Sensilla of the antenna and palp of *Hydrotaea chalcogaster* (Diptera: Muscidae)

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Abstract

*Hydrotaea chalcogaster* is a fly species of medical and forensic importance in many parts of the world. In this study, we investigated the sensilla of the antenna and palp of the adult female fly using scanning electron microscopy. The antennal scape has one type of sensillum, the sharp-tipped sensillum trichodeum; whereas, the antennal pedicel also possessed this type of sensillum in addition to an unidentified type. Three types of sensilla were found on the flagellum: (1) sensilla basiconica, with both large and small sensilla basiconica showing wall pores, (2) sensilla coeloconica, with a smooth surface, and (3) sensory pits, with wall pores of pegs. The arista is located dorso-laterally on the flagellum and has three segments. Short microtrichia are located around the distal end of its second segment and on the proximal half of the third segment. Both large sharp-tipped sensilla chaetica and small sensilla basiconica with wall pores were observed on the palps. Results of this study contribute to our overall understanding of the ultrastructural morphology of sensilla on the antenna and palp of *H. chalcogaster*.

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Keywords: *Hydrotaea chalcogaster*; Antenna; Palp; Sensilla; Scanning electron microscopy

1. Introduction

*Hydrotaea (= Ophyra) chalcogaster* is a fly species of medical and forensic importance in many parts of the world. This fly is widely distributed in the Oriental, Australasian and Ethiopian regions (Shinonaga, 2002). It is claimed to have an important role in the dispersal of fecal pathogens similar to that of *Musca sorbens*, a putative vector of trachoma (Bohart and Gressitt, 1951). The bacterium, *Mucor ambiguous*, has been found to associate with this species, a finding supported by Usui (1960). In regard to forensic importance, specimens of *Hydrotaea chalcogaster* were found in human corpses and pig carcasses by Carvalho et al. (2000).

In insects, olfactory receptor neurons are located in cuticular sensilla that exist on the antenna and palps (Anton et al., 2003). For example, this was demonstrated in the adult mosquito, *Anopheles gambiae* (Diptera: Culicidae) by Anton et al. (2003), and the pomace fly, *Drosophila* (Diptera: Drosophilidae) by Stocker (1994), de Bruyne et al. (1999), and Shanbhag et al. (1999). Evidence from works by Kelling et al. (2002) and Wasserman and Itagaki (2003) using electrophysiological analyses to assess olfactory receptors in the antenna and palps of adult flies (Diptera: Muscidae and Sarcophagidae) indicated that both organs respond to various odors. As for flies associated with corpses (particularly in the families Calliphoridae, Muscidae and Sarcophagidae), few studies have examined the sensilla on antennae and/or palps (Fernandes et al., 2004; Sukontason et al., 2004). To help increase the anatomical database on flies of medical and/or forensic importance, we describe the morphology of the sensilla on the antenna and palp of adult female *H. chalcogaster* using scanning electron microscopy (SEM).

2. Materials and methods

Adult females of *H. chalcogaster* were obtained using a bait-trap from a fly survey in Chiang Mai, northern Thailand (17–21°N and 98–99°E), in February 2003. After identification, they...
were kept in 70% alcohol for about a year before being prepared for the scanning electron microscopy (SEM) process. Since only females were collected, males were not examined in this study but only females were. The heads of all flies were removed under a dissecting microscope using a sharp blade. Five specimens were fixed in 2.5% glutaraldehyde mixed with phosphate buffer solution at a pH of 7.4 at 4°C for 24 h, then subjected to postfixation in 1% osmium tetroxide and dehydrated in a graded alcohol series. This was followed by treatment in acetone and critical-point drying. Finally, the heads were mounted on stubs, sputter-coated with gold, and viewed with a JEOL JSM-5910LV SEM (Tokyo, Japan). The terminologies of adult flies used in this study followed McAlpine (1981) and classification of sensilla follows that of Zacharuk (1985).

3. Results

SEM observations of the head of female *H. chalcogaster* revealed a pair of antennae located frontally between the large compound eyes; whereas, a pair of palps arose at the distal end of the rostrum, a part of the proboscis (Fig. 1). Each antenna consists of three segments: a proximal scape, pedicel, and distal flagellum (or funiculus) that bears a slender seta called the arista laterally (Fig. 2). All antennal segments in this species possess sensilla.

Only one type of sensilla was observed on the scape, namely the sensilla trichodea. Approximately six sensilla of similar length were seen on the scape arranged in a single row (Fig. 3). The sensilla trichodea are curved and tapered distally along their longitudinal axis. The surface of the scape is densely covered by small spinules of microtrichia. In addition to presence of sensilla trichodea, the pedicel also contained an unidentified type of sensilla. The sensilla trichodea on the pedicel are morphologically similar to those found on the scape, with exceptions of being more numerous and being variable in length (Fig. 3). Approximately four to five of the unidentified type of sensillum were observed (Fig. 3, arrows) and were characterized by having a small dome (≈2.7 μm in diameter, n = 3) in the middle of radiating folds encircled by a low round cuticular ring (≈10.8 μm in diameter, n = 3) (Fig. 4).

The flagellum is the most prominent part of the fly antenna. The arista is located dorso-laterally on the flagellum and is comprised of three segments (Figs. 2 and 5). Short microtrichia are located around the distal end of the second segment of the arista and on the proximal half of the third segment (Fig. 5). The entire surface of the flagellum is densely covered with microtrichia that taper to their tips (Fig. 6). Types of sensilla clearly observed on the flagellum include sensilla basiconica, sensilla coeloconica and sensory pits. Sensilla basiconica were classified into two types, large and small. A large sensillum basiconicum was characterized...
by having a wider base, being relatively curved in the middle, and gradually tapering to the tip (Fig. 6). Higher magnification revealed a random pattern of pits in the cuticle of this type of sensillum (Fig. 7). The small sensillum basiconica were shorter in length and rounded at their tips (Fig. 6) compared to the large sensillum basiconica. Higher magnification revealed more numerous pits along the surface of the small sensillum basiconica (Fig. 8). The second type of sensilla found on the flagellum is the sensilla coeloconica that are characterized by their pegs that project from the floor of shallow depressions. Sensilla coeloconica are observed either alone or as a group (Fig. 9) and each bears a smooth, slightly curved peg. The third type of sensilla found on the flagellum is the sensory pit, which varies in number in flies (Fig. 10).

Each sensory pit on the flagellum of *H. chalcogaster* contained a group of small sensilla basiconica inside (Fig. 11). Higher magnification of a sensillum basiconicum revealed a highly pitted cuticle (Fig. 12).

Two types of sensilla were found along the entire surface of the palps: large sensilla chaetica and small sensilla basiconica (Fig. 13). The sensilla chaetica are large straight bristles with longitudinal grooves (Fig. 14) and are wide at the basal part and taper to a sharp tip apically. The base of the bristle is seated into a socket and the bristles vary in length. Small sensilla basiconica are interspersed with the microtrichia covering the entire surface of the palp (Fig. 14). The cuticle of these small sensilla was found to possess numerous small pits along their surface (Fig. 15).

4. Discussion

In this study, the morphology of various sense organ structures seated in the antenna and palp of adult female *H. chalcogaster* is described. Of the three antennal segments, the flagellum is the biggest part with the largest surface area and is endowed with very abundant sensilla basiconica of both large and small types. The multiporous pitted structure along the entire surface of the sensilla basiconica (either alone or within a sensory pit) of *H. chalcogaster* closely resembles that of the typical wall pore feature of sensilla basiconica reported in the antennae of various insect species such as the sheep head fly, *Hydrotaea irritans* (Diptera: Muscidae) (Been et al., 1988), glasshouse whitefly, *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae) (Mellor and Anderson, 1995), parasitoid fly, *Pseudoperichaeta nigrolineata* (Diptera: Tachinidae) (Rahal et al., 1996), fruit fly, *Drosophila melanogaster* (Diptera: Drosophilidae) (Shanbhag et al., 1999), sphinx moth, *Manduca sexta* (Lepidoptera: Sphingidae) (Shields and Hildebrand, 1999), moth, *Lophocorona pediasia* (Lepidoptera: Lophocoronedae) (Faucheux, 2006), eucalyptus wood borer, *Phoracantha semipunctata* (Coleoptera: Cerambycidae) (Lopes et al., 2002), and New World screwworm fly,
Cochliomyia hominivorax (Diptera: Calliphoridae) (Fernandes et al., 2004).

SEM observations of the sensilla basiconica of H. chalcogaster revealed morphological similarity between the small sensilla basiconica on the antenna and those on the palps (see Figs. 8 and 15). This observation agrees with those of de Bruyne et al. (1999) and Shanbhag et al. (1999) in their studies of Drosophila. Been et al. (1988) documented that sensilla basiconica were found in the palps of H. irritans; however, this type of sensillum differed from those seen in the antennae. Moreover, our results in this study demonstrate that the pores are much more dense in the small sensilla basiconica (see Figs. 8 and 15) than in the larger ones (see Fig. 7). This corresponds with the findings of Lopes et al. (2002), who investigated P. semipunctata, and found that sensilla basiconica type II (similar to the small sensilla basiconica in this study) displayed a larger number of pores than sensilla basiconica type I (similar to the large sensilla basiconica in this study).

Transmission electron microscopy (TEM) was utilized in an investigation of sensilla basiconica in the antenna of the biting midge, Culicoides impunctatus (Diptera: Ceratopogonidae) to reveal their multiporous cuticle (Blackwell et al., 1992) that was similar to that of the small sensilla basiconica of D. melanogaster or M. sexta, which also bore several dendritic branches in the lumens of the sensilla (Shanbhag et al., 1999; Shields and Hildebrand, 1999). A TEM study of the antennal club of the palm weevil, Rhynchophorus palmarum (Coleoptera: Curculionidae) revealed sensilla basiconica with thin walls and high densities of wall pores and dendritic branches (Said et al., 2003). This presentation thereby implicated an olfactory function of the sensilla (Zacharuk, 1985; Blackwell et al., 1992; Rahal et al., 1996; Shields and Hildebrand, 1999), and has been verified in similar sensilla by use of electrophysiological recordings (Lopes et al., 2002).

The sensilla coeloconica observed in the flagellum of H. chalcogaster are few in number. The short, smooth peg described in this type of sensilla is similar in structure to those reported for the blow flies, Chrysomya megacephala, Chrysomya rufifacies, and Lucilia cuprina (Sukontason et al., 2004). This type of sensillum has been proposed to have a chemo-, thermo-, or hygrosensitive function (Zacharuk, 1985; Blackwell et al., 1992; Cribb, 1997).

On the palp of H. chalcogaster, the presence of both sensilla chaetica, set in sockets, and small sensilla basiconica having wall pores agrees with that seen in other flies such as Drosophila (de Bruyne et al., 1999) or the flesh fly species, Neobellieria bullata (Wasserman and Itagaki, 2003) and Parasarcophaga (Liosarcophaga) dux (Diptera: Sarcophagidae) (unpublished data of authors). The mechanosensory function of bristles of the sensilla chaetica have previously been noted by de Bruyne et al. (1999) and Wasserman and Itagaki (2003). Moreover, Zacharuk (1985) postulated that this type of sensillum is either tactile or chemosensitive.
The group of four to five sensilla of unidentified type each appeared as a small dome in the middle of radiating folds encircled by a low round cuticular ring in the pedicel of *H. chalcogaster* (see Fig. 4). These sensilla are quite similar to a group of seven to eight yet undescribed sensilla in the pedicel of flies in a different species of the same genus (*H. irritans*) that was investigated by Been et al. (1988). Moreover, the morphological feature of these sensilla in this study resemble the sensilla camponiforma demonstrated in the antenna of the ground beetles, *Bembidion properans* and *Bembidion lampros* (Coleoptera: Carabidae) (Merivee et al., 2000, 2002). Research aimed at studying the neurobiology of the individual sensilla involved in particular sensory receptors should eventually determine their function in *H. chalcogaster*.

In conclusion, we have provided an extensive description of the sensilla on the antenna and palp of adult female *H. chalcogaster* using SEM since many of these structures could not be clearly observed using light microscopy. This information will allow us to better understand the behavior of this fly species, particularly in the task of host-finding by adult females.

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**References**


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