



Scanning electron microscopic detection of an unusual giant sensilla on the abdominal cuticle of muga silk worm, *Antheraea assama* Westwood (Lepidoptera: Saturniidae)

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Abstract

Scanning Electron Microscopy of the abdominal cuticle of the fifth instar larva of the muga silk moth, *Antheraea assama* reveals the presence of some unusual sensilla, showing peculiarities in morphological and surface ultra-structural features. The length of the sensilla and its width at the base as well as at the tip are found to be exceptionally large. Further, the structural features of the sensilla are unusual in the sense that some of its characteristics are similar to those of sensilla trichodea and some to certain specialized sensilla basiconica, but with no complete similarity to any of them. The absence of longitudinal ridges and secondary ridges on the surface suggests that the giant sensilla detected in the muga silk worm is different from sensilla chaetica as well. The presence of pores in the sensilla and the non-flexible nature of its base indicate a chemoreceptive role. Irregular sculpturing in the distal portion, on the other hand, is similar to the olfactory basiconic sensilla reported in other insects by some authors. The unique features of the sensilla suggest its specific involvement in sensory reception relevant to the behaviour of the insect. © 1999 Published by Elsevier Science Ltd. All rights reserved.

Keywords: *Antheraea assama*; Scanning electron microscopy; Sensilla

1. Introduction

The adaptational diversity of an insect is best expressed by the chemical as well as structural specialization of the chitinous cuticle covering the body (Neville, 1975), which is different in different species and different body parts of the same individual.

Specialized cuticular structures, known as sensilla are reported to occur in different body parts of insects and are known to perform a variety of functions (Bland, 1983; George and Nagy, 1984; Alm and Hall, 1986; Crouau and Crouau-Roy, 1991). Scanning Electron Microscopy (SEM), because of its high resolving power and large depth of field, has become an indispensable technique for studying the detailed morphology of these cuticular structures. Several authors have used SEM for studying the distribution pattern, specialization in position, directional function, structural features of the socket, the nature of association of the sensilla base with the body cuticle and the finer detail of the surface of the sensilla (Dey, 1995; Dey et al., 1995; Dey and Biswas, 1996).

A review of literature on the subject reveals that SEM has been used extensively for studying the morphological details and surface ultra-structural features of sensilla in

different groups of insects including Diptera, Coleoptera, Siphonaptera and lepidoptera. Although reports on a number of important studies on lepidopteran sensilla exist in the literature (Calvert and Hanson, 1974; Chun and Schoonhoven, 1973; Fox, 1966; Frings and Frings, 1956; Ichinose and Honda, 1978; Kusumi and Shibuya, 1989; Roessingh et al., 1991), the diversity in the habit and habitat of the group suggests the need for further studies on sensory systems in different species.

The silkworm, *Antheraea assama*, is a species of the genus *Antheraea*, whose distribution is restricted to Assam, a province situated in the North-eastern part of India. The silk obtained from the cocoon of the insect is popularly known as “Muga” silk which is famous for its golden colour and lustre. Apart from the unique nature of the silk produced by the insect, its general morphology, behaviour and physiology are known to be different from those of other related species. It is surprising that in spite of extensive studies on sensilla of a number of lepidopterans, nothing is known on the sensory system of this important and unique species of silk moth.

It appears that the first step in understanding the complexity of behaviour of an insect is a thorough examination of its sensory structures. The present study was therefore aimed at

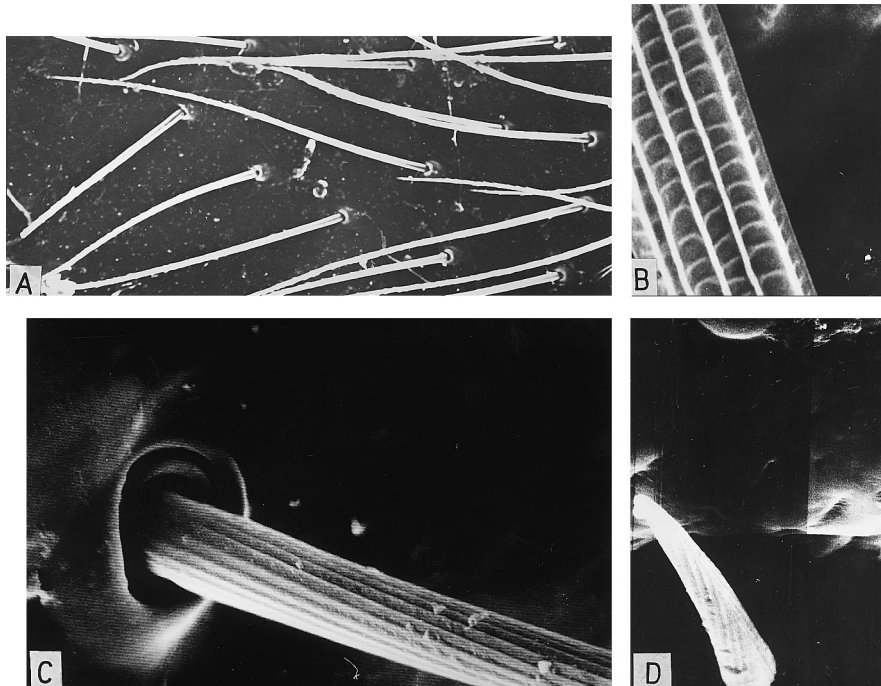


Fig. 1. Scanning electron micrograph of different types of body sensilla of the fifth instar larvae of the muga silk moth, *A. assama*: (A) distribution pattern of sensilla chaetica (bar = 100 μm); (B) enlarged view of the surface of sensilla chaetica (bar = 1 μm); (C) enlarged view of a portion of sensilla trichodea (bar = 10 μm); and (D) enlarged view of a sensilla basiconica (bar = 10 μm).

a search for peculiarities that might relate to the ecophysiology and behaviour of the muga silk moth, which is distinctly different from other silk moth species.

2. Materials and methods

2.1. Scanning electron microscopy

The fifth instar larvae of the muga silk moth *A. assama* were used in the study. The cuticle, excised from the body was fixed in 3% glutaraldehyde prepared in 0.1 M Sodium cacodylate buffer at 4°C for 4 h. The samples were washed with the buffer, dehydrated through increasing concentrations of acetone, and critical point dried in a Samdri PVT 3 (Tousimis) critical point dryer using acetone as intermediate fluid and carbon dioxide as transitional fluid. The dry samples were secured horizontally to the specimen brass stub (10 mm diameter \times 30 mm high) using double coated adhesive tape, connected via a patch of silver paint to ensure charge conduction. Care was taken to avoid any trapped air bubbles. A thin conductive coating of gold was applied to the sample using a JFC 1100 (Jeol) ion sputter, at a relatively low vacuum of 10^{-3} Torr in the sputtering chamber. The coated samples were examined in a JSM-35 CF (Jeol) scanning electron microscope operated at 15 kV. The tilt control was fixed at 0° for setting the specimen stage in a horizontal position, the working distance (WD) selector was used to set the WD to 15 mm.

2.2. Light microscopy (crystal violet staining)

In order to identify pores in the cuticle of the sensilla, specimens placed in fixative were processed with the crystal violet method and were examined with a Leitz Ortholux-2 research microscope.

Altogether 15 individual larvae were used in the present study. A comparison was made on the length, breadth, structural features of the socket, surface ultra-structure, etc. between the sensilla located in different body parts of the larvae and those of other insects described by different authors.

3. Results

In addition to the presence of sensilla trichodea, Sensilla Chaetica and sensilla basiconica, (Fig. 1(A)–(D); Tables 1–3), scanning electron micrographs of the abdominal cuticle of larvae shows the presence of a few giant sensilla with a number of unusual morphological features (Figs. 2–4), presenting new structural data of sensory receptors in relation to specialized ecophysiology of the Muga silk moth larva.

The sensilla was found to be exceptionally long and it is located on the abdominal segments. It is found neither in mouth parts nor in any other parts of the larval body. The length of the sensilla is about $1500 \pm 500 \mu\text{m}$, its breadth at the base is about 40 μm and that at the tip is about $10 \pm 2 \mu\text{m}$. The fractured part of the sensilla reveals that the

Table 1
Comparison of morphological features, number and distribution pattern of giant sensilla with those of sensilla trichodea of different insect species possessing the sensilla

Sl. no.	Name of the sensilla	Name of the insect	Location	Length (μ) (average)	Width (μ) average		Number	Surface ultra-structural features	Possible function	References	
					Base	Tip					
1	Giant sensilla	<i>Antheraea assamensis</i>	Abdominal segments	1500	40	10	6	5–7	Absence of striations, presence of irregular sculpturing, multi-porous nature	Chemoreception, olfaction	Present work
2	Sensilla trichodea type 1	<i>Graphium sarpedon</i>	Tarsus	48	6.2	2.5	2	1–3	Smooth, non-porous	Mechanoreception	Dey et al. (1995)
3	Sensilla trichodea type 2	<i>Graphium sarpedon</i>	Coxa	50	17	1.2	36	32–34	Longitudinal striation, porous	Contact chemoreception	Dey et al. (1995)
4	Sensilla trichodea type 1b	<i>Pseudalientia unipunctata</i>	Antennal flagellum	44.9	3.1	1.3	280	–	Herring bone striations	Contact chemoreception	
5	Sensilla trichodea (long)	<i>Heliothis virescens</i>	Tarsomere V	75	4.6	0.9	4	–	Herring bone striations	Contact chemoreception	Baker and Ramaswamy (1990)
6	Short sensilla trichodea	<i>Heliothis virescens</i>	Contact region of each tarsus	44	8	1	38	–	Irregular longitudinal striations	Contact chemoreception	Baker and Ramaswamy (1990)
7	Sensilla trichodea	<i>Homeosoma nebulella</i>	Antennal flagellum	27	8	1	8272	8063–8549	Presence of regularly spaced annular ridges, multi-porous nature	Contact chemoreception	
8	Sensilla trichodea	<i>Antheraea assamensis</i>	Ventral surface of head, thorax, abdomen	520	10	4	210	150–270	Longitudinal striations	Contact chemoreception	Present work

Table 2
Comparison of morphological features, number and distribution pattern of giant sensilla with those of sensilla chaetica of different insect species

Sl. no.	Name of the sensilla	Name of the insect possessing the sensilla	Location	Length (μ)		Width (μ) (average)		Number		Surface ultra-structural features	Possible function	References
				Average	Range	Base	Tip	Average	Range			
1	Giant sensilla	<i>Antheraea assamensis</i>	Abdominal segments	1500	1000–2000	40	10	6	5–7	Absence of striations, presence of irregular sculpturing, multiporous	Chemoreception, olfaction	Present work
2	Sensilla chaetica type 1	<i>Graphium sarpedon</i>	Tibia and tarsal joints of pro- and meta-thoracic legs	38	30–46	4.4	0.2	60	50–70	Smooth	Grooming	Dey et al. (1995)
3	Sensilla chaetica type 2	<i>Graphium sarpedon</i>	Edges of coxa and trochanter	283	150–416	4.4	0.1	150	100–200	Smooth	Mechano-reception	Dey et al. (1995)
4	Sensilla chaetica type 3	<i>Graphium sarpedon</i>	Tibia and tarsus	135	90–180	15	7.5	120	100–140	Presence of longitudinal ridges and secondary ridges	Chemo-reception	Dey et al. (1995)
5	Sensilla chaetica	<i>Homoiosoma nebulella</i>	Proboscis	5.9	4.5–9.6	1.1	–	112	98–124	Longitudinal ridges	Chemo-reception	
6	Sensilla chaetica	<i>Pseudalertia unipuncta</i>	Antennal flagellum	144	131–157	4	0.5	80	70–90	Presence of longitudinal ridges and secondary ridges	Mechano-reception	Baker and Ramaswamy (1990)
7	Sensilla chaetica	<i>Heliothis virescens</i>	Tarsus	122	80–165	15	2.7	21	20–22	Longitudinal ridges and secondary ridges	Chemo-reception	Present work
8	Sensilla chaetica	<i>Antheraea assamensis</i>	Ventral portion of head, thoracic and abdominal cuticle	600	400–800	20	4	100	80–120	Longitudinal ridges and secondary ridges	Chemo-reception	Present work

Table 3
Comparison of morphological features, distribution pattern and number of giant sensilla with those of sensilla basiconica of different insect species

Sl. no.	Name of the sensilla	Name of the insect possessing the sensilla	Location	Length (μ)	Width (μ)		Number	Surface ultra-structural features	Possible function	References
					Base	Tip				
1	Sensilla basiconica type 1	<i>Graphium sarpedon</i>	Tibia and tarsal segments	11	3.7	1.6	12	Striated, porous	Olfaction	Dey et al. (1995)
2	Sensilla basiconica type 2	<i>Graphium sarpedon</i>	Tarso-tibial joint	5.9	2.7	0.6	5	Striated, porous	Olfaction	Dey et al. (1995)
3	Sensilla basiconica type 3	<i>Graphium sarpedon</i>	Tarso-tibial joint	3.3	1.3	0.6	4	Striated, porous	Olfaction	Dey et al. (1995)
4	Sensilla basiconica type 4	<i>Graphium sarpedon</i>	Last tarsal segment	2.3	1.3	0.3	35	Striated, porous	Olfaction, chemoreception	Dey et al. (1995)
5	Sensilla basiconica type 5	<i>Graphium sarpedon</i>	Last tarsal segment	4.6	1.5	0.6	43	Striated	Olfaction	Dey et al. (1995)
6	Sensilla basiconica	<i>Homeosoma nebutella</i>	Antennae	18.4	1.8	0.6	648	Rough	Olfaction, chemoreception	
7	Basiconic sensillum	<i>Drosophila melanogaster</i>	Antennae	4.5	1.2	0.2	7	Irregular sculpturing	Olfaction	Itoh et al. (1991)
8	Sensilla basiconica	<i>Homeosoma nebutella</i>	Proboscis	2.9	1.4	0.1	52	Rough	Olfaction, chemoreception	
9	Sensilla basiconica	<i>Homeosoma nebutella</i>	Ovipositor	9.6	1.9	0.1	59	Rough	Chemoreception	
10	Broad-based non-socketed sensilla	<i>Hypera postica</i>	Antennae	12	0.7	-	4	Smooth, uniporous	Chemoreception	Bland (1983)
11	Sensilla basiconica	<i>Drosophila melanogaster</i>	Maxillary palp	10	1.8	-	63	Porous	Chemoreception	Singh and Nayak (1985)
12	Sensilla basiconica	<i>Antheraea assamensis</i>	Head, thorax and abdomen	27	12	3.6	25	Striated	Chemoreception	Present work
13	Giant sensilla	<i>Antheraea assamensis</i>	Abdominal segments	1500	40	10	6	Absence of striations, presence of irregular sculpturing, multi-porous	Chemoreception, olfaction	Present work

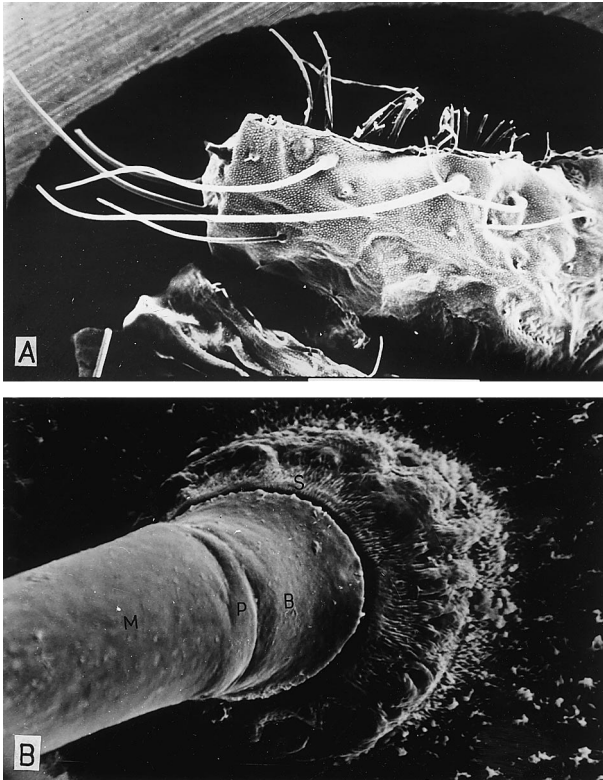


Fig. 2. Scanning electron micrograph of the giant sensilla: (A) distribution pattern on the abdominal segments (bar = 1000 μm); and (B) enlarged view of the socket(s), sensilla base (B) and its attachment (P) with the main body (M) of the sensilla (bar = 10 μm).

thickness of its wall is about 7 μm (Figs. 4(B) and 5(B)), which is perforated by a number of pores of various size.

3.1. The structural features of the socket

The giant sensilla arises from a well-developed socket with external and internal diameters of 70 and 45 μm respectively. The basal portion of the hair, attached to the socket is about 14 μm in length and is strongly joined to the major part of the hair by a small strip about 5 μm long (Fig. 2(B)).

3.2. The surface feature of the giant sensilla

The surface of the giant sensilla near the base is smooth but contains minute pores. The major portion of the hair on the other hand is rough, and is characterized by the presence of innumerable protrusions. The size of the protrusions ranges from 2 to 8 μm (Fig. 4(A)). An enlarged view of the sensilla confirms the presence of pores on the surface (Fig. 4(A)), indicating that the giant sensilla is a multiporous structure. When the sensilla was stained with crystal violet, the entire region of the sensory hair was found to take up the stain (Fig. 5(A) and (C)), further supporting the porous nature of the sensilla.

Peculiarities of the giant sensilla in comparison to other types of sensilla are given below.

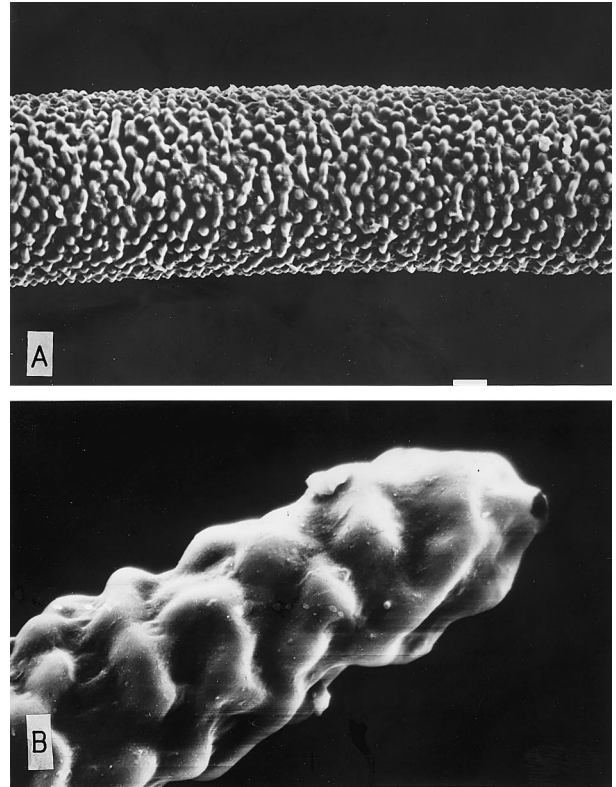


Fig. 3. Scanning electron micrograph of the surface of the giant sensilla: (A) major part (bar = 10 μm); and (B) apical portion, showing terminal pore (bar = 10 μm).

3.3. Comparison with sensilla trichodea

Length and breadth: Table 1 shows the comparative data of length and breadth of the giant sensilla detected in the muga silk worm and those of some sensilla trichodea described in various insects by different authors. The maximum length of sensilla trichodea in other insects and also in different body parts of the muga silk worm *A. assama* (Table 1) was found to be much less than that of the giant sensilla (1000–2000 μm). Similarly, the width of sensilla trichodea described by other authors was found to range from 3 to 10 μm at the base and from 0.9 to 4 μm at the tip. In contrast, the width of the giant sensilla detected in the present study was found to be about 40 μm at the base and about 10 μm at the tip, which is much larger than those of any sensilla reported so far.

3.4. Number of the sensilla

The number of the giant sensilla detected in the present work was found to be around 3–6 per segment. In contrast, the number of sensilla trichodea described in various locations in the body of Muga silk worm and also in other insects was found to be much higher (Table 1). The number of sensilla trichodea in certain moths was reported to be as high as 8549. However, in some moths, in a population of

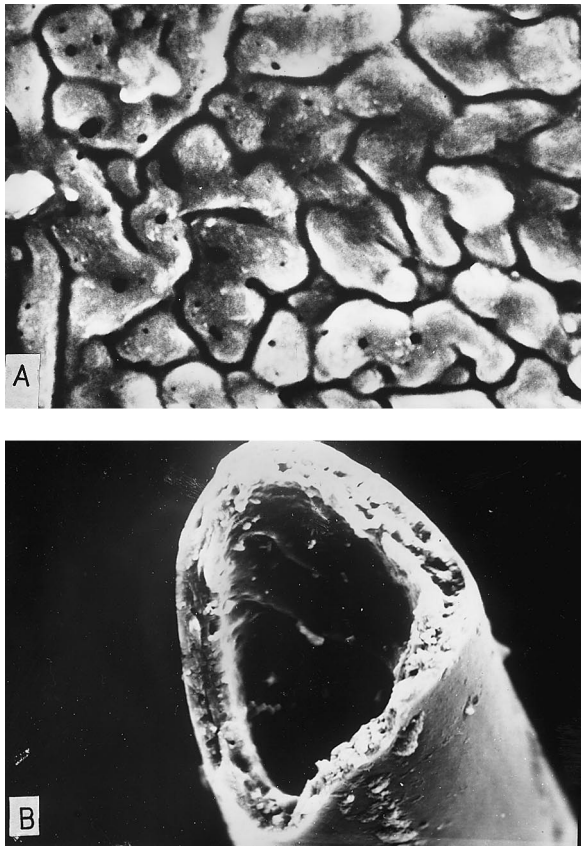


Fig. 4. (A) Enlarged view of surface protuberances of giant sensilla showing irregular distribution of pores of varying size (bar = 10 μm). (B) Sectional view of the main body of the giant sensilla showing the organization of sensilla wall and its porous nature (bar = 10 μm).

short and long sensilla, the longer ones (85–165 μm) were reported to be fewer in number (6–9) (Table 1).

3.5. Surface ultra-structure

Fig. 1(B) shows the surface ultra-structural features of sensilla trichodea from the fifth instar larva of the muga silk moth in different locations of the body. The sensilla is characterized by the presence of irregular longitudinal striations, which were not present on the surface of the giant sensilla. The comparative data on surface ultra-structural features of the giant sensilla and different types of sensilla trichodea described in various insects by other workers are presented in Table 1.

3.6. Comparison with sensilla chaetica

Length and breadth: A comparison of the length and breadth of the giant sensilla with those of sensilla chaetica are shown in Table 2. Sensilla chaetica reported in different insects, and also observed in the different locations of the body of the muga silk worm, *A. assama*, were found to be shorter and thinner than the giant sensilla. The length of sensilla chaetica is reported to range from about 5 to 416 μm which is almost one-fifth of that of the giant

sensilla. The breadth of sensilla, (chaetica 1.1–15 μm) described so far in different insects ranges from one-third to one-fortieth of that of giant sensilla.

3.7. Number of the sensilla

The number of sensilla chaetica is in general higher than that of the giant sensilla of the muga silk worm. Table 2 shows the number of sensilla chaetica reported in different locations of the body of certain insects and also in the Muga silk worm in the present work. The number of sensilla chaetica ranges usually from about 15 to 315. However, in a very few cases the number was found to be as low as 8.

3.8. Surface ultra-structural features

The surface ultra-structural features of sensilla chaetica were found to be characteristic and are different to those of the giant sensilla of the muga silk worm. The few sensilla chaetica that were detected in cephalic, thoracic and abdominal segments showed the presence of a longitudinally grooved surface with circular striations (Fig. 1(D)). Comparison of the surface features of giant sensilla of muga silk worm with sensilla chaetica described by different authors in other insects also shows that the giant sensilla is significantly different from that of sensilla chaetica, since the latter is characterized by the presence of longitudinal ridges and secondary ridges on its surface (Fig. 1(C)).

3.9. Comparison with sensilla basiconica

Length and breadth: Basiconic sensilla in general are much shorter than sensilla chaetica and sensilla trichodea and also have a smaller diameter width as compared to the giant sensilla of the muga silk worm, *A. assama*. Table 3 shows the length and breadth of sensilla basiconica in different insects and also in the muga silk worm in the present work. It was observed that the length of the sensilla basiconica (2.9–27 μm) is about 1/50–1/500th of that of giant sensilla. Similarly, the breadth of sensilla basiconica (0.7–1.2 μm) is around 1/40th of that of giant sensilla.

Number of the sensilla: The number of basiconic sensilla (2–20) was found to vary depending upon the location. In certain locations, the number may be quite high ranging from 50 to more than 1000 (Table 2). Giant sensilla, in contrast, does not show such variations in its number, and is localized in the abdominal segments only.

Surface ultra-structural features: The basiconic sensilla of the muga silk worm shows slight longitudinal striations on its surface (Fig. 1(D)) but does not show the irregular sculpturing that is observed on the surface of the giant sensilla. A comparison of surface features of the giant sensilla with different types of basiconic sensilla described in other insects indicates similarities of the former with short basiconic sensilla in the fruitfly, *Drosophila*

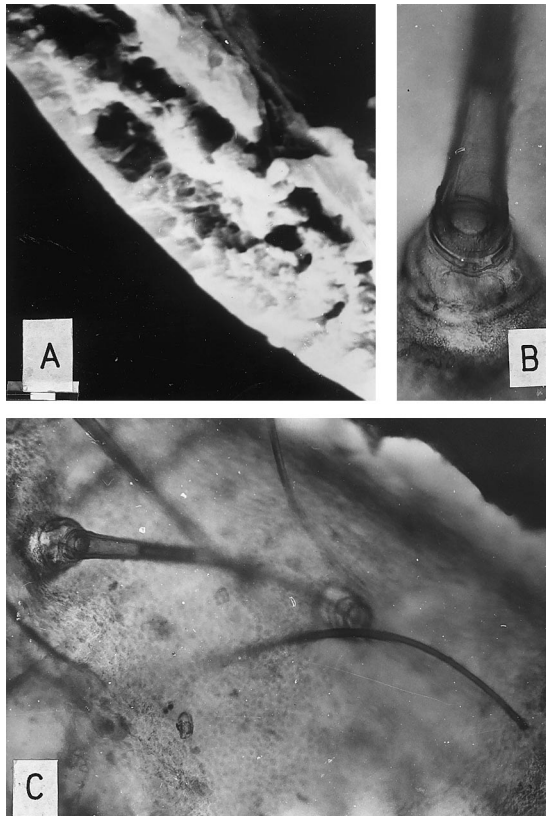


Fig. 5. (A) Enlarged view of sensilla wall showing distinct pores of varying size (bar = 1 μm). (B) Photomicrograph of socket and basal portion of giant sensilla stained with crystal violet. (C) Photomicrograph of different parts of some giant sensilla stained with crystal violet.

melanogaster (Itoh et al., 1991) (Table 3). In both the cases, the surface of the sensilla was found to be smooth near the basal portion with a few minute pores (Fig. 2(B)) and the major portion was marked by irregular sculpturing (Fig. 3(A) and (B)). However, the sculpturing on the surface of giant sensilla was found to be much more prominent than those of the basiconic sensilla of *D. melanogaster*, as described by Itoh et al. (1991).

4. Discussion

The scanning electron microscopic detection of an unusually large sensilla in the muga silk worm with structural characteristics dissimilar to any type of known insect sensilla appears to be interesting. The exceptionally large length and breadth, peculiarities in the surface ultra-structural features, unique arrangement of socket with the sensory hair, presence of a non-flexible base, a terminal pore and multiporous nature of the surface are some of the characteristic features of the sensilla. It is well known that among all the insect sensilla, the trichoids in general have the greatest length and the thickest wall (Schneider, 1964). However, the maximum length of the sensilla trichodea

described in different insects is reported to range from 80–200 μm (Singh and Nayak, 1985; Baker and Ramaswamy, 1990; Dey et al., 1995). Similarly the maximum length of the sensilla chaetica is also within this range. Sensilla basiconica are usually short (1–12 μm), and only in very rare cases are reported to be longer (120 μm) (Bland, 1983). In comparison to all the known sensilla, the length of the giant sensory hair detected in the muga silk worm (1000–2000 μm) appears to be unusual. The general morphology of the sensilla has some similarities with that of sensilla trichodea, particularly in the structure of the socket and its association with the body cuticle. The absence of longitudinal or lateral striations from the surface of the giant sensilla, however makes it different from trichoids, since the striations on the surface are regarded as one of the characteristic features of sensilla trichodea (Baker and Ramaswamy, 1990).

It is well known that sensilla trichodea acts either as a mechanoreceptor or as a contact chemoreceptor (Altner et al., 1983). The contact chemoreceptors are characterized by the presence of pores and a non-flexible base (Altner et al., 1983). The structural features of the socket of the giant sensilla of the muga silk worm, suggesting the non-flexible nature of its base, and the presence of terminal pore, as revealed by magnified scanning electron micrographs indicate its similarity with chemoreceptive sensilla. However, the multiporous nature of the sensilla suggests its role as an olfactory organ as well (Bland, 1983).

The giant sensilla observed in the muga silk worm has some marked differences compared to the sensilla basiconica, since the later is reported to be much shorter with a characteristic shape (George and Nagy, 1984). However, the smoothness of the giant sensilla in the proximal portion and irregular sculpturing in the main body is exactly similar to that of the short basiconic sensilla described in the fruitfly, *D. melanogaster* (Itoh et al., 1991). It was reported that an irregularly sculptured surface is associated with numerous irregular shaped olfactory pores (Itoh et al., 1991). However, the sculpturing of the surface of the giant sensilla, as observed by SEM in the present study, appears to be much more prominent than those described by Itoh et al. (1991). This suggests that the giant sensilla of muga silk worm has a superior efficiency in reception of olfactory stimuli. In this context, it is to be noted that olfactory reception in insects is perceived not only by sensilla basiconica, since some of the trichoids are also reported to function as olfactory receptors (Schneider, 1964). Although the multiporous nature of the giant sensilla, and the presence of sculpturing on its surface suggests its olfactory role, the sensillum, with its thick wall is an exception to the typical characterization of olfactory sensilla as having thin walls (Bland, 1983).

Comparison with sensilla chaetica shows that the giant sensilla of the muga silk worm has no similarity with the former in any of its morphological features, or its pattern of distribution pattern. The length of the sensilla chaetica

usually varies according to their position, unlike the giant sensilla which shows slight variations in length even in the same location. The base of the sensilla chaetica is inserted into a socket, whose opening is non-circular, membranous and has a prominent lip on one side. It is clear from Fig. 2(B) that the base of the giant sensilla does not show the similar structural features, and the socket opening is circular. The apex of the sensilla chaetica is usually truncated and has a few pores that are partly covered by small extensions of the wall. Some sensilla chaetica however were reported to be sharp with pointed a tip and no pore was visible. The surface feature of sensilla chaetica is very much different to that of the giant sensilla, since the former appears to have a longitudinally grooved surface with circular striations. Surface sculpturing of some sensilla chaetica however, was reported to be roof-tile-like, but this is also different to the irregularly sculptured surface of the giant sensilla.

The present study shows that the giant sensilla detected in the muga silk worm has similarities with and differences from both sensilla trichodea and sensilla basiconica. Hence, it is difficult to classify it alongside either of them, from a morphological point of view.

Although electrophysiological recordings of impulse activities from a sensilla is required to understand its exact function, inferences have also been made (Itoh et al., 1991) in this regard on the basis of morphological properties of sensilla and comparing these with sensilla, whose functional and structural properties have been well established (Altner et al., 1977; Altner and Prillinger, 1980). The morphology of the socket and the surface ultra-structural features of the giant sensilla observed in the present work, when compared with sensilla of known functions, suggest that it can act as a chemoreceptor and also as a powerful receptor for olfaction. The occurrence of very few types and a low number of chemoreceptive and olfactory sensilla on the larvae of the muga silk moth (Tables 1–3) further suggests the importance of giant sensilla in the characteristic behaviour and ecophysiology of the insect. In this context, it is interesting to note that the number of chemoreceptors have been reported to be much higher in the polyphagous plant-feeding insects than those that are host specific (Chapman, 1982). The low number of sensilla in the Oligophagous larvae of alfalfa weevil, feeding primarily on the alfalfa plant and occasionally on related species, was found to be associated with the presence of some large, multiporous basiconic sensilla (Bland, 1983). It was suggested that the sensitivity to specific odors from alfalfa and closely related species might be provided by the large sensilla. The situation appears to be similar in muga silk worm, which is also host specific in its feeding. The unusually large length and breadth of the sensilla may be associated with a very high degree of sensory function and is likely to be an important adaptation for the silk worm to its highly specific food habit and unique environmental conditions.

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