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Ultrastructure on antennae and mouthparts in larvae of soybean hairy caterpillar, *Spilarctia casigneta* Kollar (Lepidoptera: arctiidae)

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Abstract
The present study deals with ultra-morphology of antennae and mouthparts of larvae of Soyabean Hairy Caterpillar i.e., *Spilarctia casigneta* Kollar with aid of scanning electron microscopy with particular focus on sensilla. This species is a serious pest of beans and causes a serious threat to rice bean as it attacks the lower surface of the leaves of rice bean. The antennae and mouthparts of all instars have been examined to study the distribution and morphology of sensilla. The antennae possess total eight sensilla referable to three types: a) 3 small basiconica on pedicel and 3 large basiconica on flagellum, b) 1 chaeticum on pedicel, c) 1 styloconicum on flagellum. The labrum bears six pairs of sensilla chaetica. Mandibles have 3 teeth and 2 sensilla chaetica each. Maxillae have a single sensillum chaeticum on both cardo and stipe. Each galea has a total of 6 sensilla: a) 3 sensilla trichodea, b) 2 sensilla styloconica, c) 1 central sensillum basiconicum. The distal segment of maxillary palp possesses clusters of 8 sensilla basiconica and 1 sesillum digitiformium. The metrical analysis of significant structures has been documented and the probable functions of these sensilla are concluded.

Keywords: Sensilla, larva, moths, taxonomy, scanning electron microscopy

1. Introduction
The larvae are usually fleshy, soft, elongate forms of animals with a chitinized semi-circular head capsule. Head bears appendages such as antennae and mouthparts. The larvae pass through different morphological forms and reaching certain host plant, exploiting its different parts and their general behaviour depends on the chemical stimuli perceived by their sensory armature i.e., chemoreception (Zacharuk 1980) [37]. Sensilla are the smallest and functional units of chemoreception and form an essential interface between external and internal sensory environments in insects (Keil 1999; Shields & Hildebrand 2001) [21, 33]. In insects, sensilla occur superficially on different body parts and the antennae and mouthparts are the most prominent sensory appendages accountable for a diversified spectrum of stimuli (Zacharuk 1985) [38], especially considering the possession of olfactory and gustatory receptors responding to semio-chemicals associated with host seeking, orientation and food acceptance (Zacharuk & Shields 1991; Anton *et al*. 2003; Jefferis 2005) [39, 5, 19]. Out of total 10 types of sensilla categorized on the basis of the morphology of their cuticular parts, 9 types namely sensilla chaetica, sensilla trichodea, sensilla basiconic, sensilla styloconica, sensilla coeloconica, sensilla placodea, sensilla campaniformia, sensilla scolopalia and the variant scolopophora i.e., sensilla ampullaceal are represented in immatures. The sensilla squamiformia is one not found in immatures (Zacharuk & Shields 1991) [39].
The Soybean hairy caterpillar, *Spilarctia casigneta* Kollar is a serious polyphagous pest that attacks plant species across several families. It inflicts damage to field bean by defoliating its leaves. In case of rice bean, the leaves gradually turn papery brownish-yellow in colour after its attack (Khadka & Acharya 2009) [40]. The ultrastructure of larval antenna and mouthparts have been investigated for the first time in this species and here we are providing the illustrated account of these structures.

2. Materials and Methods
2.1 Collection and identification
The eggs and different instars were collected from different localities of district Kullu,

Himachal Pradesh, India (31°57′36″N, 77°6′0″E, 1279m) and further reared to adult stage according to protocol stated by Goncalves *et al.* 2020 [17]. Adults were preserved for identification purpose and identification was done on the basis of external morphological characters. (Hampson 1893, 1909).

2.2 SEM

The head of each larval instar was separated and placed in Carnoy's fixative solution (95% ethanol and glacial acetic acid with ratio of 3:1) for 3 hours in case of first 3 instars and for 12 hours for later instars and then kept in 2% glutaraldehyde at 4 °C for 2 hours in case of initial three instars and overnight for later instars. The following day, the samples were cleaned twice with a phosphate buffer (each for 10 min) and washed in 100% ethanol solution (three times, each washing for 2 min). The antennae and mouthparts were then dehydrated through a graded ethanol series of 30, 50, 70, 80, and 90% (for 15 min each) and then fully dehydrated in 100% ethanol (three times for 30 min each), and lastly cleaned in isoamyl acetate (three times for 10 min each). Samples were air dried for 1 hour before performing Scanning Electron microscopy.

Different aged instars were also preserved in glass vials containing 70% alcohol and glycerol in the ratio of 8:2. After proper drying, the sample material was mounted on aluminium stubs with the aid of double-sided adhesive carbon tape and sputter encrusted with a mixture of gold and platinum and photographed for their ultrastructure studies under scanning electron microscope (JEOL) JSM-6100 in the Instrumentation Centre, Punjabi university, Patiala.

2.3 Analysis

The sensilla were identified from SEM micrographs based on terminologies proposed by Schneider (1964) [32], Zacharuk (1980, 1991) [37, 39] and Grimes (1986 a, 1986b) [13-14]. Images were labelled using Adobe Photoshop CS4 software. Metric analyses were performed taking at least three measurements for each sensilla and summarising the results to get mean average and standard deviation using ImageJ software.

3. Results (Figs. 1-5)

A) First instar

Antenna

It comprises of three segments: scape, pedicel and flagellum. Scape has no evident sensilla. Total 8 sensilla are distributed on pedicel and flagellum. Pedicel is with three sensilla basiconica (B1-B3) and one sensillum chaeticum (C). B1 is shorter than B2 and B3 is shortest, located between B1 and C. Sensillum chaeticum is curved medially. The flagellum has total 4 sensilla, 3 sensilla basiconica (B4-B6) and one sensillum styloconicum. B4 is present between sensilla B5 and B6 and faces the styloconicum. Sensillum styloconicum (Sty) has a well demarcated socket.

Mouthparts

Labrum is broad and forms medio-dorsally a V-shaped notch. It possesses 6 pairs of sensilla chaetica on its dorsal surface. Mandibles are strongly sclerotized, darkly pigmented, arched towards anterior surface and well concealed by labrum. Each mandible bears two sensilla chaetica on its proximal margin, C1 and C2. C1 is longer than C2. Maxillae consist of cardo, stipes, galea and a maxillary palp. Stipe and cardo are connected and each bearing a single sensillum chaeticum. The galea arises from cardo and has a total of 6 sensilla on its distal surface: three sensilla trichodea (ST1, ST2 and ST3); two sensilla styloconica i.e., lateral sensilla styloconica and medial sensilla styloconica (LSS and MSS) with prominent protuberances and a small central sensillum basiconica located between two sensilla styloconica. Maxillary palp is two segmented with its distal end bearing cluster of 8 sensilla basiconica namely 3 apical (A1, A2 and A3), 3 lateral (L1, L2 and L3) and 2 medial sensilla basiconica (M1 and M2) and 1 sensillum digitiformium on lateral surface. Labium has a pair of labial palps and an elongated tube-like spinneret (Spi). The labial palp bears two types of sensilla, one socketed sensillum styloconicum (Sty) on inner side and other short sensillum chaeticum (C) on outer side.

B) Second instar

Antenna

The second segment has two hair-like sensilla chaetica C1 and C2 and three sensilla basiconica B1-B3. C1 is clearly longer than C2, B1 shorter than B2 and B3 shortest. All sensilla basiconica have round blunt ends. The final segment has three sensilla basiconica B4-B6. B4 is larger than both B6 and B5. Among sensilla basiconica of final antennal segment, a projection suspected to be sensillum styloconicum (Sty) is present facing B4.

Mouthparts

Labrum is smooth, broad with cleft in middle on distal end but has prominent 6 pairs of sensilla chaetica on its surface. Mandibles are stout with visible dentitions. A total of 4 teeth are present on its apical end and both mandibles are covered under labrum itself. Two sensilla cheatica (C1-C2) are present on each mandible. Maxillae consists of cardo, stipe, galea and a two segmented maxillary palp. Three sensilla trichodea ST1, ST2 and ST3 on distal surface of galea are much grown and noticeable. Other three sensilla, LSS, MSS and CSB are also present at similar locations. Maxillary palp has 8 sensilla basiconica A1, A2, A3, L1, L2 and M1, M2 on its apical end. Sensillum A1 is longest and bases of A1, A2 and A3 form a triangle. L1, L2 and L3 are located in a line between apical and medial sensilla. Sensillum L3 is longest among lateral sensilla. M1 and M2 are aligned with sensillum digitiformium (SD) present on lateral side. Labium has a pair of cylindrical labial palps and elongated spinneret (Spi). 1 Sensillum styloconicum (Sty) and 1 chaeticum (C) are present on each labial palp.

C) Third instar

Antenna

The antenna has total 8 sensilla. Sensillum B2 is longer than B1 and B3 is shortest here as well. Sensilla chaetica (C) is present and longest among all sensilla on second segment. B1 is located near sensilla chaetica. Third segment has total 4 sensilla, 3 sensilla basiconica B4-B6 and one sensillum stylocnicum (Sty). Sensilla basiconica are conical with blunt ends and styloconica has a well demarcated socket. B4 is longer than both B5 and B6.

Mouthparts

Labrum has a cleft and 6 pairs of sensilla chaetica are present. Mandibles are larger and more evidently visible and have outgrown labrum. Each mandible has 2 sensilla chaetica, C1 and C2. C1 is longer than C2. Maxilla has all parts intact. Galea is with 6 sensilla ST1 ST2, ST3, LSS, MSS and CSB. Maxillary palp is two segmented. The second segment on its lateral side has inverted U-shaped sensillum digitiformium (SD). All 8 sensilla basiconica are present on the distal end of palp. The apical sensillum A1 is longest among all apical basiconica sensilla whereas L3 longest among all lateral sensilla. Labium is with a pair of labial palps and sensillum styloconicum (Sty) and chaeticum (C) are present at locations

similar to those in first and second instars. Spinneret, Spi is an elongated structure with pointed tip.

D) Fourth instar

Antenna

The second segment has two sensilla basiconica (B1-B2) with rounded blunt ends and two sensilla chaetica (C1-C2). B2 is longer than B1. B3 is not observed on second segment. The third segment has three sensilla basiconica (B4-B6) and one single sensillum styloconicum (Sty). B4 is faced towards styloconicum and surrounded by B5 and B6 on its sides.

Mouthparts

Labrum has 6 sensilla chaetica pairs like previous instars. Each Mandible has two sensilla chaetica, C1 and C2; C1 clearly longer than C2. Cardo and stipes also had sensilla chaetica visible and located on same places as in previous instars. All 6 sensilla on Galea are visible. Maxillary palp has all 8 sensilla basiconica. A1 is longer than A2 and A3 and lateral sensillum L3 is longer than L1 & L2. Distal segment is also supplied with inverted U shaped sensillum digitiformium (SD). Labial palps each with sensilla chaetica (C) and styloconica (Sty) are present. Spinneret (Spi) is pointed towards end.

E) Fifth instar

Antenna

On second segment, two large sensilla basiconica (B1-B2) and two sensilla chaetica (C1-C2) are present. B1 is easily identified based on its position relative to sensillum chaeticum and an inconspicuous socket. In this instar, B2 is longer than B1. B3 is not visible. On last segment, sensilla basiconica (B4-B6) and one socketed sensillum styloconicum (Sty) are present. B4 as expected is longer than B5 and B6.

Mouthparts

Labrum notched and with 6 pairs of sensilla chaetica. Each mandible with 2 sensilla chaetica (C1-C2) and C1 longer than C2. Galea is with 3 sensilla trichodea (ST1-ST3), 2 sensilla styloconica but central sensillum basiconicum is not visible in this case. All 8 sensilla basiconica are present on the same locations as in earlier instars. A1 and L3 are longest among respective sensilla. Sensillum digitiformium (SD) of maxillary palp is inverted U-shaped in structure as observed in earlier instars. Each labial palp is with sensilla chaetica (C) and Styloconica (sty). Spinneret (Spi) is rather broad and leaf-like and not cylindrical or pointed as in earlier instars.

F) Sixth instar

Antenna

On second segment, two large sensilla basiconica (B1- B2) and small sensillum basiconica B3 are visible along with two sensilla chaetica (C1-C2). B2 is longer than B1. On last segment, 3 sensilla basiconica (B4-B6) surrounding sensillum styloconicum (Sty) are seen. B4 is longer than both B5 and B6.

Mouthparts

Labrum notched and with 6 pairs of sensilla chaetica. Mandibles and its dentitions are easily noticeable. 2 sensilla chaetica (C1-C2) are present on each mandible and C1 is longer than C2 in this case as well. Galea has 3 sharp pointed sensilla trichodea (ST1-ST3), two sensilla styloconica (LSS and MSS) and one small sensillum basiconica (CSB) which is not located in between LSS and MSS. Maxillary palp has all 8 sensilla basiconica. Sensillum digitiformium (SD) is present here as well. A pair of labial palps, each with 2 sensilla i.e., chaetica (C) and styloconica (Sty). Spinneret (Spi) is broad and leaf-like.

G) Seventh instar

Antenna

Typology and sensilla distribution is same as in sixth instar. To be specific, the second segment has three sensilla basiconica (B1-B3) and two sensilla chaetica (C1-C2). The final segment has B4 and one sensillum styloconicum (Sty). B5 and B6 are not observed.

Mouthparts

Labrum has 6 pairs of sensilla chaetica. Mandibles are stout and each with 2 sensilla chaetica (C1-C2). Galea with sensilla trichodea (ST1-ST3), two sensilla styloconica (LSS and MSS) and sensillum basiconica (CSB) is not visible here. Maxillary palp has all 8 sensilla basiconica and sensillum digitformium (SD). A1 and L3 are longest here as well. Labrum has a pair of labial palps with similar sensilla distribution as observed in sixth instar i.e., chaetica (C) and styloconica (Sty). Spinneret (SPI) is elongated, pointed and tube-like.

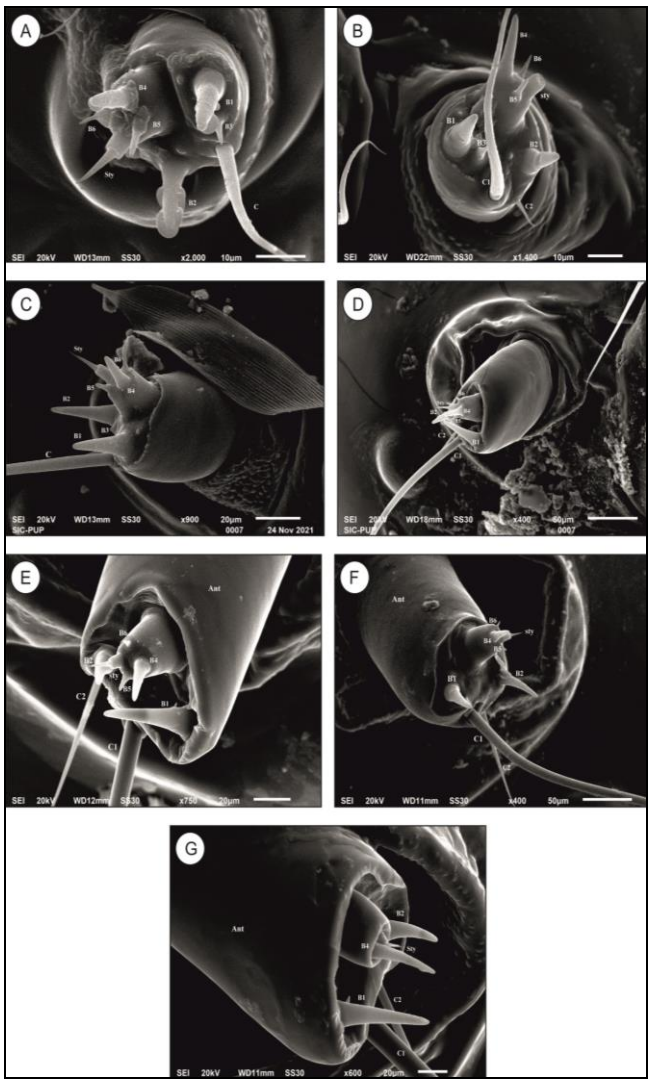


Fig 1: Morphology and structure of sensilla on antennae in all larval instars of *Spilarctia casignata* (A) antenna of first instar (B) antenna of second instar (C) antenna of third instar (D) antenna of fourth instar (E) antenna of fifth instar (F) antenna of sixth instar (G) antenna of seventh instar

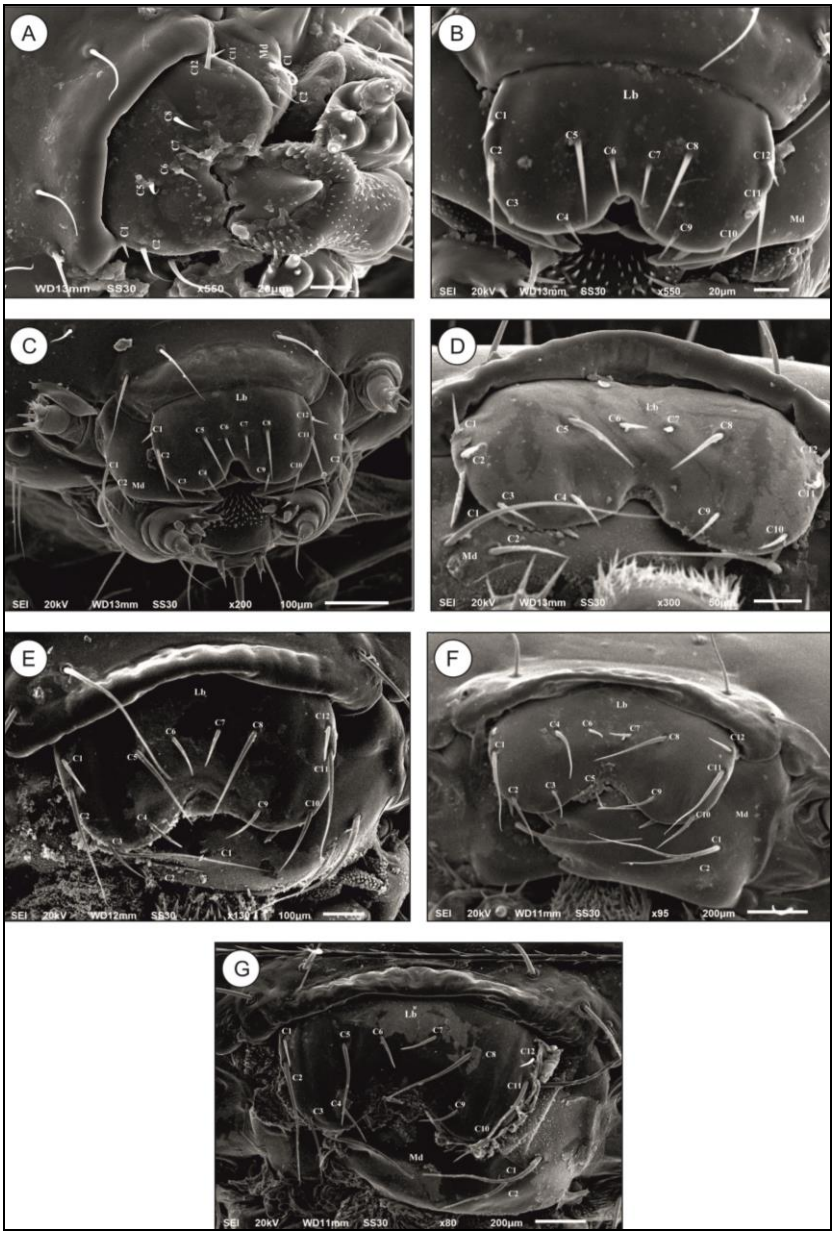
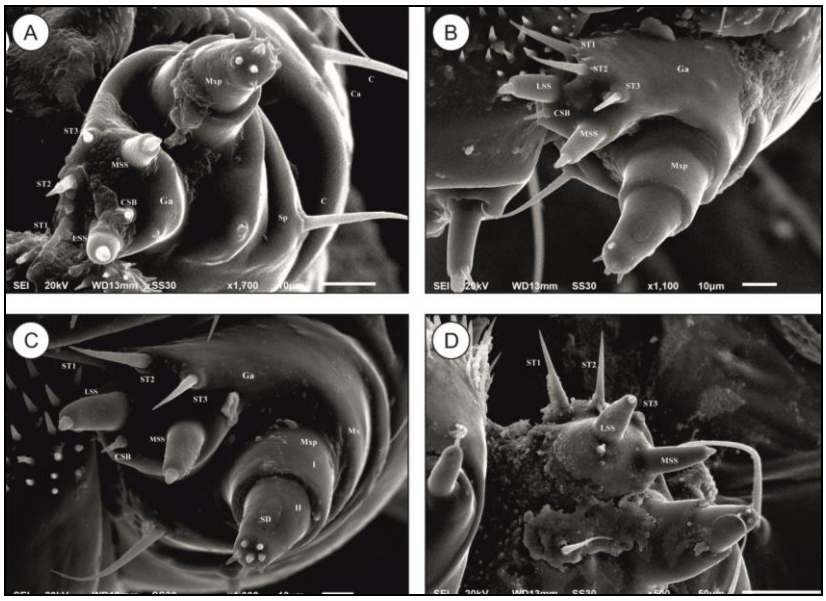


Fig 2: Morphology and structure of sensilla on labrum and mandibles in all larval instars of *Spilarctia casignata* (A) labrum and mandibles of first instar (B) labrum and mandibles of second instar (C) labrum and mandibles of third instar (D) labrum and mandibles of fourth instar (E) labrum and mandibles of fifth instar (F) labrum and mandibles of sixth instar (G) labrum and mandibles of seventh instar



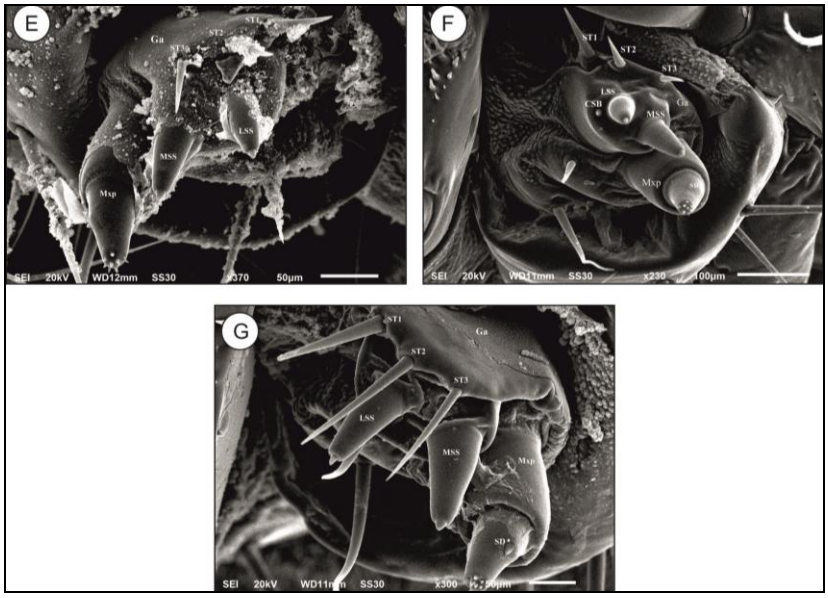


Fig 3: Morphology and structure of sensilla on galea in all larval instars of *Spilarctia casignata* (A) galea of first instar (B) galea of second instar (C) galea of third instar (D) galea of fourth instar (E) galea of fifth instar (F) galea of sixth instar (G) galea of seventh instar

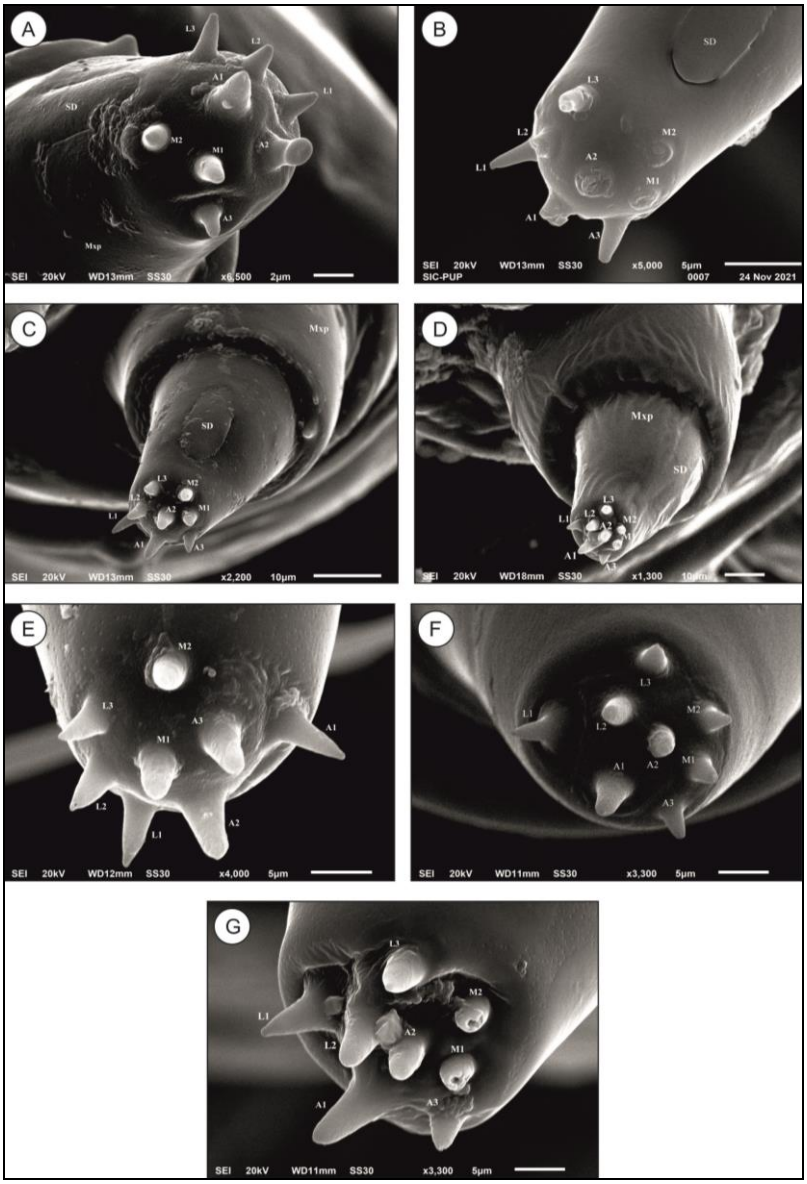


Fig 4: Morphology and structure of sensilla on distal segment of maxillary palp in all larval instars of *Spilarctia casignata* (A) maxillary palp of first instar (B) maxillary palp of second instar (C) maxillary palp of third instar (D) maxillary palp of fourth instar (E) maxillary palp of fifth instar (F) maxillary palp of sixth instar (G) maxillary palp of seventh instar

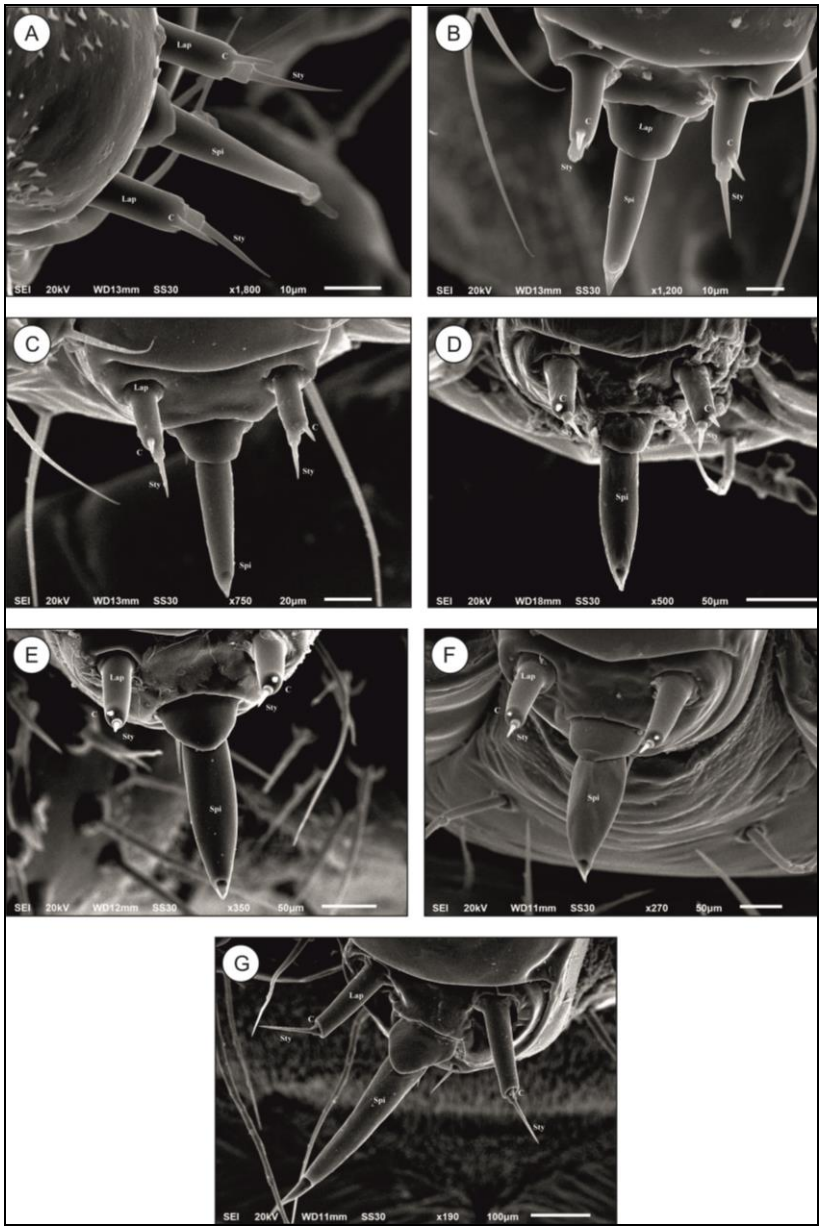


Fig 5: Morphology and structure of sensilla on labial palp in all larval instars of *Spilarctia casignata* (A) labial palp of first instar (B) labial palp of second instar (C) labial palp of third instar (D) labial palp of fourth instar (E) labial palp of fifth instar (F) labial palp of sixth instar (G) labial palp of seventh instar

4. Discussion

In holometabolous insects, the caterpillars have different morphology than adult forms. The antennae of immatures are rather simple and differentiated into three segments: scape, pedicel and flagellum. The first segment, scape has no evident sensilla and a total of 9 sensilla of 4 types namely sensilla basiconica, sensilla chaetica, small sensilla basiconica and sensilla styloconica are distributed on last two segments (Schneider 1964) [32].

Throughout order Lepidoptera, mouthparts also follow a general plan of sensilla distribution. Taxonomically, galea and maxillary palpi are most significant structures. The lateral and medial sensilla styloconica on galea are thought to be the primary organs involved in feeding. The terminology for sensilla on Galea and palpi is well established on the basis of extensive studies performed by Grimes (1986a, 1986b) [13-14] and the same has been followed in the present study.

In *Spilarctia casigneta*, the larval antenna has three sensilla basiconica on second segment until third instar stage and in later instars B3 is not observed. Similarly, the distribution of sensilla chaetica on second segment varies among instars. Smaller sensillum C2 is not observed in case of first and third instar. The final segment has three small sensilla basiconica (B4-B6) and one sensilla styloconicum in all instars except final instar where B5 and B6 are absent. B2 on second segment and B4 on last segment of antenna are longest among respective sensilla basiconica in all instars.

Although these ultrastructure of antennae and mouthparts in larvae of the present species have been quantified for the first time during present study, but its typology, distribution and number is similar to most of other lepidopteran larvae. The morpho-metric analysis of sensilla in all instars has been summarized in Table 1 and 2. It is evident from various studies of Adamski and Brown (1987) [2]; Faucheux (1995) [12]; Lin (2002) [26]; Adamski *et al.* (2006) [3]; Landry & Adamski (2006) [23]; Li *et al.* (2008) [24]; Liu *et al.* (2011) [25]; Adamski (2013) [1]; Chen & Hua (2014) [8] and Song *et al.* (2014) [35]. The structure and function of the sensilla basiconica, sensilla chaetica and sensilla styloconicum have been well studied in the past few decades. The multiparous

sensilla basiconica play an important role in sensing olfactory functions (Schoonhoven & Dethier 1964; Hanson and Dethier 1973; Dethier 1980) [27, 15, 10]. The uniporous sensilla chaetica are suggested to function as mechanoreceptors (Zacharuk 1980; Baker *et al.* 1986; Faucheux 1995) [37, 7, 12]. The uniporous sensilla styloconica is characteristic of cold-sensitive receptors (Schoonhoven 1967) [29].

On mouthparts, five types of sensilla were observed: sensilla chaetica, sensilla digitiformia, *sensilla basiconica*, sensilla trichodea and sensilla styloconica. On the labrum, there are six pairs of sensilla chaetica. This number is similar to other Lepidoptera, and reported to have mechano-receptive functions in this taxonomic group (Albert 1980; Faucheux 1995; Davis *et al.* 2008) [4, 12, 9]. The two sensilla chaetica on the mandible are mechanoreceptors (Albert 1980; Kent & Hildebrand 1987) [4, 22] and in each instar C1 is longer than C2. Each mandibula possesses teeth for cutting off pieces of food and crushing them. The most notable variation in the larval mouthparts of Lepidoptera exists on the maxillae. each maxillary palp possesses eight basiconica sensilla and are uniformly arranged as three apical, three lateral and two medial basiconica sensilla in different specimens. A prominent apical ridge supporting all sensilla is found in all instars as reported by Grimes 1986a [13]. Second instar is found to be an exception as it lacks apical sensillum A2, lateral sensillum L2 and both medial sensilla M1 and M2. The absence is probably owed to shrinkage caused while handling specimen. Sensillum A1 is longest among three apical basiconica sensilla and is aligned with sensillum digitiformium. Both medial sensilla are peg like structures and are found medially, flanking apical sensilla. Sizes of both these sensilla varies among instars. Sensillum L1 is longest among lateral basiconica sensilla in all instars where reported. All lateral sensilla are occurring in single line with L3 being the one near to SD. These sensilla are probably related to olfactory functions (Schoonhoven 1972; Devitt & Smith 1982) [31, 11] and may also have mechanoreceptory functions (Schoonhoven & Dethier 1966) [28]. In addition to basiconica sensilla, an inverted U shaped sensilla also occurs on distal segment of maxillary palps called the sensillum digitiformium. The length of this sensilla type progressively increases across different aged instars of species. It seems to be a consistent structure in larvae since it has been found in 36 species of Lepidoptera (Devitt & Smith 1982; Baker *et al.* 1986; Keil 1996; Lin 2002; Liu *et al.* 2011) [31, 7, 21, 26, 25], even though the distribution and external appearance are different. Devitt & Smith 1982 [31] reported the sensillum digitiformium is sensitive to temperature by the lamellated structure of the single dendrite. Galea has total 6 sensilla of three types: trichodea, basiconica and styloconica. Two sensilla styloconica on the galea may contribute to finding sources of food (Ishikawa *et al.* 1969) [18]. The two sensilla on the labial palp have been examined electro-physiologically and were shown to be typical mechanoreceptors (Albert 1980; Devitt & Smith 1982; Faucheux 1995) [4, 31, 12]. Labium has a pair of labial palp and a spinneret In all instars with its length increasing with age of instar. Labial palps bear a pair of cone shaped sensilla chaetica and elongated sensilla styloconia, consistent in all instars. The present work is a precise benefaction, in regards to improve and escalate the morphological personation of different moth families.

Table 1: Metrical analysis of sensilla of antennae of different aged instars of *Spilarctia casigneta* (represented as mean length±SD micrometers)

Sensilla type	1st instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	7th instar
B1	10.09±0.91	9.48±1.32	26.53±0.62	18.14±1.09	18.18±2.066	30.81±0.84	30.83±1.23
B2	12.55±0.39	10.60±0.33	29.24±0.51	41.976±0.651	48.13±0.81	42.95±2.64	33.14±0.662
B3	4.30±0.23	3.987±0.829	3.094±0.09	Not seen	Not seen	Not seen	Not seen
B4	8.713±0.88	16.684±1.025	14.67± 0.28	17.91 0±.09	20.17±0.91	19.62 ±2.03	43.89± 0.37
B5	7.13±0.30	5.89±0.210	6.424± 0.14	8.34± 1.05	9.19 ±0.13	6.87± 0.41	Not seen
B6	4.98±0.24	6.468±0.193	6.73± 0.36	4.93 ±0.34	3.89± 0.44	5.21± 0.36	Not seen

Table 2: Metrical analysis of mouthparts and its sensilla of different aged instars of *Spilarctia casigneta* (represented as mean length±SD micrometers)

Name of structures	1st instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	7th instar
Labrum	52.13±1.45	74.74±1.94	115.96±3.54	125.19± 5.00	288.57±7.60	320.61±13.91	387.66±13.38
Distal segment of Mxp	7.27±0.81	21.73±0.40	22.40±1.31	31.80±4.04	62.98±0.94	46.14±6.09	78.23±1.24
Galea							
ST1	8.979±0.13	20.07±0.10	36.28±0.53	42.13±1.50	57.11±2.00	79.32 ±1.16	119.71 ±2.41
ST2	6.06 ±0.06	15.60±0.62	25.87±0.53	34.41±0.83	2.97±0.96	45.87 ±2.78	151.85 ±1.00
ST3	2.92±0.25	8.99±0.99	16.94±0.35	21.97±0.60	47.0±1.12	33.78 ±0.62	127.49 ±0.76
Sensilla of Maxillary Palp							
A1	2.30±0.07	2.54±0.15	4.06±0.20	3.88±0.32	6.53 ±0.14	3.65±0.33	10.22± 0.42
A2	1.85±0.18	Shrinkage	2.90± 0.37	2.016±0.16	5.52±0.25	2.26±0.33	3.84± 0.38
A3	1.57±0.05	2.75±0.009	2.91± 0.11	2.55± 0.17	4.63±0.50	3.46± 0.15	3.62± 0.26
L1	2.46 ±0.14	2.69± 0.14	4.32±0.055	4.74±0.55	5.73± 0.31	4.03±0.06	8.77± 0.13
L2	1.83±0.1	Shrinkage	2.96±0.053	3.73±0.24	5.03±0.27	1.70±0.06	6.55± 0.68
L3	2.46 ±0.14	2.75±0.009	1.92± 0.19	1.92±0.40	4.48±0.18	2.80± 0.34	3.50± 0.52
M1	1.19±0.33	Shrinkage	1.667±0.196	1.75± 0.07	3.569±0.298	2.50± 0.27	2.30 ±0.10
M2	1.090±0.06	Shrinkage	1.082±0.194	2.10± 0.41	2.386±0.18	2.96±0.18	3.08± 0.35
SD	5.19±0.35	9.05±0.67	11.05±0.42	12.45±0.54	19.49±0.77	11.7±1.34	14.20±0.75
Sensilla of Labial palp							
C	8.37±0.96	8.155±0.10	7.88±0.39	8.90±0.13	6.28±0.86	4.93± 0.65	18.078±0.26
Sty	12.70±11.02	19.16±0.19	20.45±0.18	21.02± 0.29	12.94±0.33	22.2±2.04	99.46 ±0.59

5. Conclusion

To summarise, three types of sensilla on antennae and five types of sensilla on mouthparts are identified. The present study shows consistency with sensilla reported in recent studies on other species of lepidopteran larvae (Shields 2009, Xu *et al*. 2017, Aruna *et al.* 2019, Gui-Lin Hu *et al.* 2021) [34, 36, 6, 41]. The ultrastructure of antennae and mouthparts in all seven instars of the present species have been described and illustrated along with its metrical analyses for the first time. In addition, the probable functions of these sensilla have also been summarized. The study will provide a great aid to the morpho-taxonomy of Lepidoptera, as it will serve as a basis for further electrophysiological studies in order to understand the function of these sensilla, feeding mechanism of pest, understanding of the behavioural mechanisms with a perspective of designing pest control methods.

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7. References

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