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Sensilla on the Mouthparts and Antennae of the Elephant Louse, *Haematomyzus elephantis* Piaget (Phthiraptera: Haematomyzidae)

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ABSTRACT The labial palpus of the elephant louse *Haematomyzus elephantis* has six sensilla that represent three different types: trichoid, basiconic, and styloconic. Two rows of basiconic sensilla are situated on the dorsal and ventral surfaces of the rostrum, and each row consists of three sensilla. Male and female antennae have 15–17 trichoid sensilla situated on the scape, pedicel, and three antennal annuli. Both sexes have two sensilla basiconica on the dorsal surface of the pedicel near the junction of the scape and pedicel. Two coeloconic (tuft) sensilla are situated on the antennae of both sexes, one sensillum on each of the last two annuli. There are three plate organs, two on the last annulus and one on the penultimate annulus of the male and female antennae. Sexual dimorphism is exhibited in the male and female antennae, in that the male has about twice as many sensilla basiconica on the apex of the last annulus as does the female. The total number of sensilla basiconica on the apex of the male antennae is at least two times the number that is known to be present in any other species of lice.

The elephant louse, *Haematomyzus elephantis,* is one of two species in the family Haematomyzidae, which is often placed in a separate suborder, Rhynchophthiraptera. The mandibulate mouthparts are situated on a long rostrum, and a well-developed sucking apparatus is associated with the mouthparts (Weber, '38; Snodgrass, '44; Mukerji and Sen-Sarma, '55). The adults and immatures of the elephant louse feed in the folds of the elephant's skin and must be able to cut through the tough and thick epidermis with their heavily sclerotized mandibles.

Currently, most of our knowledge of sensillar types, distribution, and numbers, and sensory physiology of lice is based upon studies of members of the suborder Anoplura, sucking lice (Wigglesworth, '41; Dethier, '57; Miller, '69, '70a,b, '71a,b; Ubelaker et al., '73; Szczesna, '78, '84; Slifer and Sekhon, '80; Hatsushika et al., '83). Similar information on the members of the suborders Amblycera and Ischnocera, biting lice, is found mainly in papers by Slifer ('76) and Clarke ('90) and references within. Weber ('38, '69) and Mukerji and Sen-Sarma ('55) provide detailed descriptions of the morphology and anatomy of *Haematomyzus elephantis,* but there are no descriptions of cuticular sensory receptors on the antennae and mouthparts of *Haematomyzus elephantis.* The objective of the present report is to provide detailed information on the morphology, number, and distribution of sensilla on the mouthparts and antennae of male and female *Haematomyzus elephantis.*

MATERIALS AND METHODS

Specimens of *Haematomyzus elephantis* Piaget were obtained from elephants in the Bangkok Zoo. They were collected from behind the ears where the skin is more penetrable. The lice were placed either in 70% ethanol or buffered formalin fixative. Those placed in ethanol were cleared in KOH and were used to make measurements and counts of the sensilla. Six specimens of each sex were used for the measurements that were obtained with a light microscope supplied with a calibrated ocular micrometer. The measurements are given as a mean plus the range. Some of the specimens placed in fixative were processed with the crystal violet method of

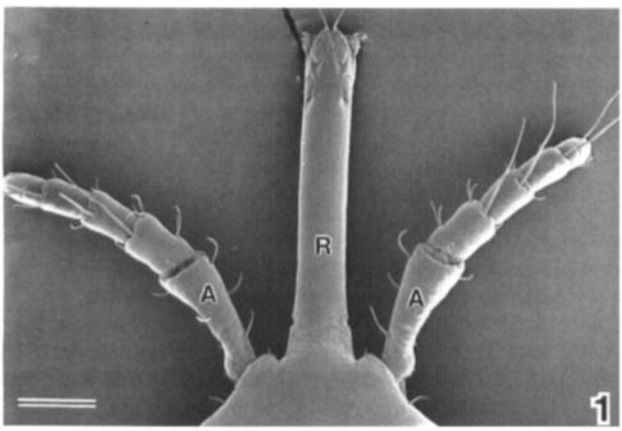
Slifer ('60) in order to identify pores in the cuticle of sensilla.

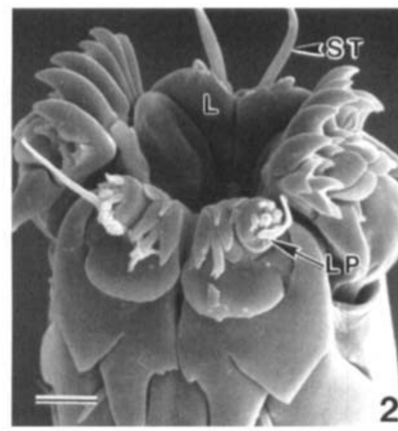
Another group of specimens was rinsed several times in distilled water and then placed in 2% osmium tetroxide for 8 hours. The lice were rinsed, dehydrated in ethanol, critical-point dried, and mounted on stubs with double-sided sticky tape. The specimens were coated with gold-palladium and examined with a JEOL 35 CF SEM and a Cambridge 360 at 10 kV. Images were recorded on Polaroid P/N type 55 film.

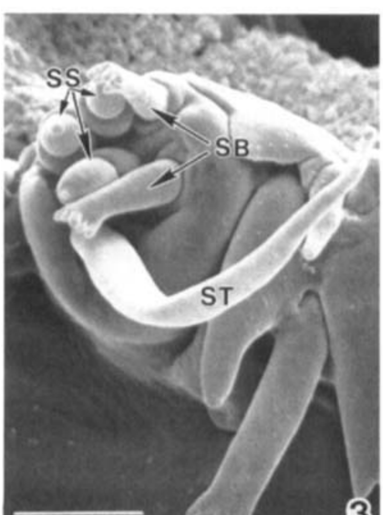
RESULTS

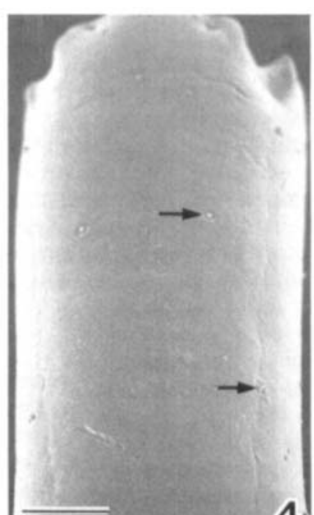
Mouthparts

The most obvious difference in the mouthparts of *Haematomyzus elephantis* compared to other species of lice is the presence of a long rostrum (R), which bears the highly modified mouthparts at the apex (Fig. 1).









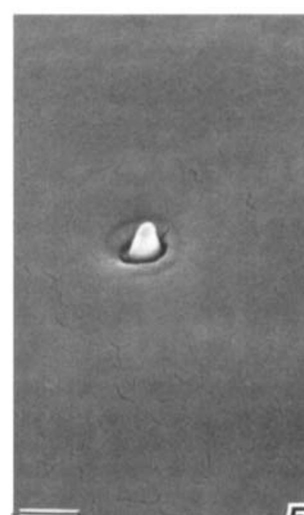


Fig. 1. *Haematomyzus elephantis.* Dorsal view of the antennae (A) and rostrum (R). Scale bar = 100 μm.

Fig. 2. *Haematomyzus elephantis.* Venter of rostral apex showing the location of the labial palpus (LP) and labrum (L). ST, trichoid sensillum. Scale bar = 10 μm.

Fig. 3. *Haematomyzus elephantis.* Labial palpus with three types of sensilla. SB, sensilla basiconica; SS, sensilla styloconica; ST, sensillum tricodeum. Scale bar = 5 μm.

Fig. 4. *Haematomyzus elephantis.* Dorsum of rostrum with rows of basiconic sensilla (arrows). Scale bar = 20 μm.

Fig. 5. *Haematomyzus elephantis.* High magnification of rostral sensillum basiconicum. Scale bar = 2 μm.

There are two rows of three sensilla basiconica (SB) on the ventral and dorsal surfaces (see Fig. 4). These conically shaped sensilla are 1.2 μm (1.10–1.25 μm) long and 0.9 μm (0.8–1.1 μm) wide at the base and are found in both the immature and adult stages of *Haematomyzus elephantis* (Fig. 5). These sensilla stained with the crystal violet thus indicating their porosity. The labrum (L), which is found at the apex of the rostrum on the dorsal surface, is deeply indented at the midline (Fig. 2). A trichoid sensillum (ST) (28 μm, 27–30 μm long; 3.5 μm, 3.4–3.7 μm wide) and a stout conical projection are situated on each side of the indentation. Neither of these structures is stained with crystal violet, suggesting that they might be mechanosensilla.

The labial region (Figs. 2, 3) is the other area of the mouthparts that has sensilla. The labium is deeply incised, and on each portion there is a raised disc-like zone comprising the labial palpus (LP). Each palpus has six sensilla: one trichoid (ST), two basiconic (SB), and three styloconic (SS). The trichoid sensillum is 31 μm (29–34 μm) long and 2.5 μm (2.2–2.7 μm) wide at the base. This sensillum is situated on the basal portion of the labial palpus. The longer of the two basiconic sensilla measures 3.2 μm long (2.9–3.4 μm) and 1.3 (1.2–1.4 μm) wide at the base. The distal end of this sensillum has five or six finger-like projections in a row. The shorter basiconic sensillum, which is 2.2 μm (2.0–2.4 μm) long and 0.7 μm (0.6–0.9 μm) wide at the base, has its finger-like projections in a circular pattern. The three sensilla styloconica are similar in shape, but the central one is larger than the two peripheral ones. The central styloconic sensillum is 3.4 μm (3.3–3.6 μm) long and 2.0 μm (1.9–2.2 μm) wide at the base, whereas the peripheral styloconic pegs are 2.2 μm (2.1–2.3 μm) long and 1.8 μm (1.7–1.9 μm) wide at the base. Both females and males have similar types, distributions, and numbers of sensilla on their mouthparts. All of these sensilla, except the trichoid type, stained intensely with crystal violet.

Antenna

The antenna (A) consists of five annuli with the following lengths: scape (200 μm, 196–205 μm), pedicel (112 μm, 105–117 μm), flagellomere one (75 μm, 72–77 μm), two (74 μm, 71–77 μm), and three (58 μm, 56–63 μm) (Fig. 6). Most of the trichoid sensilla are situated along the lateral, inner surface, and dorsal surface of the antenna (Fig. 6). A long trichoid sensillum (148 μm, 140–155 μm) is located on the dorsal surface of the scape and the three flagellomeres. Trichoid sensilla along the lateral inner surface of the antennal annuli are (48 μm, 45–50 μm) long. These sensilla are situated in a row on the scape and as pairs near the apical region of the pedicel and the three flagellomeres (Figs. 7, 8). The scape has a second pair in the basal region. Shorter trichoid sensilla (37 μm, 35–40 μm) also are found at the apical region of each annulus. Thus, every annulus has a ring of trichoid sensilla at the apex (Figs. 6–8). There are 15–17 trichoid sensilla on the ventral surface of the antennal annuli (Fig. 7). These ventral trichoid sensilla did not stain with crystal violet. A summary of some of the types and numbers of sensilla known to be present in biting and sucking lice is given in Table 1.

Two sensilla basiconica are situated on the dorsal surface of the pedicel near the junction of the scape and pedicel (Figs. 8, 9). They are 4.3 μm (4.0–4.5 μm) long and 2.4 μm (2.2–2.6 μm) wide at the base and are found on male and female antennae. These two sensilla are stained with crystal violet which is suggestive of their porous nature with a chemoreceptive modality. Near the location of the basiconic sensilla, there appears to be a gland opening (GO) which is surrounded by an area consisting of rounded protuberances (Fig. 10).

One sensillum coeloconicum (tuft organ, TO) is situated on the apical and second flagellomeres of the male and female antennae. This sensillum consists of a circular array of sensory pegs that arise from a deep pit (Figs. 13, 14). The number of pegs in the array varies from 12–15, and they are 1 μm–1.5 μm long. The plate organ (PO) which also is situated on the apical and second flagellomeres is found in proximity to the sensillum coeloconicum (Figs. 13, 14). There are two plate organs on the apical flagellomere and one on the second. This plate organ sensillum appears as a shallow, disc-like depression with slightly curving ridges radiating out from a central raised portion to the outer edge. The diameter of the sensillum is 5.5 μm (5.3–5.8 μm). The size and number of the plate organs do not differ in male and female antennae. Both types of sensilla are stained with crystal violet.

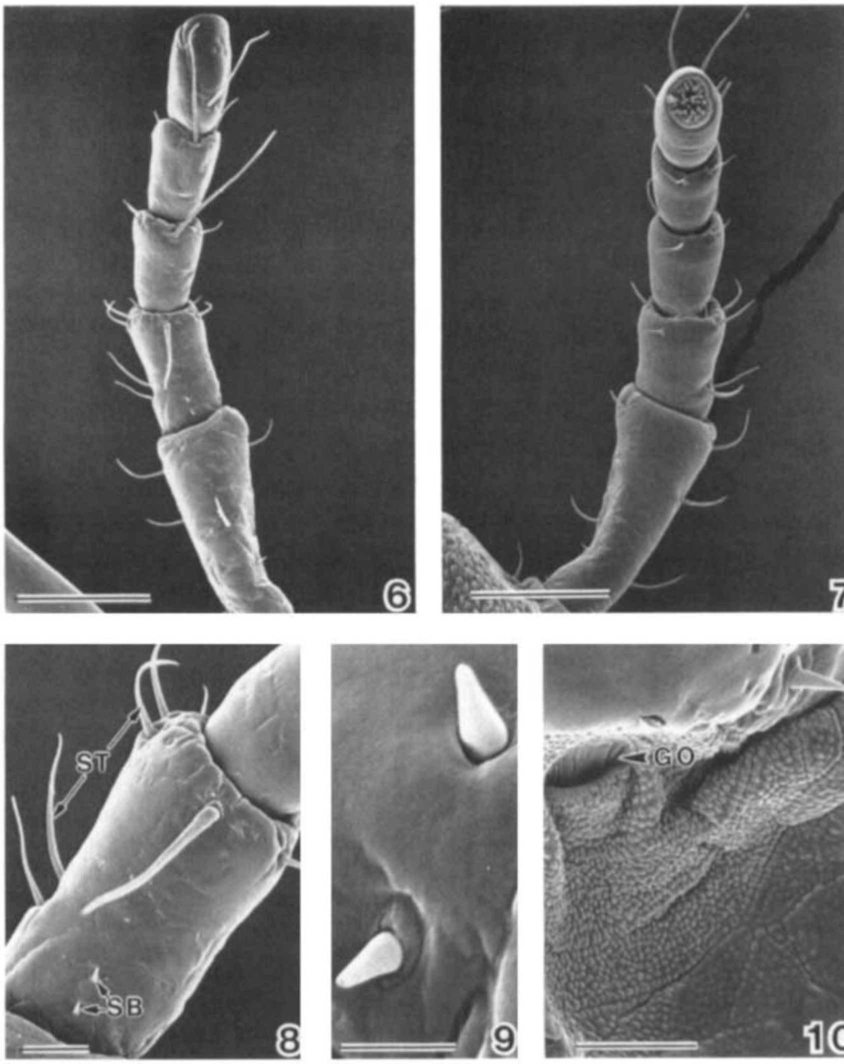


Fig. 6. *Haematomyzus elephantis.* Distribution of sensilla on the dorsal and lateral surfaces of the antenna. Scale bar = 100 μm.

Fig. 7. *Haematomyzus elephantis.* Distribution of sensilla on the ventral surface. Scale bar = 100 μm.

Fig. 8. *Haematomyzus elephantis.* Trichoid (ST) and basiconic (SB) sensilla on the pedicel. Scale bar = 20 μm.

Fig. 9. *Haematomyzus elephantis.* Higher magnification of the sensilla basiconica on the pedicel. Scale bar = 5 μm.

Fig. 10. *Haematomyzus elephantis.* Gland opening (GO) at the junction of the scape and pedicel. Scale bar = 10 μm.

A group of sensilla is situated at the apices of male and female antennae (Figs. 11, 12), composed of one trichoid sensillum and two types of basiconic sensilla. The trichoid sensillum is 6 μm (5.8–6.3 μm) long and 1.6 μm (1.4–1.7 μm) wide at the base, and it is located on the periphery of the apical cluster of sensilla on the male and female antennae. Both types of basiconic sensilla are found on the male and female antennae. The first type of basiconic sensillum is stout with a pointed apex, and ranges in length from 3.5 μm–6.0 μm. The second type of basiconic sensillum is stout with a rounded apex, and ranges in

TABLE 1. Numbers of coeloconic sensilla, plate organs, and apical sensilla on the antennae of biting and sucking lice

	Coeloconic	Plate organ	Apical	References
Biting lice				
So. Amblycera				
Menoponidae	2 (1-1)[1]	—[2]	—[3]	Clay ('70)
Laemobothriidae	3 (2-1)	—	—	Clay ('70)
Ricinidae	2 (1-1)	—	—	Clay ('70)
Boopiidae	2 (1-1)	—	12	Clay ('70)
Gyropidae	4 (4)	—	10	Clay ('70)
Trimenoponidae	4 (4)	—	—	Clay ('70)
So. Ischnocera				
Philopteridae	4 (2-2)	3 (2-1)	12	Slifer ('76)
Tricodectidae	4 (4)	3 (3)	11	Clarke ('90)
So. Rhynchophthirina				
Haematomyzidae	2 (1-1)	3 (2-1)	26 m; 14 f	Present report
Sucking lice				
So. Anoplura				
Echinophthiriidae	2 (2)	2 (2)	11	Miller ('71c)
Haematopinidae	2 (1-1)	2 (2)	14	Miller ('71a)
Enderleinellidae	2 (1-1)	2 (2)	11	Baker (unpublished data)[4]
Hoplopeuridae	2 (1-1)	2 (2)	10	Baker (unpublished data)[5]
Linognathidae	2 (1-1)	1 (1)	11	Miller ('70b)
Pediculidae	2 (1-1)	2 (2)	10	Slifer and Sekhon ('80) Szczesna ('84)
Polyplacidae	2 (1-1)	2 (2)	11	Miller ('70a)
Pedicinidae	2 (1-1)	2 (2)	10	Miller ('71b)
Phthiridae	2 (1-1)	2 (2)	10	Miller ('69) Ubelaker et al. ('73)

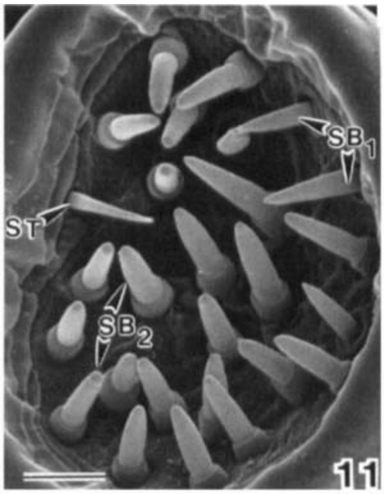
[1]First value is the total number of sensilla. In parentheses, first and second number of sensilla on apical annulus and number on penultimate annulus, respectively.
[2]No plate organs in these families.
[3]Data not available on a particular family.
[4]Enderlenellus spp.
[5]*Hoplopleura erratica* (Osbourn).

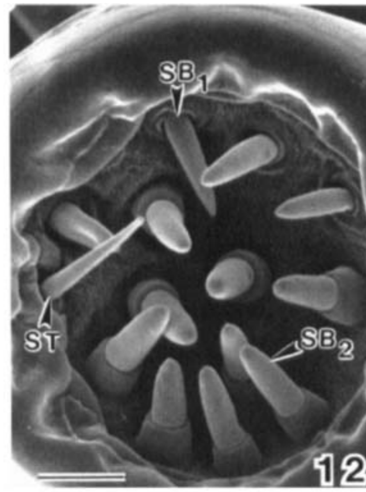
total length from 4 μm–7 μm. These sensilla are also situated on a round basal support that is 2 μm–2.5 μm high.

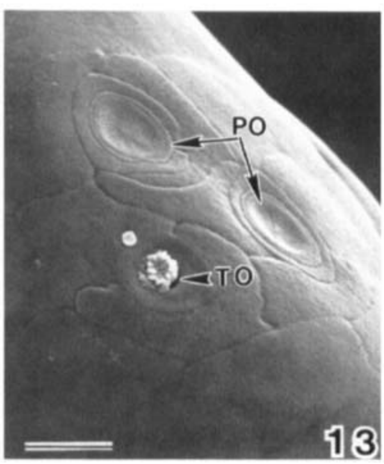
The major difference between male and female antennae is the total number of apical sensilla. Both sexes have a trichoid sensillum, whereas the male has 26 sensilla basiconica, the female has 13. The apical sensilla on the antennae stain with crystal violet.

DISCUSSION

The highly modified rostrum of the elephant louse is used for attachment to its host and this differs from most other biting and sucking lice, which use their modified tarsal claws (Ferris, '31; Mukerji and Sen-Sarma, '55; personal observations). Sucking lice do not have distinct palpal areas as are found in biting lice, and, therefore, the number and type of mouthpart sensilla are greatly reduced. Most sucking lice have only a few trichoid sensilla in the region around the oral opening, e.g., *Solenopotes capillatus* Enderlein (Linognathidae), Miller ('70b); *Pthirus pubis* (Linnaeus) (Phthiridae), Ubelaker et al. ('73); *Pediculus humanus capitis* De Geer (Pediculidae), Hatsushika et al., '83; *Haematopinus suis* (Linnaeus) (Haematopinidae) (Baker, unpublished data), whereas *Haematomyzus elephantis* has a distinct labial palpal region with a cluster of six sensilla that represent three distinct types. Most of the biting lice species have a well-developed labial palp that has three to five setae at the apex of the palp (Clay, '70). This also differs from the number and types of sensilla on the labial palpus of *Haematomyzus elephantis*. The rows of short sensilla basiconica found on the rostrum of *Haematomyzus elephantis* are (at present) the only ones to be documented and associated with the mouthparts of a louse. This type of sensillum is not found on the external surface of the piercing and sucking mouthparts of Hemiptera (Schoonhoven and Henstra, '73; Ave' et al., '78; Hatfield and Frazier, '80) and Homoptera (Backus, '88). At present, behavioral and electrophysiological data on the sensilla of the labial palpus and rostrum are lacking, but sensilla on mouthparts of species in other orders are involved in chemoreception and possibly thermo- and/or hygro-reception (Alt-







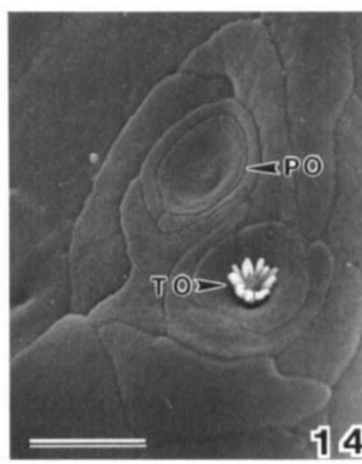


Fig. 11. *Haematomyzus elephantis.* Apex of the male antenna (ST, sensillum trichodeum; SB_1, sensilla basiconica pointed apex; SB_2, sensilla basiconica blunt apex). Scale bar = 5 μm.

Fig. 12. *Haematomyzus elephantis.* Apex of the female antenna. ST, sensillum trichodeum; SB_1, sensilla basiconica pointed apex; SB_2, sensilla basiconica blunt apex.Scale bar = 5 μm.

Fig. 13. *Haematomyzus elephantis.* Plate organs (PO) and tuft organ (TO) on the third flagellomere. Scale bar = 5 μm.

Fig. 14. *Haematomyzus elephantis.* Plate organ (PO) and tuft organ (TO) on the second flagellomere. Scale bar = 5 μm.

ner and Loftus, '85; Zacharuk, '85; Backus, '88).

The various types of sensilla on the antennae of *Haematomyzus elephantis* are similar to those found on the antennae of other biting and sucking lice (Table 1). The major difference between the elephant louse and other lice is the number of sensilla on the apex of the antennae (Table 1). The male of *Haematomyzus elephantis* has at least two times more apical antennal sensilla than what is known for other lice. The trichoid sensilla on the ventral and dorsal surfaces of the antennae are similar to those on other lice but there are differences in the total number of trichoid sensilla: 15–17 in *Haematomyzus elephantis;* 65–94 in *Damalinia ovis* (Clarke, '90); 25 in *Pediculus humanus* (Szczesna, '84); 12 in *Craspedorrhynchus americonus* (Slifer, '76); and 28–30 in *Polypax serrata* (Miller, '70a).

The antennae in lice may or may not exhibit sexual dimorphism. In *Haematomyzus elephantis,* the male antennae have about twice as many apical sensilla than those of the female; and in *Polyplax serrata* and *Damalinia ovis,* the male antennae have a hook-like structure (Miller, '70a; Clarke, '90), whereas the antennae of *Echinophthirius horridus, Antarctophthirus callorhini,* and *Proechinophthirius fluctus* do not exhibit any sexual dimorphism (Miller, '71c).

As indicated in Table 1 there are no significant differences in the number or distribution of the plate organ or coeloconic "tuft" sensilla on the antennae of biting and sucking lice. The major difference in the tuft organ is that the sensillum is deeply recessed in a pit on different lice species of various families. There are distinct differences in the antennal plate organ. The disc-shaped sensillum on *Pediculus humanus capitis* has a central pore surrounded by an area of smooth cuticle from which grooves radiate outward in a circular fashion (Hatsushika et al., '83, Fig. 12); *Haematopinus* species have a pore organ that has concentric rings (Miller, '71a, Fig. 4); *Haematomyzus elephantis* has grooves radiating from a central protuberence; the plate organ of *Polyplax serrata* is smooth (Miller, '70a, Figs. 1, 4). Clarke ('90) does not state that *Damalinia ovis* has any plate organs, but in his Figure 5, there appear to be three plate organs associated with the pit sensilla.

The two sensilla basiconica on the pedicel are the only ones to be found on the antennae of a louse at a location other than the apex. These sensilla are situated next to an area of the antenna that appears to have a glandular opening. These two sensilla may be involved in monitoring any chemicals that may be secreted from the opening of a dermal gland. Sex pheromone glands and other dermal glands are known to occur on the antennae of some insects (Dahms, '84; Bin and Vinson, '86; Noirot and Quennedey, '74).

It is known that lice respond to temperature, humidity, olfaction, and contact (Weber, '29; Wigglesworth, '41; Murray, '57a,b). The sensilla that are responsible for the detection of these stimuli are located on the antennae (Wigglesworth, '41). Electrophysiological and transmission electron microscopy information is needed to elucidate the function of the various types of sensilla especially the plate organ and coeloconic (tuft) sensillum. More work is needed on the morphology, number, and distribution of antennal sensilla from genera in all the families of lice. This may provide information that could be useful in studying the phylogeny of this insect order.

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