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SCANNING ELECTRON MICROSCOPY OF *ECHINOPHTHIRIUS HORRIDUS* (VON OLFERS), *ANTARCTOPHTHIRUS CALLORHINI* (OSBORN), AND *PROECHINOPHTHIRIUS FLUCTUS* (FERRIS) WITH EMPHASIS ON THE ANTENNAL STRUCTURES (ANOPLURA: ECHINOPHTHIRIIDAE)

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ABSTRACT: The 4-segmented antennae of *Echinophthirius horridus* and *Proechinophthirius fluctus* have 2 sensilla basiconica (previously called tuft organs) and 2 pore organs on the fourth or terminal segment. The sensilla basiconica of *E. horridus* have 11 to 13 hairs projecting from a ring near the apex of a stalk, whereas those of *P. fluctus* have 7 primary hairs which divide into 2 or 3 branches yielding a total of approximately 17 secondary hairs. *Antarctophthirus callorhini* has a 5-segmented antenna in the adult stages. Two sensilla basiconica and 2 pore organs are found on the fifth or terminal segments. The sensilla basiconica have 13 primary hairs of which 3 or 4 usually branch at their midpoint forming a total of 17 to 19 secondary hairs. The number and characters of the hairs on the sensilla basiconica may lead to an understanding of the evolution of the family. The pore organs appear associated with the distal sensillum basiconicum in each case. The squamous integument and variation in the types of setae are also discussed.

Recent studies of the Anoplura by Miller (1969, 1970a, b, 1971) and of the Amblycera by Clay (1970), using the scanning electron microscope (SEM), have shown that variations of the antennal sensilla can be of taxonomic value. It is possible by comparing the variations of the sensilla among groups that the evolution of the sensilla can be deduced. This would ultimately lead to an understanding of the phylogenetic relationship of lice. Before undertaking a study of the phylogenetic relationships, or assigning taxonomic significance to the antennae and their sensilla, it is necessary to study the variations found within the orders, families, and genera.

The family Echinophthiriidae, with some 10 known species (Kim, pers. comm.), is found exclusively upon marine animals of the suborder Pinnipedia. The genus *Echinophthirius* with the single species *horridus* (von Olfers) occurs on seals of the genera *Halicherus* and *Phoca*. The genus *Antarctophthirus* contains six species. *A. callorhini* (Osborn) is found on the fur seals *Callorhinus*. The genus *Proechinophthirius* contains two species. *P. fluctus* is also found on the fur seals *Callorhinus*. The antennae of *A. callorhini*, as with most Anoplura, are five-segmented, whereas those of both *E. horridus* and *P. fluctus* are four-segmented.

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MATERIALS AND METHODS

This study is based on 9 specimens of *E. horridus*, 12 specimens of *A. callorhini*, and 12 specimens of *P. fluctus*. The 2 males and 7 females of *E. horridus* were collected from around the mouth of *Phoca hispida* in Gambell, Alaska, by Dr. Robert L. Rausch, who also submitted several specimens to Dr. K. C. Emerson for identification. The 4 males, 6 females, and 2 nymphs of *A. callorhini* and 4 males, 6 females, and 2 nymphs of *P. fluctus* were collected from *Callorhinus urinus* on St. Paul Island, Alaska, and contributed to this study by Dr. Ke Chung Kim.

The specimens were cleaned in a lactophenol solution (50 ml lactic acid, 50 g phenol) and rinsed in 3 changes of 70% ethyl alcohol, air dried, and cemented to metal SEM stubs with aluminum paint. They were then coated with approximately 200 Å of gold by means of vacuum evaporation

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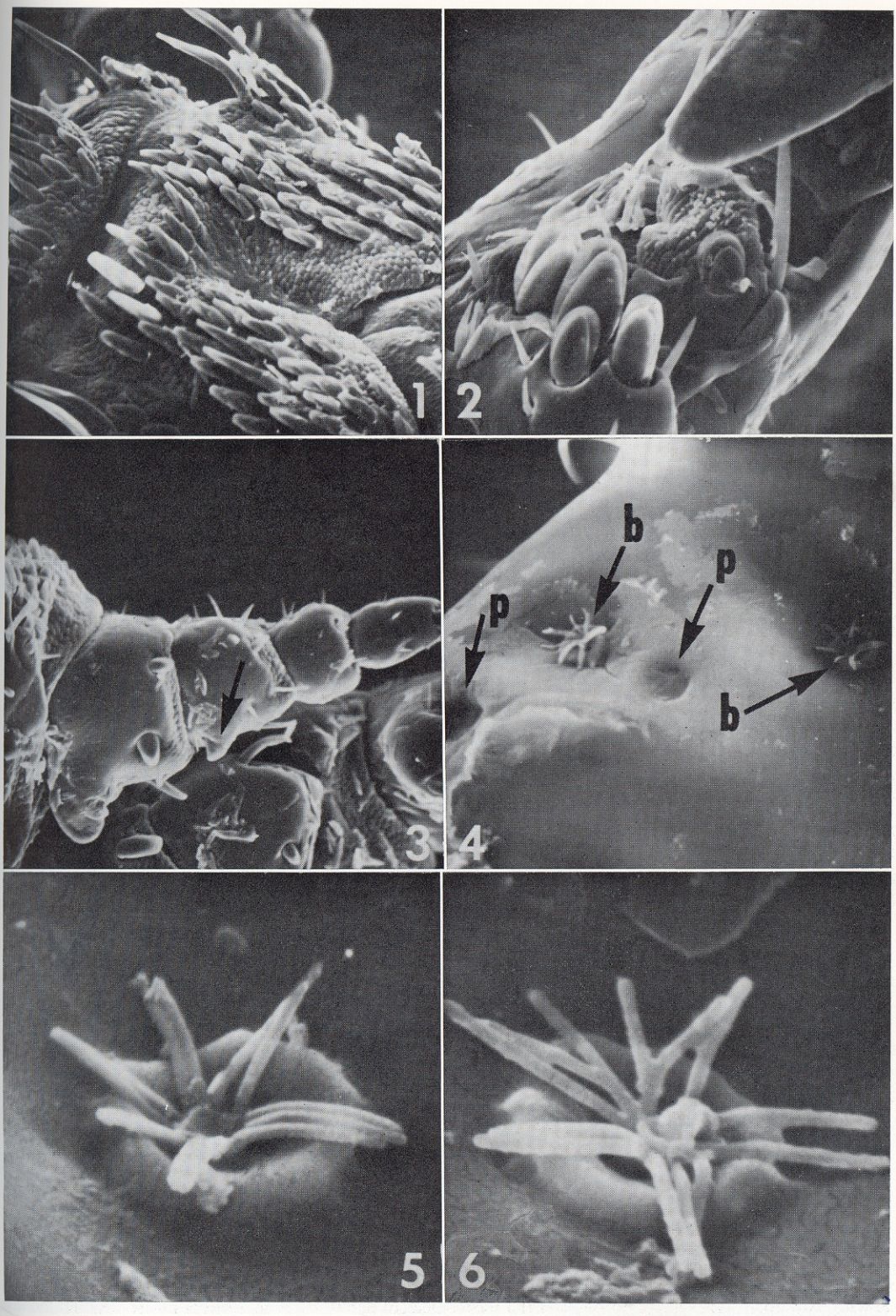
FIGURES 1–6. *Echinophthirius horridus*. **1**. Thorax, dorsal aspect showing squamous texture of integument and numerous setae. 220 ×. **2**. Setae and tarsal pad on basal lobe of tarsus of second leg. 500 ×. **3**. Antenna showing ventral lobes of first and second segments. 200 ×. **4**. Terminal antennal segment showing two pore organs (p) and two sensilla basiconica (b) 2,000 ×. **5, 6**. Sensilla basiconica. 11,000 ×.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and studied with a Cambridge Steroscan Mark II SEM at 20 kv. The specimens are on file at the Parasitology Section, Department of Pathology and Laboratories, Nassau County Medical Center, East Meadow, New York.

RESULTS

Echinophthirius horridus (von Olfers)

The general description of *E. horridus* can be found in the monograph by Ferris (1934). A review of some of the topographical characters was undertaken prior to studies of the antennal structures. Ferris (1951) describes the abdominal integument for the entire family as membranous or leathery and the genus (Ferris, 1934) *Echinophthirius* as entirely membranous in both sexes except for the ninth tergum and genital plates. However, he does not indicate whether the integument is smooth or reticulated. Scanning electron microscopy reveals that the abdominal integument of *E. horridus* has a squamous appearance (Fig. 1). The abdomen, thorax, and head are covered with numerous setae of various lengths. The long stout setae appear to be of the same type and texture as the short stout setae. The short stout setae are most common on the head, thorax, and ventral side whereas the longer setae are most common on the abdomen. There are long, slender setae scattered over the thorax and abdomen on the dorsum, similar to those seen in the region of the genitalia. Ferris (1951) illustrates the setae at the basal lobe of the tarsus opposite the claw of each of the legs as being fingerlike and bent. However, these setae are of the short stout type (Fig. 2).

The antenna is four-segmented and the first and second segments each have a lobe on the ventral aspect (Fig. 3). There is a circular elevation measuring approximately 2 μ in its diameter on the distal end of the first segment on its dorsal aspect which may be a campaniform organ. There are two sensilla basiconica and two pore organs on the fourth or terminal segment (Fig. 4). The sensilla basiconica have 11 to 13 hairs projecting from a ring, near the apex of a stalk (Figs. 5, 6). The two pore organs do not have any slits or plates and appear to be anatomically associated with the distal sensillum basiconicum. There is no evidence of sexual dimorphism of the antennae.

Antarctophthirus callorhini (Osborn)

The general description of *A. callorhini* can be found in the monograph by Ferris (1934). A review of some of the topographical characters reveals the abdominal integument to have a squamous appearance. The abdomen is beset with setae of various lengths and sizes (Fig. 7). Scales (Fig. 8), although somewhat variable in form, are for the most part elongated, pointed, and possess irregular serrations near the apex.

The antennae are five-segmented (Fig. 9). There is a circular elevation measuring approximately 2 μ in diameter on the dorsal aspect of the first segment, which may be a campaniform organ. There are two sensilla basiconica and two pore organs on the fifth or terminal segment (Fig. 10). The sensilla basiconica have approximately 13 primary hairs of which at least four branch at their midpoint to form approximately 17 to 19 secondary hairs (Fig. 11). Three or four hairs appear to be upright, whereas the remaining appear to lie upon the edge of the opening and surrounding integument. The two depressions considered to be pore organs appear to be anatomically associated with the distal sensillum basiconicum. There is no evidence of sexual dimorphism of the antennae.

Proechinophthirius fluctus (Ferris)

The general description of *P. fluctus* can be found in the monograph by Ferris (1934). A review of some of the topographical structures reveals a squamous integument on the abdomen and numerous setae (Fig. 12). The legs appear similar, with the tibia and tarsus entirely

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FIGURES 7–11. *Antarctophthirus callorhini.* **7.** Abdominal integument (4th to 7th segments) dorsal aspect. 200 ×. **8.** Abdominal integument (5th segment). 500 ×. **9.** Five-segmented antenna. 100 ×. **10.** Fifth antennal segment showing two pore organs (p) and sensilla basiconica (b). 2,000 ×. **11.** Sensilla basiconica on fifth antennal segment. 10,000 ×.

FIGURE 12. *Proechinophthirius fluctus.* Dorsal aspect of 6th to 8th abdominal segments showing squamous integument and setae. 200 ×.


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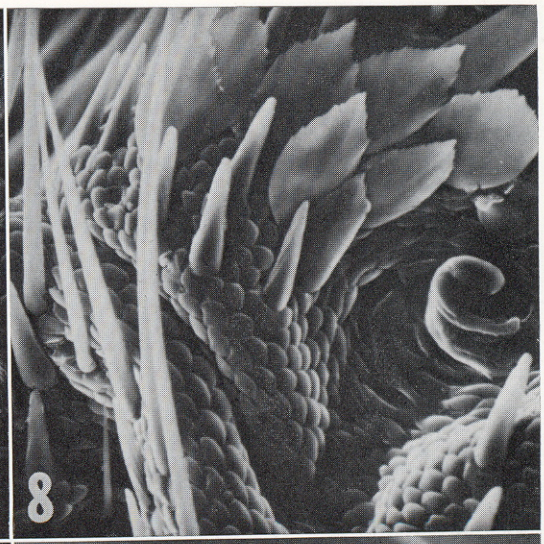
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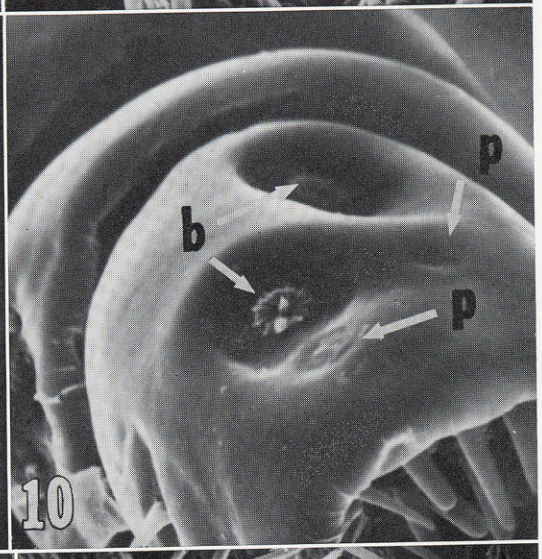
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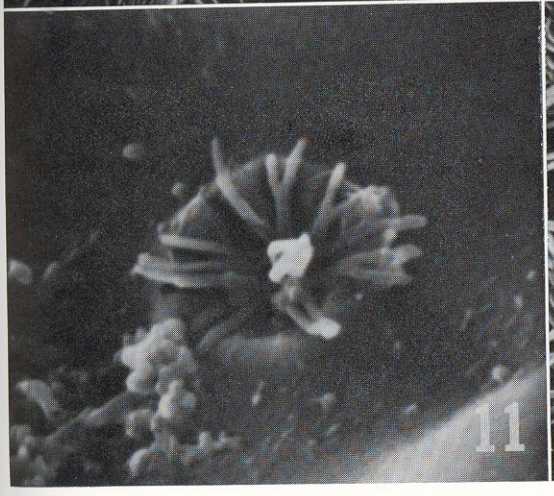
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fused (Fig. 13), and a pronounced basal lobe with three distinct pads between the lobe and claw (Fig. 14).

The antenna is four-segmented. The same campaniformlike organ described above is found on the dorsal aspect, near the distal end of the first segment. There are two sensilla basiconica and two pore organs on the fourth (Fig. 15) or terminal segment. The sensilla basiconica have what appear to be approximately seven primary hairs which divide into two or three branches (Figs. 16–18) forming approximately 17 secondary hairs. The two pore organs appear to be associated with the distal sensillum basiconicum. There is no evidence of sexual dimorphism of the antennae.

DISCUSSION

Mjöberg (1910) describes the cuticula of most Sphunculata (Anoplura) as being sculptured. In describing the texture of the abdomen other authors used terms such as leathery, membranous, or slightly sclerotized when referring to the abdomen lacking sclerotization. Ferris (1951) illustrates dermal reticulation of *Linognathus vituli* which was demonstrated by Miller (1970b) to be of squamous texture. The same squamous texture, seen on the three species studied here, is found on the abdomen of the Anoplura which are described as sculptured, reticulated, and many of those described as leathery or membranous in the previous literature.

Wigglesworth (1941) originally described the sensilla on the fourth and fifth segments of *Pediculus humanus* as tuft organs. He described three such organs on the fifth or terminal segment and one on the fourth. Miller (1969) demonstrated that there was only one such organ on the fifth and one on the fourth antennal segments. The pore organs were located where Wigglesworth described the other two tuft organs. However, the term tuft organ was held for most studies of the Anoplura. Roth and Willis (1951) use the term sensillum basiconicum (peg organ) when they describe a similar organ on the antennae of the *Tribolium* species. Although more studies are needed to confirm the facts, both Wigglesworth (1941) and Roth and Willis (1951) consider the sensilla to be humidity receptors. Therefore it seems practical to establish similar terminology for these sensilla. This would lead to a better understanding of the sensilla in question. I suggest that the tuft organs of the Anoplura hereafter be referred to as sensilla basiconica.

Ferris (1951) indicates that the Anoplura usually have a ringlike structure on the posterior border of each of the two terminal antennal segments. Studies by Miller (1969; 1970a, b; 1971) have shown these ringlike structures to be either sensilla basiconica or sensilla coeloconica. Clay (1970) has demonstrated sensilla coeloconica in a similar region on Amblycera. It has also been shown that a family or genus having sensilla coeloconica on their antennae have a variation in the size of the opening, hairs on pegs in the atrium as well as position, texture, and distinctness of pore organs associated with the sensilla (Miller, 1971; Clay, 1970). Those of the same family (Miller, 1969) having sensilla basiconica have a different number of hairs projecting from the stalk of the sensilla. The present communication demonstrates this variation in Echinophthiriidae.

Although the Anoplura usually have a total of five antennal segments in the adult stages, the nymphal stages usually appear to have less. In these nymphal stages two sensilla basiconica or coeloconica are still present, but both are present on the terminal segment.

In those Anoplura having a four-segmented antenna it therefore appears understandable that two sensilla basiconica or coeloconica, depending on family, would be present on the terminal segments. Of the family Echinophthiriidae, two of the members in this study, *E. horridus* and *P. fluctus*, have four-segmented antennae in the adult stages. Two sensilla basiconica are found on each of their fourth or terminal antennal segments. Although the third member, *A. callorhini*, has a five-segmented antenna, it differs from most Anoplura

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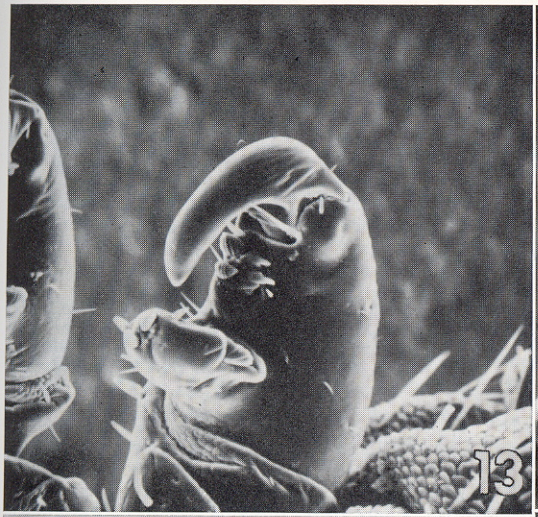
FIGURES 13–18. *Proechinophthirius fluctus*. **13**. Fused tibia and tarsus of third leg. 200 ×. **14**. Three pads between lobe and claw of tarsus of third leg. 500 ×. **15**. Antenna showing two sensilla basiconica on terminal segment. 500 ×. **16**, **17**, **18**. Sensilla basiconica showing branching of primary hairs. 10,000 ×.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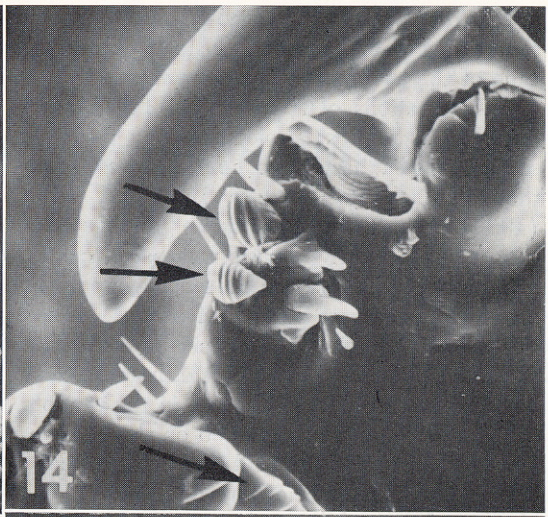
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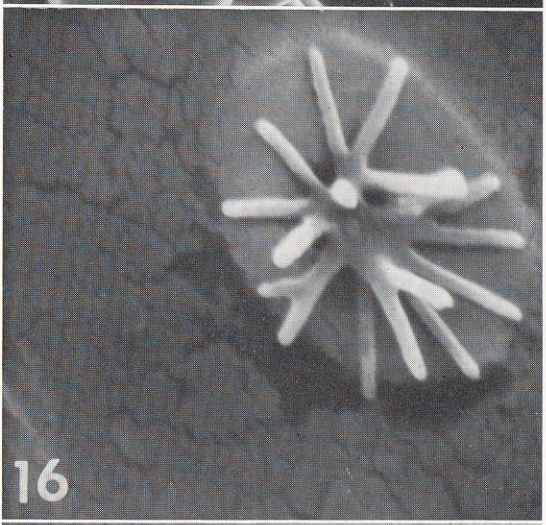
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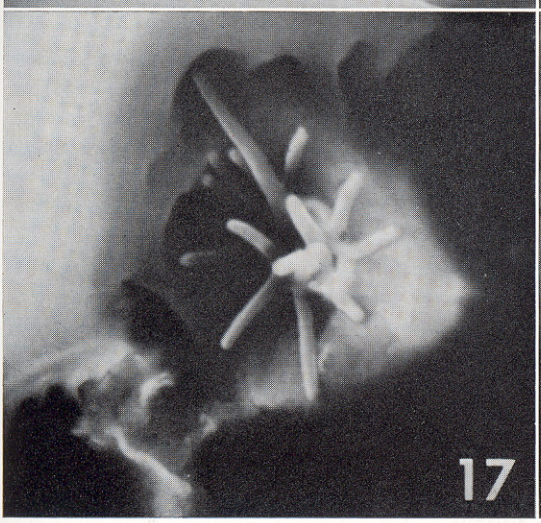
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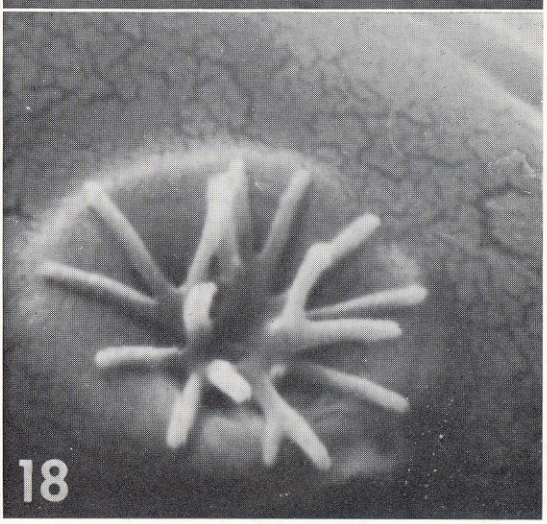
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in that the two sensilla basiconica are found on the fifth antennal segment instead of one on each of the two most distal segments.

The variations of the number of hairs (referred to as prongs) projecting from the stalk of the sensilla basiconica on the antennae of the *Tribolium* was used by Roth and Willis (1951) to indicate the possible phylogeny of that genus. The hypothesis was based on the evolution of the basiconica sensilla from the simplest form (least number of prongs). They studied only six of the 26 species of *Tribolium* and therefore could only indicate the possibility of this hypothesis. A difference in the number of hairs has been demonstrated on the basiconica sensilla of some lice and this may well lead to the understanding of the evolution of the genus and family. It is also possible, and the author's belief, that the sensilla basiconica evolved from the closing of the atrium and elevation of the peg of the sensilla coeloconica. Thus, by use of these sensilla, the phylogenetic relationship of the Anoplura and Mallophaga (Phthiraptera) may be demonstrated. In addition they may prove to be of taxonomic value. Studies to substantiate these possibilities are continuing as specimens become available.

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