



Study the versatile nature of *Aedes albopictus* mosquito antennae in districts Agra, Uttar Pradesh India

Seema Yadav, Rajvir Singh Ojha

Department of Zoology, R.B.S. College, Dr. Bhimrao Ambedkar University, Agra, Uttar Pradesh, India

Abstract

The long, feather-like antennae of *Aedes albopictus* mosquitoes are used to detect carbon dioxide in breath and air movement. Blood-feeding mosquitoes have three olfactory organs: the antennae, maxillary palps, and proboscis. On each of these organs, there are multiple anatomically different forms of multiparous sensilla. The antennae of the dengue vector are known to include three different kinds of receptors. Two families of receptors: odorant receptors (ORs) and ionotropic receptors (IRs), which are sensitive to carbon dioxide, and gustatory receptors (GRs). There is minimal overlap between the molecules identified by these two families, which are responsive to a variety of compounds. It seems that carbon dioxide and at least some of these sensors work in concert.

Keywords: Sensilla, odour, receptor

Introduction

The Asian tiger mosquito, or *Aedes albopictus*, is a pestiferous and invasive species that has implications for both veterinary and medical care. Skuse first described the species in 1894 using specimens. Antennae are significant non-visual sense organs in mosquitoes. The antennae of *Aedes albopictus* mosquitoes serve as movement receptors, allowing them to react to internal air particle oscillations. Male mosquitoes feel vibrations with their antennae, which are fin- and hair-like appendages that react to air particle oscillations. Understanding mosquito hearing is essential for controlling them because most of their courtship behavior is auditory.

Neurological investigations and behavioral research have shown the nonlinear properties of the mosquito hearing organ. Consequently, mosquitoes are able to identify and synchronize with one another. Numerous theories have been proposed on the function of the antenna's fibrillae and flagellum in mosquito hearing, and the neurological mechanism is thought to be the source of nonlinearities. Many of the reported nonlinear characteristics are produced by the model, indicating that the antenna base is important for mosquito hearing. This is surrounded by auditory sensing, sometimes referred to as hearing. Male mosquito antennae are especially well-adapted to detect sound in order to locate mates; they can identify the distinct wing beats of female mosquitoes while in flight.

Mosquitoes are structurally composed of two antennae with two segments located beneath their eyes. In males, the main segment is made up of a plumose shaft, which is covered in long hairs or fibrils that resemble feathers. These hairs grow longer toward the back of the shaft after becoming shorter at the tip. The main section containing the Johnston organ. The Johnston organ is a neuronally densely packed spherical base. When the shaft hairs are manipulated, this bundle of sensory receptors is extremely sensitive to the forces acting on them; the sensitive neurons in the Johnston organ rapidly convey and identify the forces.

Depending on the frequency of sound in the vicinity of the mosquito, sounds produce oscillating waves or vibrations that exert stress on the hairs. While lower frequencies

produce lesser forces, higher frequencies produce greater ones. It is believed that there is a very strong correlation between the frequency of female mosquito wing beats and the hairs on the male mosquito antennae shaft. The male mosquito's antennal hairs move in a specific direction when it is in close proximity to the female mosquito due to the female flight sound's oscillations of air particles, which may also be thought of as vibrations or sound waves. This movement of the antenna shaft (resulting in an even greater signal) having this relationship raises the auditory sensitivity of the mosquito at the biological frequency of a female mosquito's wing beat.

The approximate frequency of female flight sound is 380 Hz. At this frequency, male mosquitoes are drawn to the tuning fork when it is used. This suggests that male mosquitoes use sound and its vibrational wave patterns as their primary sensory organs. While each frequency produces a distinct wave pattern, 380 Hz and its associated wave pattern effectively signal the presence of a female mosquito for the purpose of reproduction. The radial array of scolopidial mechanoreceptors that react to movement and possibly position of the more distal antennal segments (flagellum) in relation to the head is commonly referred to as Johnston's organ. Johnston's organ nearly completely occupies the second antennal segment (pedicel) in mosquitoes and their cousins with comparable anatomy.

Internal cuticular structures have evolved to connect the numerous sense cells—about 14–15,000 sensory neurons in almost half the number of scolopidia in each male *Aedes albopictus* Johnston's organ (Boo and Richards 1975a)^[2],^[3]—to the movement components of the antenna. The ring-shaped first antennal segment (scape) has two pairs of hinges that join the pedicel to the head. This allows the pedicel and distal flagellum to move in a 45-degree cone. The tapered and slightly bent first flagellar segment is located in a deep, vase-shaped pit in the pedicel. It is attached to a thicker cuticle disk, or basal plate, that occupies most of the pit's base. It is commonly known about the scolopidial sensilla's ultrastructure.

The scolopidial sensilla's ultrastructure is widely recognized (Boo and Richards 1975a^[2], 1975b^[3]; Belton 1974^[4];

Risler and Schmidt 1967^[10]; Boo 1980, 1981). The acoustically sensitive scolopidia type A (radial) and likely also type B (apical) of Boo and Richards are composed of two and three bipolar neurons, respectively. Their dendrites are oriented inward toward a radial series of up to seventy cuticular prongs that start at the basal plate and extend upward and outward to the inner surface of the toroidal mass of scolopidia. The axons and cell bodies of these neurons are located at the edge of Johnston's organ, while their dendrites are directed inward. Each pair or triplet of dendrites has a scolopale cell at the foot of the narrow ciliary area that houses a cylindrical array of roughly eight (six to nine).

The length of this section of the dendrite is made up of these inner scolopale rods, which range in length from half to two thirds. Types A and B of the mosquito's Johnston's organ have an additional accessory cell (Hiilzelle of Schmidt; envelope cell of Boo and Richards) that overlaps and is located outside the distal end of the scolopale cell, in contrast to the majority of chordotonal sensilla reported in insects. A radial arrangement of electron-dense material is also present in this second sheathing cell; in certain places, these rods resemble the inner scolopale rods in structure. About 25% of the ciliary portion of the dendrites are covered by these outer scolopale rods, which are closely related to the inner scolopale rods and a third array of cuticular rods that lies inside the second, Schmidt (1967) demonstrated that this third array of rods fuses together and adheres to the septa that are located between each prong. While there are generally six to nine rods surrounding each scolopidium, published diagrams often display eight. However, the number of cuticular, outer, and inner rods surrounding a single scolopidium is always the same. Dendrite ends are firmly bonded to a delicate conical cuticular cap, which is connected to a neighboring prong by a tiny filament.

Mosquito hearing

Among insects with the best hearing are mosquitoes (Gopfert et al., 1999)^[7]. The pair of antennae forms the perimeter of the mosquito's hearing organ. Avitabile et al. (2010)^[1], Warren et al. (2010), Saltin et al. (2019)^[11], and Tischner (1953)^[13], Boo and Richards (1975), and Warren et al. (2010)^[14] are a few examples of publications that describe and illustrate the morphology of the antenna. An antenna is made up of a flagellum, which is a prominent black line, to which fibrillae of various lengths are attached. The immotile, bulbous pedicel encapsulates the base of the flagellum and houses the Johnston's Organ (JO).

Particle velocities are detected by mechanoreceptors (Davis and Sokolove, 1976)^[6]. This facilitates hearing sources of sound. However, the mosquito can also sense wind and its own flight tone, which are essential for navigation, making the JO a somatosensory system. The JO also has many kinds of chemoreceptors and thermoreceptors. As a result, not all 15,000 neurons in the JO are auditory-only (Menda et al.)^[8]

General description of the sensilla of *Ae. albopictus*

Female *Ae. albopictus* mosquitoes have thirteen different flagellomeres with a huge number of sensilla on their antennae. Based on the descriptions and terminology provided by Zacharuk [1991]^[15] and Pitts [2006]^[16], we categorized the sensilla based on their physical

characteristics. The forms and distributions of female antennal sensilla are described in detail below.

1. The trichoid Sensilla The most prevalent and abundant variety of sensilla on the antennae, featuring a structure resembling hair. Sensilla trichoid were classified into two subgroups based on their shapes: sharp trichodea (sp. trichodea) and blunt trichodea (bl. trichodea). Sharp trichodea were extensively dispersed throughout the antennae, primarily at the flagellomeres numbered two through thirteen segments....
2. The longest sensilla, Sensilla chaetica, has robust bristles that are socketed and grooved. Additionally, two subtypes of Sensilla chaetica were identified based on length: small chaetica (sm. chaetica) and big chaetica (lg. chaetica). The little chaetica were located closer to the distal edge of flagellomeres 2–13, whilst the large ones were organized on the basal end. From the proximal to the distal flagellomeres, their numbers dropped.
3. Sensilla basiconica, also known as grooved peg: This species of sensilla is distinguished from Sensilla chaetica by having grooved hair instead of socketed thorn-shaped hair. We observed the sensilla basiconica on flagellomeres 3–13
4. With pitting pegs, Sensilla coeloconica is the smallest sensilla. Such sensilla were also rare; they were only found on flagellomeres 1–7 and on the distal tip of the 13th flagellomere with 2. The numbers of each sensillum on each flagellomere were then utilized to find some specials, taking into account the possibility that some sensilla, which were arranged on flagellomere 6 and 7, would be highly numerous and signal essential roles in the biting assay. Regrettably, nevertheless, flagellomeres 6 and 7 did not provide any indication of a discernible pattern of sensilla type distribution.



Fig 1: Female antennae (*Aedes albopictus*)



Fig 2: Male antenna (*Aedes albopictus*)

Materials and Method

Study area and sampling

The *Aedes albopictus* mosquitoes were collected from specific sampling sites of Agra i.e. Bichpuri, Dayal Bagh, Kamla Nagar, Agra cantt, Sikandra and Tajganj area were surveyed and the mosquito breeding sites were periodically observed from may to November throughout the survey, *Aedes* species were collected using sampling techniques and male or female antenna slide were prepared.

Identification

The morphological analyses of the male and female *Aedes* species were identified using a binocular microscope (figure 1-2). by using the Christophers (1960), Bar, and Andrew (2013)^[5] identifying key. They were photographed using an image documentation system, their photos were downloaded to a computer, and morphometric analysis software was used to estimate their dimensions (length/width).

Statistical Analysis

The morphometric data that were documented underwent statistical analysis. Sigma Plot software was used in conjunction with Mean± Standard deviation (SD) to assess the significant difference between the readings using Kruskal-Wallis One Way Analysis of Variance (ANOVA).

Result and Discussion

The antenna of *Aedes albopictus* is significantly reduced, with 13 flagellar segments and a substantially shortened antenna that originates from a globular pedicel. Antenna length: female (0.52±0.07mm) and male (0.57±0.03mm). Male have bushy, plumose antennal hairs, while females have smaller, less dense hairs (Nelson, 1986^[9]; Bar and Andrew, 2013b)^[5]. that, with only minimal adjustments, were embraced by other scholars after being proposed by the WHO (1975). *Aedes* has lengthy antennae with a whorl-like arrangement of antennal hairs. Scape is drastically decreased. The globular pedicel is where flagellum originate. Males have plumose-type antennae. Several publications have noted that *Aedes albopictus* has different numbers of antennal segments in adult males and females in this investigation. Both the male and female antennae in this study have 13 segments following the pedicel. Compared to the proboscis, the antennae was shorter. According to Christopher, both the male and female antennae's basal lobes featured white scales. The antenna used in this study had a black color. There were lengthy, whorled hairs. The male antenna has plumose bushiness. Less hair was present on female antennae. Female antenna length was 1.95 mm, according to Sathe and Girhe's description in this investigation, in males.

Conclusion

In this current study the morphology of *Aedes albopictus* in Agra was detail and the important adult characters of the male and female antenna according to Bar and Andrew minor modification. The morphologic features of adult *Aedes albopictus* in Agra will help for the better understanding of the key characters of this mosquito. The primary goal of this work was to observe and describe morphological and material differences and similarities in antennal hearing organs of the investigated species. While it is possible to consider the antenna as a simple beam, we have shown that the actual material properties of these antenna are more complex.

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