection, searching for an ovipositor site, intersexual communication, and so on (Zacharuk, 1985; Shields, 2004; Zhang et al., 2015). Moreover, the insect antennae had several sensory structures called sensilla, which can recognize the volatile with odorant-binding proteins (Zacharuk, 1980; Pitts & Zwiebel, 2006). The greater part of these sensillae are involved in the detection of odors, temperature, and humidity but those located on the scape and pedicel are mostly mechano-receptors that allow the individual to monitor the

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movement of antennae (Liu et al., 2013). To better understand the olfactory mechanisms and aid in the identification of electro-physiologically active molecules, studies of the structures of sensillae in insects are crucial. As a result, studies of the chemical ecology of insects for behavioural control and their use in elucidating the communication system between conspecific insects are becoming more and more dependent on the olfactory sensory system (da Silva et al., 2019).

In beetles, antennae show coordinated responses to the pheromones in the presence of host plant volatiles (Lopes et al., 2002; Ploomi et al., 2003; Crook et al., 2008; Giulio et al., 2012; MacKay et al., 2014). Sexual dimorphism in antennae is a common occurrence that is sometimes associated with the occurrence of various sense organs. Male antennae are more complex than female antennae, and it has been regarded as an expression of the needs of the male, who has relatively more sensillae to find his partner (Schneider, 1964). The control and management of a pest is important for the reduction of damage caused by invasive pests like jewel beetles, and which are often included in the introduction of biological control programs (Bauer et al., 2008) and also in the uses of pheromone traps (Vuts et al., 2016; Silk et al., 2019). In the case of "stem borers", semiochemical based management is more effective than pesticide-based management. It is critical to investigate the ultrastructure of antennal sensilla because olfactory antennae in insects capture sex pheromones and host volatiles. *Belionota prasina* (Thunberg, 1789) commonly known as the buprestid stem borer or metallic wood-boring beetle, is a polyphagous insect pest, widely distributed in India, China, Taiwan, Thailand, Malaysia, Indonesia, Borneo, Africa, USA and Northern Australia (Fletcher, 1918; Thery, 1929; Tung, 1983; Bellamy, 2002; Ramasamy, 2018; Schnepp et al., 2020).

Belionota prasina has been reported to cause damage to *Ceiba pentandra* (L) Gaetn, *Delonix regia* (Boj. ex Hook.) Raf., *Anacardium occidentale* L., *Casuarina* spp., and *Mangifera indica* L. (Tung, 1983; Bellamy, 2002; Hawkeswood, 2002; Sing & Kaur, 2014; Ramasamy, 2018). The larvae, which are mainly found in the dead trunks of the mango trees, cause approximately 20% of damage to the trees (Sing & Kaur, 2014); similar kinds of damage were also observed in cashew (Ramasamy, 2018). In this study, we examined the ultrastructure of antennal sensilla of male and female *B. prasina* by means of light and scanning electron microscopy. The goals of this research are to identify the different types of sensillae, their distribution, function, and differences in their number, which will give us a better understanding of the olfactory sensory system in *B. prasina*.

MATERIAL AND METHODS

Reference specimens. Adult beetles of *B. prasina* were collected from the Botanical Garden (11º08'01"N 75º53'24"E, 70m), University of Calicut, Kerala, India using Malaise traps. Identity of the species was confirmed by CO1 barcoding according to Seena and Shibu Vardhanan (2022). The amplified COI sequence of *B. prasina* deposited in NCBI GenBank, and the accession number is OM033623. Collected specimens were brought to the laboratory in separate vials, subjected to cold anesthetization, and fixed in 2.5% glutaraldehyde in sodium cacodylate buffer for 6 h. at 4ºC. In order to remove the debris from the specimen prior to fixation, the collected specimens were initially subjected to a brief indirect sonication in a water bath for 1 min. The sex of the individual specimens was determined by genitalia dissection. All specimens were stored in separate vials in 75% alcohol till further examination under a stereo microscope and scanning electron microscope (SEM).

Light microscopy. To observe the type of sensillae, the antennae from both sexes were separated and placed in 75% ethanol in order to separate the lamellae. For light microscopic studies, images were taken with a Carl Zeiss, SteREO Discovery V.20 attached with a 6 MP CCD sensor camera and resized in Adobe Photoshop CS8 for the standardization of background and removing artifacts formed during stacking; Image J software was used for measurements (Fig. 1).

Scanning electron microscopy (SEM). For scanning electron microscopy, 2.5% glutaraldehyde fixed antennae were dehydrated through a graded acetone series (70%, 80%, 90%, 100%) of 20 min each and then dried in an oven at 35ºC for 2 h. The dried samples were mounted on an aluminium stub with double-sided sticky carbon tap and sputtered with gold.

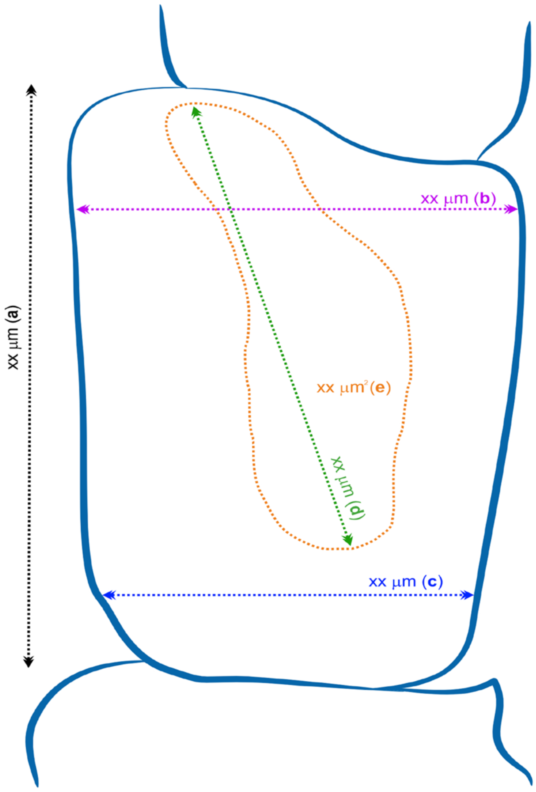

Figure 1. Schematic representation and morphometry of antennomere. *a* - Length of antennomere or antennal segment; *b* - Distal width; *c* - Proximal width; *d* - Area of apical organ.

The fine structures of male and female antennae were examined with a scanning electron microscope (Zeiss Field Emission Scanning Electron Microscope FE-SEM Gemini-300). Six antennae from each sex were used for the entire analysis. Nomenclature and classification of sensilla were done following Zacharuk (1985) and Volkovitsh (2001). The SEM images were processed in Adobe Photoshop CS8, and measurements were conducted with Image J software. Sensilla were classified based on their morphology, location and possible function.

Statistical analysis. Statistical significance differences between male and female were analysed by independent t-test. All data were expressed as mean±standard error (M±SE); SPSS v. 20 software used for statistical analyses.

RESULTS

Taxonomic hierarchy

Class Insecta Linnaeus, 1785

Order Coleoptera Linnaeus, 1758

Family Buprestidae Leach, 1815

Genus *Belionata* Eschscholtz, 1829

***Belionota prasina* (Thunberg, 1789)**

The general structure of antennae. Antennae comprised of 11 antennomeres: antennomere 1 (scape) and 2 (pedicel) invariable in all specimens and bear only trichiod sensillae; antennomere 3 longer than segment 2; antennomeres 4–10 serrate and highly variable between sexes; antennomere 11 irregular in shape. The location and shape of the sensory organs vary in shape on the apical antennomeres; however, all antennal fossae are open and form long furrows (Figs 3 & 4)

Types of sensilla. There are five different types of sensilla (Fig. 2) with their subtypes identified in the antennae of *B. prasina*: Böhm sensilla, sensilla chaetica (four subtypes), basiconica (five subtypes), sensilla trichodea, and multigrooved peg.

Böhm's sensilla (BS). The sensilla have a tight socket and short, smooth, thorn-like bristles with a sharp tip (Fig. 5E) which are mainly located at the base of the scape and pedicel. The average length is 23.9±2.6 µm. These are actually sensilla trichodea and recently have been named Böhm sensillae by Böhm who described that in Lepidoptera in 1911.

Sensilla chaetica (C1–C4). Sensilla chaetica can be identified by their longitudinal furrows and specialised, circular rings at their bases, which are inserted in a large circular ring. The bristles of this sensillae are sharp and pointed without apical pores or wall pores. There are four subtypes of sensillae chaetica were identified in both sexes of *B.prasina*

a. *Subtype 1 (C1).* Aporous sensilla chaetica: Sensilla chaetica 1 are long and slender sensilla, with longitudinal grooves on the wall without pores (Fig. 5A). In *B.prasina* these types sensilla are located in the apical region of antennomeres from 4th to 11th and which is the longest sensilla with a length of 178.6±1.2 µm .

b. *Subtype 2 (C2).* Uniporous sensilla chaetica: Sensillae chaetica 2 are curved sensillae (Fig. 5A), which are shorter than C1 inserted into funnel-shaped depression and the average length is 100.9±2.7 µm.

c. *Subtype 3 (C3).* Aporous sensilla chaetica: Sensilla chaetica 3 aporous chaetoid sensillae with a basal socket. These are short and stout and the walls are smooth without pores (Fig. 5B). C3 type sensillae are located at the sides and outer margins of antennomeres in both sexes. The average length is 33.8±0.03 µm.

d. *Subtype 4 (C4).* Aporous serrated sensilla chaetica: Aporous serrated sensilla chaetica (Fig. 5C, D) which are distributed along the inner side of antennomeres in males from 4th antennomers onwards. The average length of these sensilla is 268.2±31.4 µm

Sensilla basiconica (Sb1-Sb5). All subtypes of sensilla basiconica usually present inside apical organs and their number depends on the size. These are the trichoid type of sensilla without any basal membrane. These come under Type B4.

a. *Subtype 1 (Sb1).* These are multiporous cone-like sensilla with filamentous tips (Fig. 6A) present inside the apical organ. The average height of Sb1 is 8.7±0.9 µm.

b. *Subtype 2 (Sb2).* These sensilla are multiporous peg-like or cone-like sensilla, (Fig. 6A), and the apical end is curved in appearance. The average length is 5.07±0.5 µm.

c. *Subtype 3 (Sb3).* Subtype 3 sensilla basiconica is short cone-shaped multiporous sensilla that are flattened and round tip, which is present at the inner margin of the apical organ (Fig. 6B). The average length of these sensilla is 3.6±0.1 µm,

d. *Subtype 4 (Sb4).* Short cone-shaped with sharp tip sensilla (Figs 6C, 6D) having multiporous walls located at upper edges of apical organ only in 4th flagellomeres in females which comes under type B4 (subtype B4c) and the average length is 6.4±0.8 µm.

e. *Subtype 5 (Sb5).* Short cone-shaped multiporous basiconic sensilla located singly at the lateral sides of male antennomeres in between the C4 sensilla from 4th flagellomeres onwards and the average length is 7.6±0.04 µm (Fig. 6E).

Multiporous sensilla trichodea (MST). Long, slender, and tapering at the tip. It has three glandular pores on one side. MST are present in both sexes with an average length of 22.6±0.1 µm (Fig. 5F).

Multiporous grooved pegs (MGP). The MGP is a bulbous-headed cone-shaped sensillum having 8 wide grooves running from the middle to the tip (Fig. 6A). Iit appears singly inside the apical organ only in males. The average length is 2.6±0.2 µm. It comes under type M5 (according to Volkovittsh, 2001).

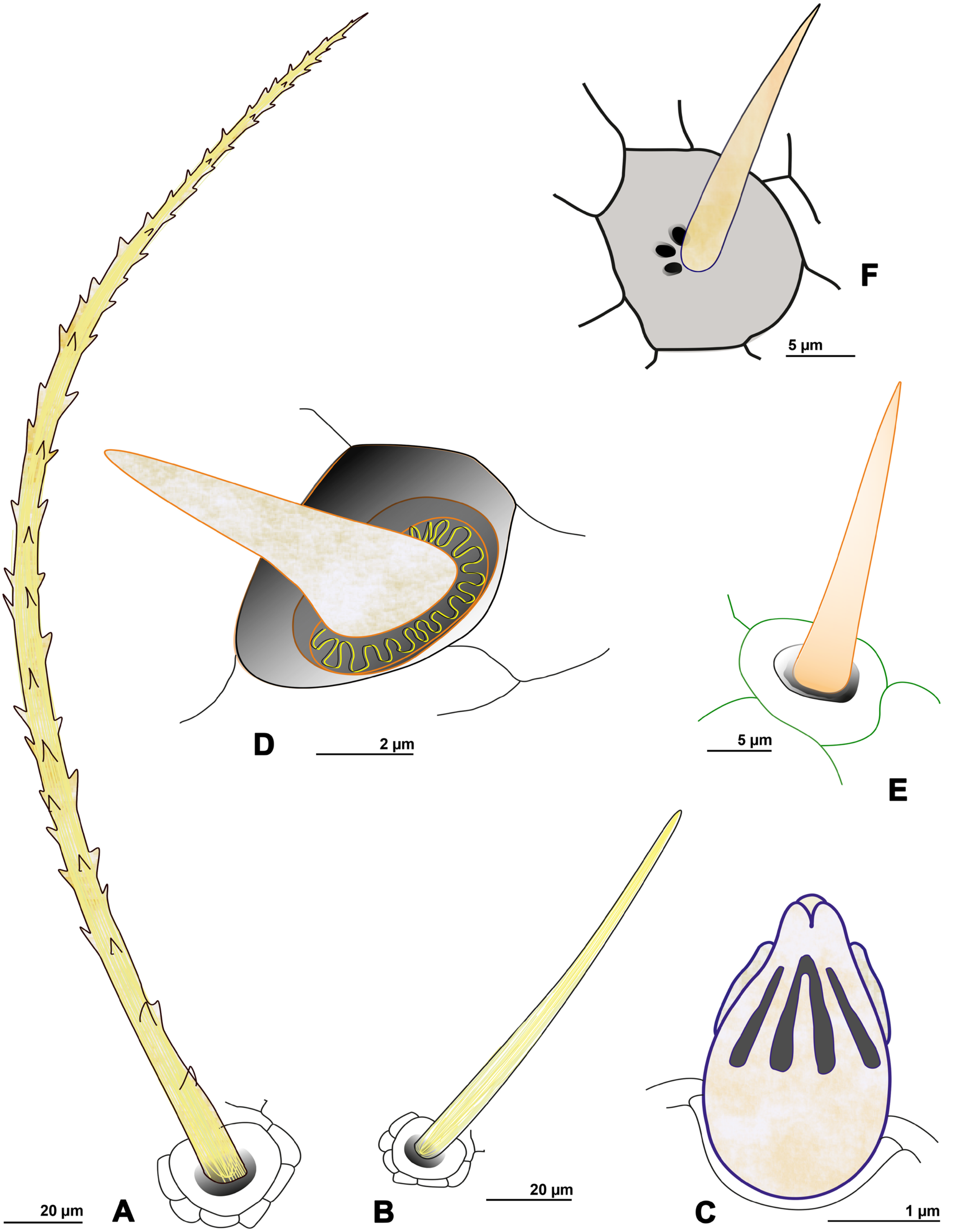

Figure 2. Schematic representation of major types of sensilla present in *B. prasina*. **A.** Sensilla chaetica (C4); **B.** Sensilla chaetica; **C.** Multigrooved peg; **D.** Sensilla basiconica; **E.** Böhm sensilla; **F.** Trichoid sensilla.

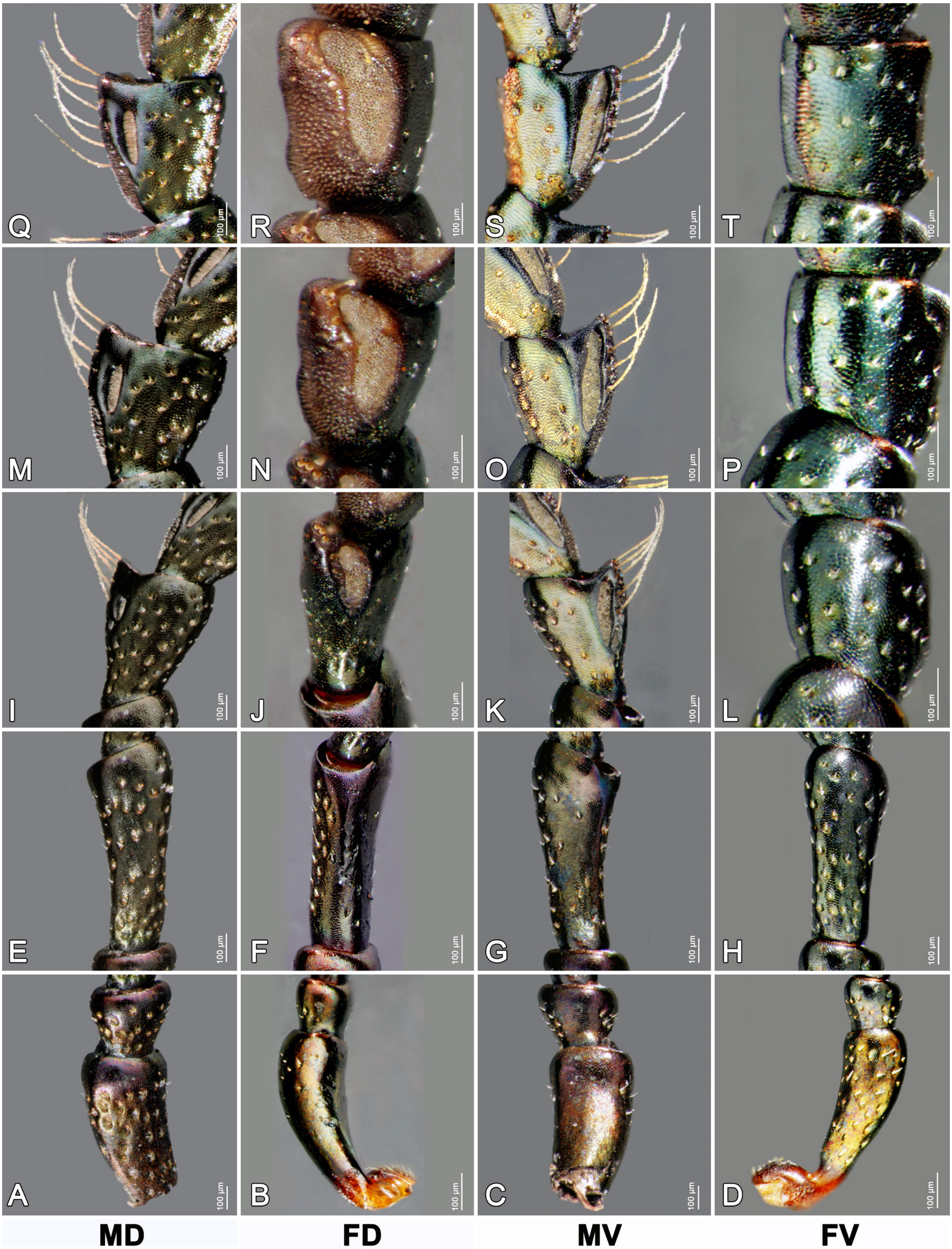

Figure 3. General morphology of antennomeres in male and female *B. prasina.* MD – Male dorsal, FD – Female dorsal, MV – Male ventral, FV – Female ventral; antennal segments 1-6 (bottom to top).

Figure 4. General morphology of antennomeres in male and female *B. prasina*. **MD** – Male dorsal, **FD** – Female dorsal, **MV** – Male ventral, **FV** – Female ventral; antennal segments **7–11** (bottom to top).

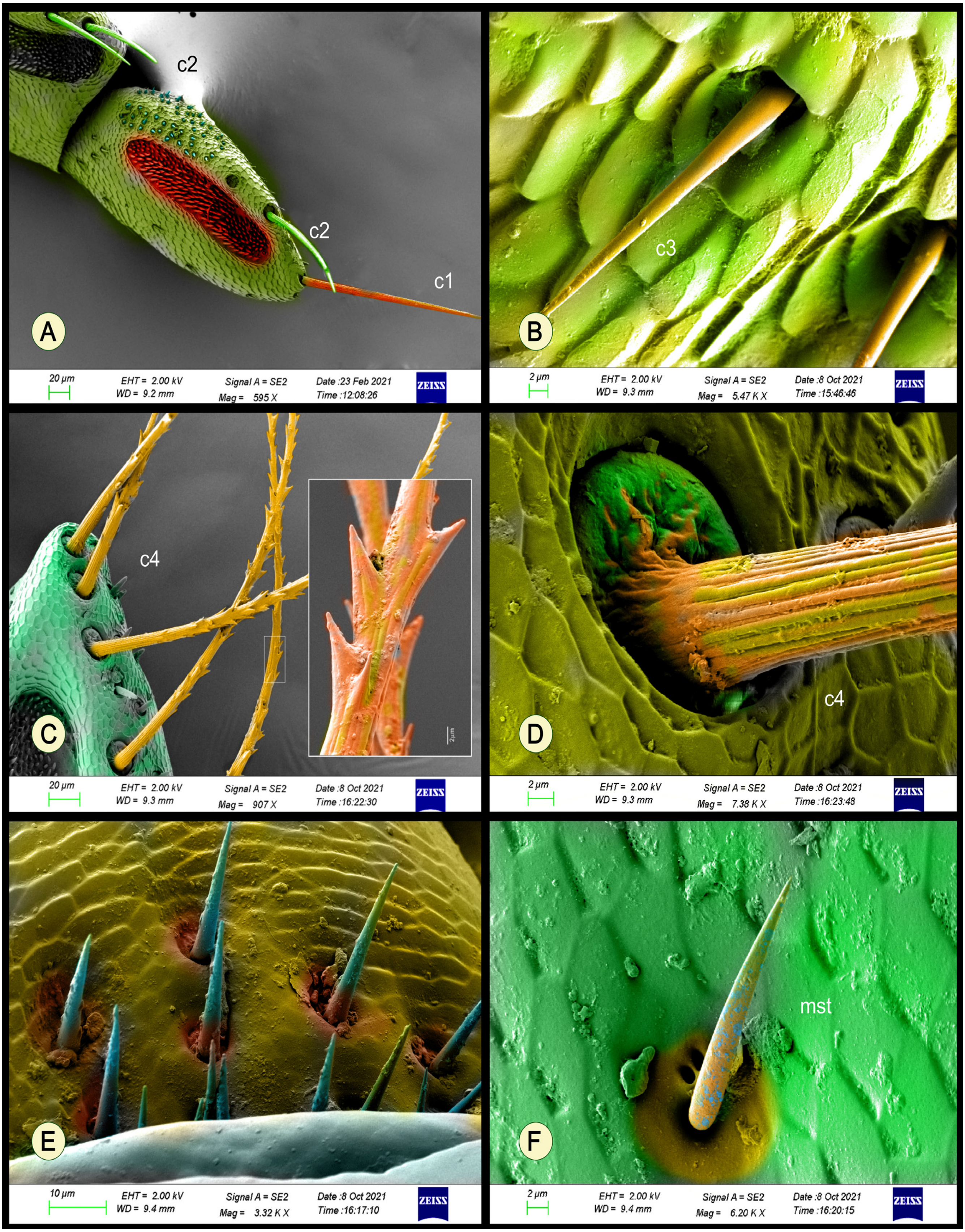

Figure 5. SEM micrographs of the antennal sensilla of *Belionota prasina*. **A.** Aporous sensilla chaetica C1 & C2 on the 11th antennomere, ♀; **B.** Aporous sensilla chaetica C3; **C.** Aporous serrated sensilla chaetica C4 on the 11th antennomere, ♂; **D.** Basal region of Aporous serrated sensilla chaetica; **E.** Bohm's sensilla of male on the pedicle; **F.** Multiporous trichoid sensilla (MST) with glandular pores.

Sexual dimorphism. The male antenna is longer (length: 5321.9±144.8 µm) than the female (length: 4351.8±183 µm), as well as the lengths of segments 3–11 (Table 1). Also, male and female antennomeres show considerable variation in their basal and distal widths where, except for segment 11, female antennomeres are considerably wider (Table 1). The number and types of sensillae is significantly different between the sexes. C4 (Figs 5C, 5D) is the most noticeable sex difference, is present only in male antennomeres. Sb3 (Figs 6B) is present in both sexes, but is more numerous in females than in males. Sb4 (Figs 6C, 6D) is present only in female antennae, while multiporous grooved pegs (Figs 6A) are present in male antennae. Sb5 (Figs 6E) is present only in the lateral sides of the 4th flagellomere onward in male antennae, and the 11th flagellomere is longer and has more C4. This has a somewhat round and small apical organ with less basiconic sensilla. Male and female apical organ arrangements also differed significantly. Male *B. prasina* antennae have apical fossae on both the dorsal and ventral sides, with the dorsal fossae being small and arranged on the 4th to the 10th segments, and the ventral side having well-developed apical fossae with sensilla basiconica on the 4th to 11th segments. In females, the apical organ is well developed on the dorsal side of antennomeres 4–11, but it is only present on the ventral side of the 10th antennomere. In addition, the area and length of apical fossae is different between males and females (Table 2, Table 3).

Table 1. Morphometric features of the antenna; segments in male and female *B. prasina* (n=6). Independent t-test used for testing the statistical significant differences between the means for female and male comparison, *p<0.05, ns- non significant.

Antennal segments	Length (µm)		Width (µm)			
			Basal		Distal	
	Male	Female	Male	Female	Male	Female
1st	549.06±55.40	782.70±105.9*	273.69± 83.07	320.90±69.30ns	173.00±35.1	291.70±42.0*
2nd	270.54±62.20	281.90±53.50ns	192.90±44.00	275.95±74.30*	215.90±33.7	247.10±47.0ns
3rd	843.20±96.20*	639.30±94.70	198.81±44.50	290.35±78.60*	175.90±34.4	241.50±55.6ns
4th	490.67± 98.96ns	433.00±92.23	190.56±33.40	349.09±83.50*	157.30±22.0	255.00±52.0*
5th	370.15±83.40ns	316.80±72.80	206.70±47.60	339.02±83.00*	161.20±23.3	248.40±71.6*
6th	406.00±80.40*	329.10±80.87	188.80±45.30	306.61±63.30*	180.82±30.5	241.60±73.7ns
7th	405.20±91.70*	319.90±73.90	201.50±42.60	282.10±71.50ns	175.30±22.2	224.54±79.4ns
8th	476.07±84.50*	324.90±71.80	170.00±32.30	238.80±55.50ns	159.60±24.2	200.30±41.1ns
9th	474.10±94.30*	332.75±91.20	107.70±19.30	142.40±33.20 ns	131.41±12.7	170.40±61.6ns
10th	501.40±85.70*	310.46±60.90	080.40±14.10	146.09±31.70*	103.33±21.7	137.73±32.7ns
11th	535.60±98.20*	281.04±65.80	086.49±11.20ns	057.15±17.60	076.40±13.5	035.38±12.9
Total length	5321.9±144.8	4351.8±183.0				

Table 2. Morphometric features of apical organ on the dorsal side of antennomers in male and female *B. prasina* (n=6). Independent t-test used for testing the statistical significant differences between the means for female and male comparison (male dorsal area *vs.* female dorsal area and male dorsal length *vs.* female dorsal length), *p<0.05.

Segments	Male Dorsal		Female Dorsal	
	Area (µm²)	Length (µm)	Area (µm²)	Length (µm)
4th	1894.70±103.2	089.44±12.0	08439.15±126.2*	155.45±15.0*
5th	4110.27±133.0	150.45±14.0	21114.69±141.3*	265.04±36.9*
6th	4575.40±121.3	166.20±13.9	18048.55±124.0*	256.24±28.1*
7th	3414.89±118.8	169.40±10.6	20383.45±127.9*	260.24±22.5*
8th	3023.90±120.0	165.80±21.3	18451.01±124.4*	244.87±22.6*
9th	1949.80±126.1	125.60±11.8	14775.81±123.7*	238.67±23.2*
10th	1051.00±114.0	060.60±08.2	11509.50±118.7*	234.71±21.9*
11th	Absent	Absent	04429.87±118.0	186.30±20.8

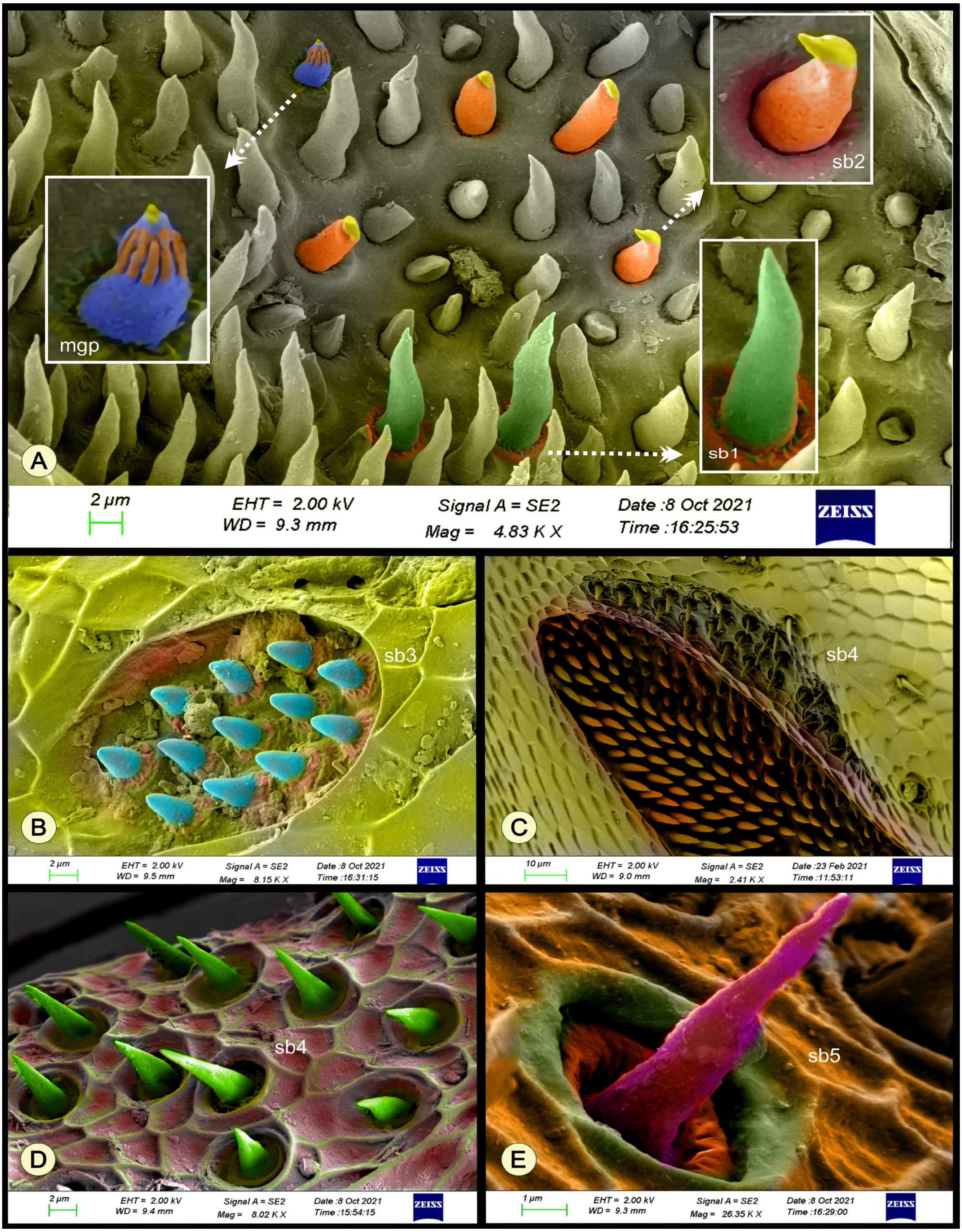

Figure 6. SEM micrographs of the antennal sensilla of *Belionota prasina.* **A.** Multiporous sensilla basiconica Sb1 and Sb2 and multiparous grooved peg (mgp); **B.** Multiporous sensilla basiconica Sb3 present inside the apical organ; **C.** 4th antennomere of female showing apical depression and multiporous sensilla basiconica Sb4; **D.** Multiporous sensilla basiconica Sb4; **E.** Sensilla basiconica Sb5 in male antennomere.

Table 3. Morphometric features of apical organ on the ventral side of antennomers in male and female *B. prasina* (n=6). Independent t-test used for testing the statistical significant differences between the means for female and male comparison (male ventral area *vs.* female ventral area and male ventral length *vs.* female ventral length), *p<0.05.

Segments	Male ventral		Female ventral	
	Area (μm²)	Length (μm)	Area (μm²)	Length (μm)
4th	10553.19±127.2	265.07±12.3	Absent	Absent
5th	15130.48±129.3	314.93±14.3	Absent	Absent
6th	15076.69±123.4	322.46±11.7	Absent	Absent
7th	14219.79±135.9	300.16±14.0	Absent	Absent
8th	11048.07±133.0	341.45±12.9	Absent	Absent
9th	09898.11±129.1	295.69±14.2	Absent	Absent
10th	05372.45±140.6*	255.60±11.5*	1549.3±132.6	96.3±12.3
11th	00406.54±128.3	34.2±4.7	Absent	Absent

DISCUSSION

In this work, more attention was given to the type, location, and potential function of antennal sensillae in male and female *B. prasina*. Our main goal was to determine if sexual dimorphism in antennal structure occurs. The antennae of both sexes are serrated with 11 antennomeres. Male and female antennae differ morphologically due to the presence of special aporous serrated sensilla chaetica (C4) on the outer surface of male antennae that are absent in females, and male antennomeres are slightly larger and more robust than females. While comparing the sensilla in both sexes reveals certain differences. From the SEM analysis, we identified five different types of sensillae, two of which have subtypes. Böhm sensilla, sensilla chaetica, sensilla basiconica, sensilla trichoid and multiporous grooved peg are the main sensillae in both sexes. All nomenclature and classification of sensillae are based on the work of Volkovitsh (2001), Zacharuk (1985) and Faucheux et al. (2020a, 2020b). Volkovitsh (2001) did a comparative morphology study of buprestid antennae of 412 species from 316 genera, and six genera of Elateriformia using SEM and grouped buprestid sensillae into seven types.

The types of sensilla present in the *B. prasina* is somewhat similar to the sensilla of *Lamprodila festiva* (Coleoptera: Buprestidae) reported by Faucheux et al. (2020b) except for the aporous serrated sensilla chaetica which are present in *B. prasina*. The apical organ contains different types of basiconic sensilla, sensory organ of each antennomere is the abundance of sensilla, which is common among buprestid species and has high taxonomical importance. It has been used for the systematics and classification of the groups (Bellamy, 1985; Volkovitsh, 1990, 2001). Böhm bristles are very common among coleopterans. They are located in the basal region of scape and pedicel and might act as mechanoreceptors with a proprioceptive function (Schneider, 1964; Zachauruk, 1985); their location in many insects indicates that these are responsible for the positioning and movement of the antennae (Merivee et al., 2002). Sensilla chaetica found in our study is a common sensillae in all insects (Merivee et al., 1998; Faucheux et al., 2006) including Coleoptera (Dyer & Sea brook, 1975). In the present study, we identified four subtypes of sensilla chaetica and it is believed that these sensillae have dual functions like mechanoreception and chemoreception (Isidoro & Solinas, 1992; Jourdan et al., 1995). C1 are long aporous sensilla chaetica, which are present in both sexes, mainly found at the apical region of antennomeres from 4th antennomeres onwards, and function as tactile mechanoreceptors and responds to mechanical stumuli (Zacharuk, 1985; Altner, 1977). C2 are uniporous sensilla chaetica which function as contact chemoreceptor (gustatory) (Zacharuk, 1985). C3 are aporous sensilla chaetica with a mechanoreceptive function, while C4 are aporous serrated sensilla chaetica, are only present in the male with tactile function; these sensilla resemble *Hylastinus obscurus* type II aporous sensilla chaetica (Palma et al., 2013) and its tactile function in male antennae seems to be more significant than in female antennae. Sensilla basiconica also has been reported in many Coleoptera species and Yi et al. (2016) reported four types of sensilla basiconica in *Agrilus mali* Matsumura; each subtype are specialised for particular plant volatiles and involved in the host selection and location (Zachuruk, 1985; Shields & Hildebrand, 1999). In *B. prasina* clusters of basiconic sensillae seen in the apical organ is believed to play an important role in the olfactory system in the case of food searching during flight (Faucheux et al., 2006), while in *Agrilus planipennis* Fairmaire basiconic sensilla are located at the distal region of flagellomeres (Crook et al., 2008). The MST with three glandular pores found in this study has a similar sex pheromone-receiving function to the trichoid sensillae found in many insects. The presence of pores along the cuticle of MST suggests an olfactory function for detecting odour molecules and insect pheromone molecules (Hansson, 1995; Li et al., 2018). In *B. prasine,* sensilla trichoidea are present in both sexes but the role of such sensilla in females is not understood. MGP or multiporous basiconic groove-walled sensilla is observed only in male *B. prasina* and serves as an olfactory function. This multiporous sensory organ's large number of chemosensory neurons suggests that it may be capable of fine odour discrimination in relation to plant-host location (Giglio et al., 2008). Several insects have antennae that emit and detect semiochemicals. Chemical and behavioural studies show that females emit compounds that are recognised by the males' olfactory system (antennae), resulting in behavioural activity (Ando et al., 2004; Johnson et al., 2017).

Antennal sexual dimorphism is a common occurrence that is sometimes linked to the development of various sense organs. Male antennae are more complex than female antennae, and this has long been thought to be an expression of the male's need to find his partner, as he has more sensilla. In the present work, we could observe a well-known sexual dimorphism in the antennal morphology of *B. prasina*. Here male antennae are larger and more robust than female antennae and the type of antennomeres are remarkably different. The length of the apical organ is also showed differences; males have a more elongated apical fossa, which may contain more olfactory sensillae. A total of five sensillae with their subtypes were identified through SEM analysis. Sb4 is present only in females while Sb5 is present in males only. C4 is present throughout the outer margins of antennomeres, with tactile function. Meanwhile, MGP present inside the apical organ of males, are similar to the MGP present in both sexes of *Lamprodila festiva* for perceiving odors from host plants (Faucheux et al., 2020b). Male and female antennae have different apical organs. Male antennae have apical fossae on both sides, which are accumulated with sensilla basiconica, and serves an olfactory function. Because the apical organs would be exposed directly to the airflow as chemoreceptors, the location of these organs in relation to antennal position during flight would allow for the concentration of odour stimuli within the lumen of the slit. The efficiency of odour detection by sensilla basiconica within the slit would appear to be increased, as the probability of an odour molecule striking a sense hair would also be increased, as odours are concentrated within the slit (Scott & Garra, 1975).

We investigated the type, distribution, and function of antennal sensilla in male and female of *B. prasina* and discovered significant sexual dimorphism. Except for the presence of C4 in males, MGP and Sb3 all other sensilla types present in both sexes are similar. Böhm sensilla, sensilla chaetica with its three subtypes, sensilla basiconica with its five subtypes, MGP and MTS are the main types of sensilla identified. Such research is critical for the development of semiochemicals for the management of invasive pests such as jewel beetles.

AUTHOR'S CONTRIBUTION

The authors confirm their contribution in the paper as follows: S.S. & Y.S.V.: Conceptualization; S.S., P.P.A. and Y.S.V.: Conceived and designed the experiments; S.S. and P.P.A.: Performed the experiments; S.S., P.P.A. and Y.S.V.: Analysis and interpretation of the data; S.S. and P.P.A.: Wrote the main manuscript; P.P.A. and Y.S.V.: Reviewing and editing the manuscript; Y.S.V.: Supervision. The authors read and approved the final version of the manuscript.

FUNDING

The present study was financially supported by UGC-SAP (F.3-6/2012 (SAP-II) dated 10.10.2012).

AVAILABILITY OF DATA AND MATERIAL

The specimens listed in this study are deposited in the Biochemistry & Toxicology Division, Department of Zoology, University of Calicut, and are available from the corresponding authors, upon request. The data sets generated during and/or analyzed during the current study are presented in the main manuscript

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

ACKNOWLEDGMENTS

We thank the Department of Zoology, the University of Calicut for providing the infrastructural facility. Also, gratitude to the Central Sophisticated Instrumentation Facility (CSIF), the University of Calicut for providing the SEM facility.

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ریخت‌شناسی، فراساختار و دوشکلی جنسی در گیرنده‌های حسی شاخکی سوسک *Belionota prasina* (Coleoptera, Buprestidae) (Thunberg, 1789)

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| **تاریخ دریـافت:** ۲۹ آذر ۱۴۰۱ | **تاریخ پذیرش:** ۰۳ مرداد ۱۴۰۲ | **تاریخ انتشار:** ۱۶ مرداد ۱۴۰۲ |

چکیــده: سوسک جواهر - *Belionota prasina* (Thunberg, 1789) آفتی چندخوار است که در سرتاسر هند و کشورهای مجاور آن انتشار دارد. به منظور توسعه روش‌های کنترل آفت مبتنی بر پیام‌رسان‌های شیمیایی، ضروری است که شناخت کافی از خصوصیات ریخت‌شناسی ساختار گیرنده‌های شاخکی حشره داشته باشیم. این تحقیق، اولین مطالعه‌ای است که ریخت‌شناسی و فراساختار گیرنده‌های حسی شاخک حشرات نر و ماده گونهٔ *B. prasine* را با استفاده از تصاویر میکروسکوپ نوری و الکترونی گزارش می‌کند. شاخک هر دو جنس از نوع اره‌ای و شامل ۱۱ بند می‌باشد. در هر دو، انواع مختلف گیرنده‌ها شامل Böhm، trichodea، basiconica، chaetica و multiporous grooved peg به فراوانی دیده می‌شود. دوشکلی جنسی در مورد نسبت طول و عرض (قاعده‌ای و انتهایی) در کل بندها و در بند وجود دارد. بندهای شاخک حشرهٔ نر بزرگ و ستبر هستند و به طور کلی دو شکلی جنسی در شاخک این گونه زیاد است. نوع C4 گیرنده‌های غیر متخلل اره‌ای از نوع chaetica، که نقش لامسه‌ای دارد در شاخک حشره نر بسیار اختصاصی توسعه یافته است. گیرنده‌های زیرگروه ۴ از نوع basiconica در بندهای شاخک حشره ماده یافت شد در حالی‌که گیرنده‌های نوع چندشیاری به صورت زواید میخ‌مانند و تنها در بندهای شاخک نر وجود دارند. تعداد و نوع گیرنده‌ها در شاخک نر نسبت به ماده بیشتر است. حفره‌های انتهایی در بخش پشتی و شکمی هر یک از بندهای شاخک سوسک نر وجود دارند. وظیفه و توزیع همه انواع گیرنده‌های روی شاخک در این مقاله تشریح و به تصویر کشیده شده است.

واژگــان کلیدی: گیرنده‌های شاخک، گوهرسوسکان، میکروسکوپ نوری، میکروسکوپ الکترونی، اکولوژی شیمیایی