

## TARSAL SENSORY RECEPTORS OF TICKS\*

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### ABSTRACT

From scanning and transmission electron microscopy, the arrangement and types of sensilla on the first tarsi of the hard tick *Amblyomma americanum* (L.) are described. Chemoreception, mechanoreception, and both functions combined, are attributed to particular sensilla on the basis of fine structure. A diagram of the sensilla types in this model species is presented as a basis for comparative studies with other species. The tarsal sensilla of the soft tick, *Argas arboreus* Kaiser, Hoogstraal, and Kohls are compared to those of the hard tick.

Ticks wave their first legs in the air, similar to the way insects use their antennae, to detect environmental stimuli and to orient to hosts. The tarsal segment of the first pair of legs of ticks has a variety of setae including those of Haller's organ which is composed of setae in an anterior pit and in a capsule (providing various degrees of enclosure and protection). These setae are innervated and may properly be called sensilla. Obviously the sensilla on the tarsi are important receptors mediating the behavior of ticks. Behavioral and electrophysiological investigations are needed to demonstrate the functions of individual sensillum. However, from examining their ultrastructure it is possible to suggest functions for the types of sensilla and to provide a guide for future experimental verification.

This report summarizes our knowledge of all the sensilla on the first tarsi of the hard tick, *Amblyomma americanum* (L.). The types of sensilla in the soft tick, *Argas* (*Persicargas*) *arboreus* Kaiser, Hoogstraal, and Kohls are compared to the hard tick. These are the only species of ticks whose tarsal sensilla have been investigated in detail by transmission and scanning electron microscopy. A series of reports from this laboratory have documented the results of these investigations (AXTELL *et al.*, 1973; CHU-WANG and AXTELL, 1973, 1974; FOELIX and AXTELL, 1971, 1972; FOELIX and CHU-WANG, 1972; ROSHDY *et al.*, 1972).

### AMBLYOMMA AMERICANUM

The arrangement and types of sensilla on the first tarsus of *Amblyomma americanum* are diagrammed in Fig. 1. The diagram applies to both the adult and nymphal stages.

**Chemoreceptors.** There are 4 basic types (Fig. 2) of chemoreceptive sensilla (having dendrites in the shaft lumen and pore openings in the shaft wall). Sensilla of chemoreceptive type-1 have large pore openings (with plugs) in the wall of the

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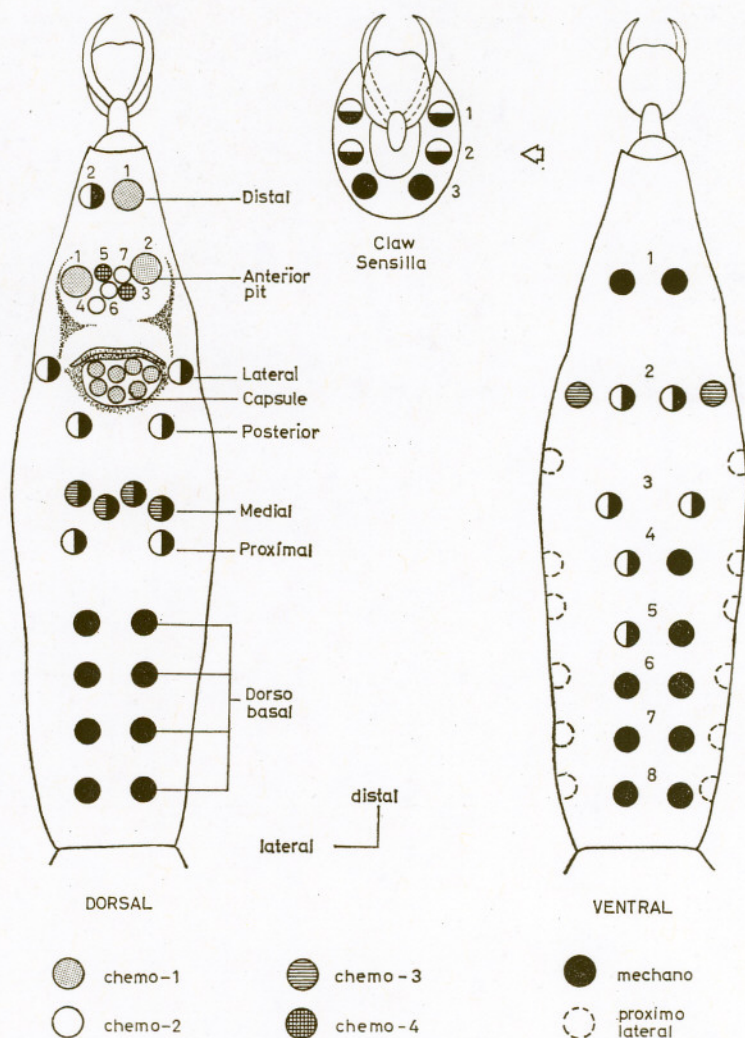


FIG. 1. Diagram of the number, arrangement and type of sensilla on the first tarsus of the hard tick *Amblyomma maricanum* (adult and nymphal stages)

shaft. The wall may be relatively thin or thick. The 7 sensilla in the capsule are thin-walled; the distal-1 and anterior pit sensilla Nos. 1 and 2 have thicker walls. The invaginations on the shaft wall which lead to the relatively large plugged pores are usually easily seen in scanning electron micrographs. It is likely that these sensilla are the olfactory type of chemoreceptors.

The type-2 chemoreceptive sensilla have very thick walls and an opening at or near the tip of the shaft. Because the opening is frequently subterminal and small it is difficult to find in sections. These sensilla probably function as contact chemoreceptors. This type is found in the anterior pit sensilla Nos. 4, 6 and 7 and in combination with a mechanoreceptive capability in other sensilla which will be discussed below.

The type-3 chemoreceptive sensilla have longitudinal slits in the thick-walled shaft. In cross-section, there are vase-shaped channels leading from the lumen to

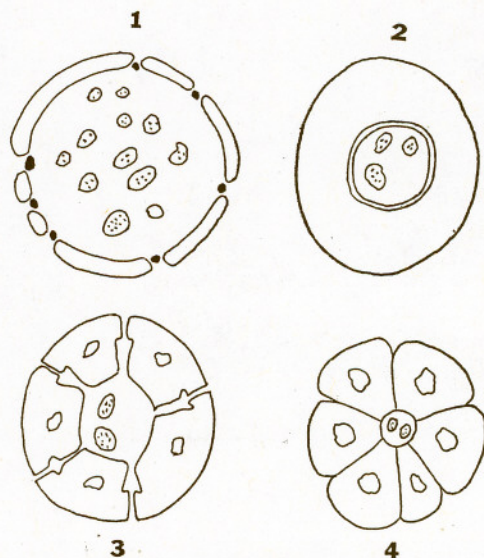


FIG. 2. Diagrams of cross-sections of the shafts of the 4 basic types of chemoreceptive sensilla in *A. americanum*

the exterior slit openings. This form is found in the 2 outer sensilla of ventral group no. 2 and combined with a mechanoreceptive capability in the medial sensilla on the dorsal surface of the tarsus.

The type-4 chemoreceptive sensilla have very small pores and canals in an extremely thick-walled shaft. This form occurs in the anterior pit sensilla Nos. 3 and 5.

**Mechanoreceptors.** Many tarsal sensilla are clearly mechanoreceptors since they possess dendrites (usually 2) terminating with a tubular body at the base of the shaft, no dendrites in the shaft lumen and no openings in the shaft wall. Sensilla of this type are the dorso-basal pairs (4 usually), the ventral pairs Nos. 1, 6, 7 and 8, the medial sensillum of ventral pairs Nos. 4 and 5, and the ventral pair (no. 3) of sensilla around the base of the claws. There are also several (usually 6 on a side) sensilla along the proximo-lateral aspect of the tarsus which may be mechanoreceptors. A few sections through these sensilla have shown the presence of a tubular body.

**Combined receptors.** Many sensilla fulfill the requirements of a mechanoreceptor by having dendrites with a tubular body inserted at the base of the shaft as well as having additional dendrites entering the shaft lumen and leading to an opening at or near the tip of the shaft as described for a type-2 chemoreceptive sensillum. These sensilla appear to have a combined function: contact chemoreception and mechanoreception. Sensilla of this type on the dorsal aspect of the tarsus are the distal-2, lateral, posterior and proximal; those on the ventral aspect are the inner pair of group no. 2, pair no. 3 and the lateral sensillum of pairs no. 4 and 5. Also, the middle and dorsal pairs of sensilla around the base of the claws are of this type. It is interesting to note that the sensilla on the palps are also this type.

These sensilla and their arrangement appears to be the same in the nymphal and adult stages. In the larval stage there are 5 sensilla in the anterior pit of Haller's organ while the other stages have 7. Whether or not the number of sensilla in the capsule of Haller's organ is less than the 7 in the nymph and adult has not been determined. The larvae generally have fewer pairs of sensilla in the basal portion of the tarsus than the other stages.



The same types of sensilla as described for the hard tick have been found in the adult soft tick, *Argas arboreus*. The capsule sensilla (4) are the thin-walled plug-pore chemoreceptor type-1 and the anterior pit sensilla Nos. 1 and 2 are the same but thick-walled. The type-2 chemoreceptor occurs in the anterior pit sensilla Nos. 6 and 7 while the no. 4 sensilla is a combined type-2 chemoreceptor and mechanoreceptor. Closely associated with the anterior pit sensilla are 2 sensilla which are interpreted to be distal ones. The distal-1 is a combined type-2 chemoreceptor and mechanoreceptor while the distal-2 is a simple type-2 chemoreceptor. The posterior sensilla pair are also type-2 chemoreceptors. Type-3 chemoreceptors occur in the medial sensilla while type-4 occur in the anterior pit sensilla Nos. 3 and 5.

The ventral pair of sensilla around the base of the claws are simple mechanoreceptors while the other 5 pairs of claw sensilla are combined type-2 chemoreceptors and mechanoreceptors. Probably many other sensilla on the ventral and basal portions of the tarsus are mechanoreceptors or combined receptors but those sensilla have not been examined.

### SIGNIFICANCE

Obviously the tarsal sensilla of ticks provide for the reception of a variety of stimuli. The ultrastructural evidence suggests which ones are involved in mechanoreception, chemoreception (contact and olfactory) and in a combination of mechanoreception and chemoreception. Certain sensilla may be involved in humidity and temperature detection but we unfortunately cannot interpret those functions from only the ultrastructure. Careful, precise behavioral and electrophysiological investigations are needed to demonstrate the functions of the tick sensilla. The detailed studies now available provide a basis for these investigations.

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