# STRUCTURE OF SELECTED BODY SETAE OF IMMATURE AND ADULT *AEDES AEGYPTI* (DIPTERA: CULICIDAE)

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ABSTRACT. Setae located on the abdomen and scape of both sexes of adult *Aedes aegypti* (L.) as well as selected thoracic and abdominal setae of fourth instar larvae and abdominal setae of pupae were found, using transmission electron microscopic techniques, to have the structural features of cuticular mechanosensilla. Each sensillum is innervated by one neuron, the dendrite of which terminates at the setal base or in the setal shaft as a tubular body, a parallel arrangement of microtubules within an electron dense material. These results coupled with those from previous light and electron microscopic studies indicate that all of the setae on the bodies of larval, pupal, and adult *Ae. aegypti* are probably mechanosensory. The likely roles of these sensilla in the mosquitoes' behavior are discussed.

## INTRODUCTION

Concentrations of sensilla occur on the antennae, maxillary palps, and mouthparts of adult and larval mosquitoes and on the tarsi of adults. Numerous recent fine structural investigations have revealed that most of these sensilla have the structure usually associated with contact or olfactory chemosensilla, a finding substantiated by behavioral and electrophysiological studies.

On the bodies of immature and adult mosquitoes are also a variety of setae, single and branched, some of which are known from light microscopic studies to be innervated. For example, using methylene blue stain Burgess and Rempel (1966) elegantly elucidated the innervation of the anterior head setae of fourth instar larval *Aedes aegypti* (Linnaeus). The various setae of all life stages have been tacitly assumed to be mechanosensilla.

The present work was undertaken to determine if selected setae of *Ae. aegypti* are innervated and if so, to make observations on the fine structure of the neurons that might give insights into their functions. The results aid in our understanding of the sensory basis of mosquito behavior. The structures investigated: (a) on adults were setae on abdominal segments II and III of females and abdominal segment II of males, and small setae on the scape of both sexes; (b) on pupae were seta 1–I (numbering scheme after Belkin 1952) undesignated antero-lateral setae on abdominal segment I, and setae 4- and 9-VIII; and (c) on fourth instar larvae were lateral setae on thoracic segments I and II and abdominal segment II. In sections of larvae it was impossible to identify the individual setae of chaetotaxonomic significance.

## MATERIALS AND METHODS

Specimens were obtained from a laboratory colony that originated from a collection made near Orlando, Florida and fixed for transmission electron microscopy in a solution containing glutaraldehyde and osmium tetroxide buffered with sodium cacodylate (according to the method of Franke et al. 1969) for 2 hr at 4°C. After postosmication the tissues were dehydrated in a graded alcohol series, followed by propylene oxide, and embedded in Spurr's low viscosity epoxy medium (Spurr 1969). Sections were stained in uranyl acetate and lead citrate.

## RESULTS

ABDOMINAL SETAE OF ADULTS. On abdominal segments I to VII of adult *Ae. aegypti* are a line or so of inconspicuous setae mainly confined to the posterior and lateral borders of the sclerites. The

setae are more noticeable on the sternites and occur in much greater number on segments VI and VII (Christophers 1960). The setae are simple, slender, and tapered, and set into well defined sockets (Figures 1,2). The sides of the sockets are composed of sturdy cuticle continuous with the abdominal cuticle. A spongy-appearing, presumably more flexible, layer occurs within the socket (Figures 1,2).

Associated with each seta are one neuron and 2 sheath cells (Figures 1,2). The dendrite of the neuron is divided into inner and outer segments by a region assuming the structure of a cilium with a $9 \times 2 + 0$ arrangement of microtubules. Extending proximally from the ciliary region is a basal body with a $9 \times 3 + 0$ arrangement of microtubules and ciliary rootlets. Distally the neuron contains a tubular body, a parallel arrangement of microtubules in an electron dense material, that is attached to the setal base by the cuticular sheath which covers the outer segment of the dendrite (Figure 1).

The outer sheath cell wraps tightly around the inner one (Figure 2) and extends farther distally to the bases of the cuticular sides of the socket (Figure 1). The outer sheath cell encloses an extracellular space, the receptor-lymph cavity (Figure 1). The inner sheath cell is closely apposed to the dendrite except at the junction region of the segments of the dendrite where it withdraws forming the extracellular receptacle cavity (Figure 1).

SCAPAL SETAE OF ADULTS. On each scape near the inter-antennal suture are three short, slender, pointed setae that arise from rimmed, bulbous bases (Figures 3,4). The sides of the bases are composed of extensions of the body cuticle (Figure 4). A very darkly staining material forms the rims of the bases and the shallow areas adjacent to the setal bases (Figure 4). For the setae to be movable flexibility would presumably be imparted by the dark material. Suspensory fibers can be seen extending from the darkly staining material to the sides of the bases (Figure 4).

The neuron and sheath cells are as described for the abdominal setae, except that the dendrite extends about 0.33–0.50 the length of the seta where the tubular body covered by the cuticular sheath completely fills the setal lumen. The cuticular sheath merges with the surrounding setal cuticle; distally the seta is solid cuticle.

THORACIC AND ABDOMINAL SETAE OF LARVAE. Projecting laterally from the thoracic and abdominal segments are setae which are largest on the second thoracic segment, posteriorly becoming progressively smaller. Except for the posterior few abdominal segments that have quite simple arrangements, the lateral setae consist of basal plaques from which several setae arise and one or more single setae (Christophers 1960).

Associated with each seta, including the highly branched ones, are one neuron (Figure 5) and 2 sheath cells generally similar to those previously described. Unlike adult *Ae. aegypti* the outer segment of the dendrite and covering cuticular sheath are highly convoluted (Figure 5); perhaps an adaptation for support of the dendrite in the soft-bodied larva. The tubular bodies associated with branched setae are larger than those innervating simple setae, undoubtedly a reflection of the relative differences in sizes and numbers of branches served.

ABDOMINAL SETAE OF PUPAE. Seta 1 on abdominal segment I and setae 6 and 4 on abdominal segment VIII are each innervated by one neuron with a tubular body (Figure 6) and has 2 sheath cells. The distal tip of the dendrite extends through a fibrous region associated with the socket, presumably very well developed suspensory fibers necessary for attachment of large branched setae, to terminate at one side of the base. Sections through a few undesignated simple setae on abdominal segment I revealed the presence of a tubular body in each.

## DISCUSSION

All of the setae studied in this work are

each innervated by a neuron with a dendrite that distally contains a tubular body, a characteristic of cuticular mechanosensilla in insects (McIver 1975). Using honeybees, Thurm (1964) demonstrated electrophysiologically that excitation of the nerve occurs when the hair is deflected resulting in compression of the tubular body. The variations in socket structure, site of termination of dendrite, and size and shape of hair in the sensilla observed herein are undoubtedly all adaptations to facilitate deformation of the tubular body by the specific type of mechanical force perceived.

Deflection of the abdominal setae of adult *Ae. aegypti* could be brought about by either touch or movement of air. The scapal setae are likely tactile receptors, most probably stimulated by contact with the pedicel and thereby possibly being part of a system for control of antennal position.

The thoracic and abdominal setae of the larvae and the abdominal setae of pupae studied herein likely respond to vibrations in the water. The variations in sizes of setae, whether they are simple or branched, and whether they occur singly or in groups arising from plaques, presumably correspond with the strength of the vibrations sensed. For mosquito larvae and pupae water vibrations may indicate approaching danger and hence, trigger evasive movements. In predaceous mosquito larvae, such as *Toxorhynchites* spp., vibrations of the water may indicate the presence of potential prey and elicit capture behavior (Steffans and Evenhuis 1981). In addition many of the presumed mechanosensitive setae, such as seta 9-VIII of the pupa, are in advantageous locations for responding to changes in water pressure brought about by body movements. These setae, consequently, may form part of a feedback mechanism for control of body position.

The results reported herein coupled with those from previous electron microscopic studies of hair mechanosensilla on the tarsi (McIver and Siemicki 1978), antennae (McIver 1972), and terminalia (Rossignol and McIver 1977) of both sexes of *Ae. aegypti*, and abdominal tufts of *Tx. brevipalpis* Theobald (McIver and Siemicki 1980) and the reports from many light microscopists seem to indicate that all of the setae scattered on the bodies of larval, pupal, and adult mosquitoes are innervated by mechanosensitive neurons.

## ACKNOWLEDGMENT

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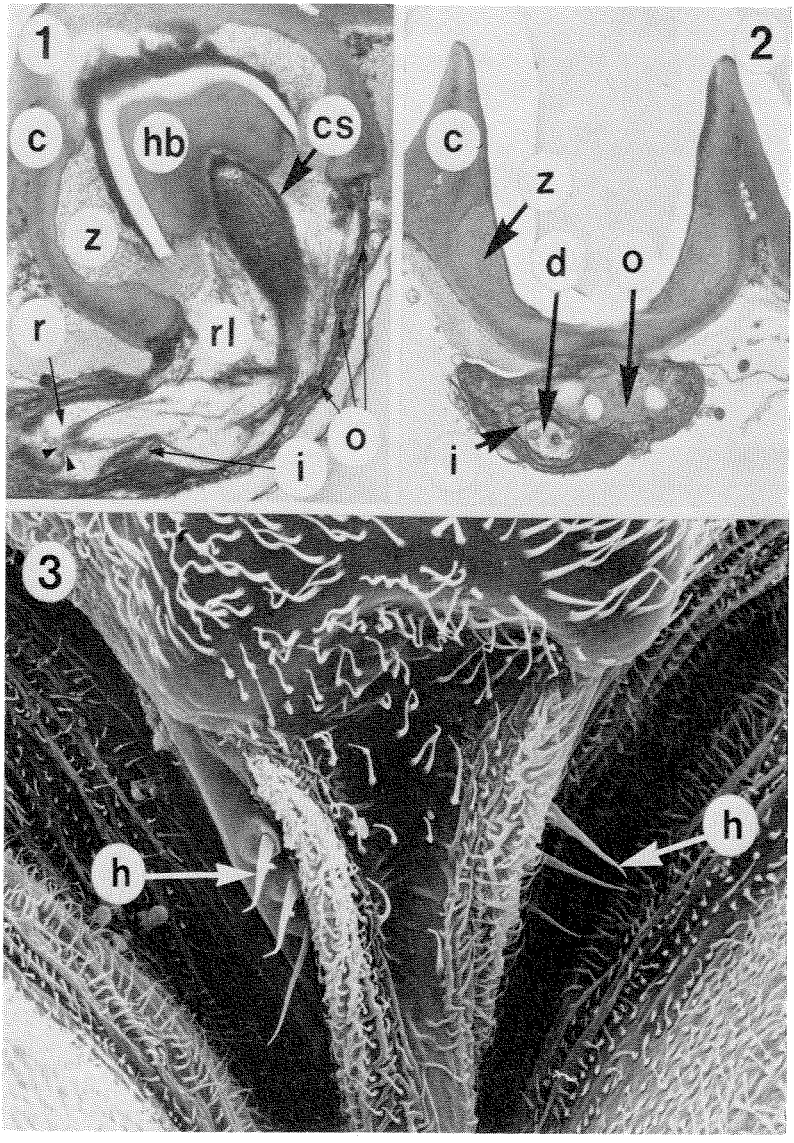
Fig. 1. Oblique section through socket region of sensillum on abdominal segment II of male showing spongy-appearing layer (z) within sturdy cuticular sides (c) of socket and tubular body covered by cuticular sheath (cs) attached to the setal base (hb). Visible also are the inner (i) and outer (o) sheath cells, receptor-lymph cavity (rl), receptacle cavity (r), and junction region (arrowheads) between inner and outer segments of the dendrite. X 16,950.

Fig. 2. Section through socket from which seta has fallen and associated cells of sensillum on abdominal segment II of male. Note cuticular sides (c) and inner spongy-appearing layer (z) of socket, dendrite (d) cut in distal region of inner segment, and inner (i) and outer (o) sheath cells. X 9,000.

Fig. 3. Scanning electron micrograph of dorsal inter-antennal region of male showing the bases of the pedicels and 2 groups of 3 short, pointed setae (h) located on the scapes. Numerous microtrichia occur in the micrograph. X 3,430.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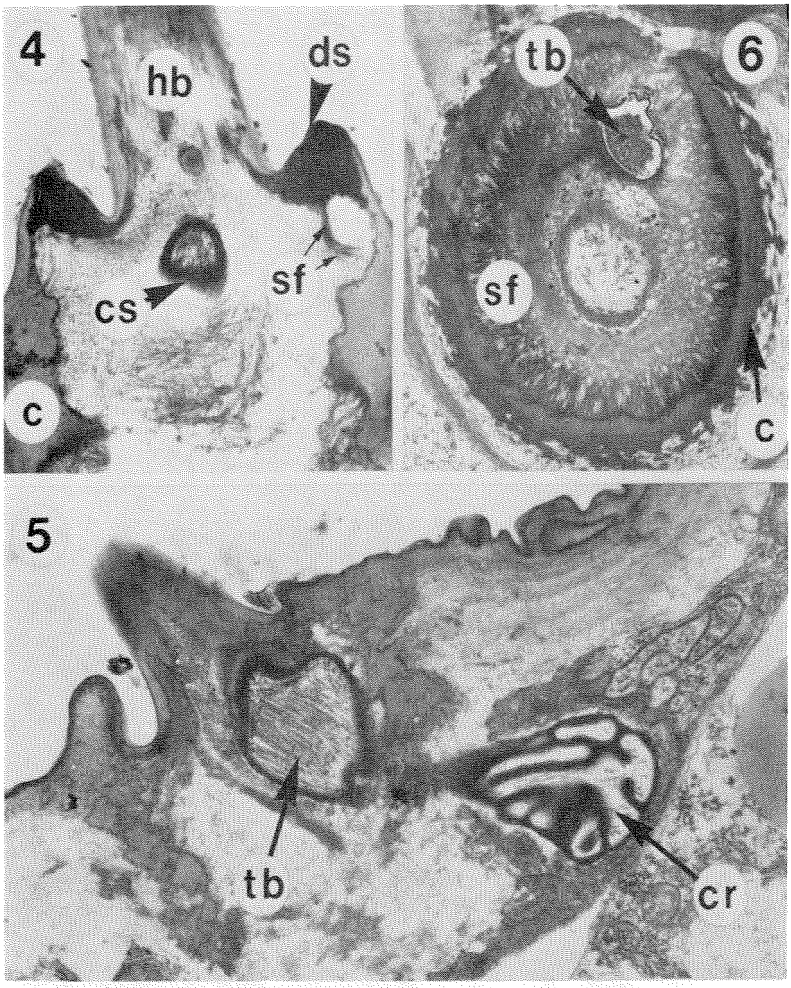


Fig. 4. Oblique section through socket region of scapal seta of female showing setal base (hb), cuticular sides (c) of bulbous base and darkly staining presumably flexible material (ds). Within the receptor-lymph cavity are the remains of suspensory fibers (sf) and the tubular body surrounded by the cuticular sheath (cs). X 17,700.

Fig. 5. Oblique section through base of setal tuft on abdominal segment II of fourth instar larva. Note highly convoluted region (cr) of outer segment of dendrite proximal to large tubular body (tb). X 14,400

Fig. 6 Section through socket region of seta 6 on abdominal segment VIII of pupae showing cuticular sides (c), fibrous suspensory fibers (sf), and tubular body (tb). X 4,320

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## ERRATUM

Several errors have been found in two recent articles published in "Mosquito News." These articles may be located in the June 1981 (Vol. 41, No. 2) issue on pages 331 to 338 and 339 to 347 respectively. On pages 333 to 336 delete: Fig. 1. 35 Min Exposure to 3.10 ppm *Bti*—24 HR Posttreatment; Fig. 2. 70 Min Exposure to 1.55 ppm *Bti*—24 HR Posttreatment; Fig. 3. 70 Min Exposure to 1.55 ppm *Bti*—48 HR Posttreatment; and Fig. 4. 70 Min Exposure to 1.55 ppm *Bti*—72 HR Posttreatment. Referring to page 343, the footnote should read, "See opposite page (342) for corresponding legend." Footnotes on pages 344 to 346 should read, "Refer to Figure 1 footnotes 1 to 4."