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Morphology, distribution and abundance of antennal sensilla of the oyster mushroom fly, *Coboldia fuscipes* (Meigen) (Diptera: Scatopsidae)

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ABSTRACT

We investigated the distribution, morphology and abundance of antennae sensilla of *Coboldia fuscipes* (Meigen) using scanning electron microscopy. Antennae of *C. fuscipes* consisted of scape, pedicel, and flagellum with eight flagellomeres. Antennal scape and pedicel had only one type of sensillum, i.e., sensilla chaetica. Significant differences were found between the number and distribution of these sensilla. Four types of morphologically distinct sensilla on the flagellum were identified, including sensilla chaetica, sensilla trichoidea, sensilla coeloconica, and sensilla basiconica (three subtypes). Significant differences were found in the abundance and distribution of sensilla among the antennal flagella and diverse flagellomeres in both sexes. Sensilla trichoidea is the most abundant of sensilla discovered on the antennal flagellum. Sensilla chaetica is the largest and longest sensilla among all the types of sensilla found on the antennal surface of *C. fuscipes*. Sensilla coeloconica is widely distributed all over the flagellum surface except for the first of female. Some significant differences in the abundance and distribution were also observed among sensilla basiconica of flagellum. The probable biological function of each sensillum type was deduced based on the basis of their structure. These results serve as important basis for further studies on the host location mechanism and mating behavior of *C. fuscipes*.

Introduction

Oyster mushroom (*Philomycus* spp.), considered as one of the most important economic fungi worldwide (Oh et al., 2004), is seriously damaged by mushroom flies. *Coboldia fuscipes* (Meigen, 1830) is one of the most important fly pests of oyster mushroom (Yi et al., 2008). *C. fuscipes* belongs to the family Scatopsidae and to the genus *Coboldia* (Cook, 1974). This fly species is cosmopolitan and also closely associated with human life, and its larva is usually found in decaying plant or animal materials (Cook, 1974; Amorim, 2007). *C. fuscipes* larvae can ingest the mycelium, mushroom bed, and sporophore of mushroom, resulting in reduced of quality and productivity (Choi et al., 2000). Secondary damage to the mushroom is also introduced through transported pathogen, mites, and nematodes (Bae et al., 2001).

The type-species of *C. fuscipes* is deposited in the National Museum of Natural History, Smithsonian Institution (USNM) (McAtee, 1921). The species total length is 1.34–2.40 mm, the tergum of segment 7 of abdomen with a long process, rather variable and usually asymmetrical, and a dull blackish species which posses R3 reaching scarcely beyond middle of wing (Cook, 1974). Scatopsidae includes 33 genera (Amorim, 1994), whose segmented antennae varies significantly (Cook, 1969), such as in *Anapausis inermis* (Ruthé) with 9 segments (Cook, 1965), and *Scatopse notata* (L.) with 10 segments (Yang and Lv, 1992). Antenna of *C. fuscipes* contains 10 segmented, and flagellum with 8 flagellomeres, which is considered as a typical for many Scatopsidae (Cook, 1971, 1974). In insects, antennae possess various sensilla with different functions important in life behaviors, including searching for foods, mating, and oviposition (Setzu et al., 2011; Zhang et al., 2013). Moreover, antennae are organs of chemoreception, thermoreception, and hygroreception (Liang and Fletcher, 2002), enabling their owner to perceive various environmental signals, such as host volatility, temperature, humidity, and communication signals (Ramdya and Benton, 2010; Liu et al., 2013). Olfactory

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sense plays an important role in guiding the behavior of the flies. Antennal sensilla have been extensively recorded to bear several olfactory receptors in many insects (Merivee et al., 2002; Sukontason et al., 2004). Therefore, understanding the morphology and type of chemosensilla would contribute to the elucidation of a comprehensive model of olfactory systems (Zacharuk, 1980). However, despite the crucial functions of antennae, little is known about their function, morphology, and distribution of antennal sensilla of *C. fuscipes*.

Our study aimed at investigating and describing the morphology, type, and distribution of sensilla on the antenna of male and female *C. fuscipes* using scanning electron microscopy (SEM). Detailed characterization on the sensilla of this species was reported for the first time. We speculated the functions of various *C. fuscipes* sensilla and compared them with those that have been discussed based on morphology and ultrastructure. Knowledge of such functions could benefit the understanding of the probable biological role of these organ components in chemical communication, and also provide baseline information for further sex-communication studies of this species.

Material and methods

Insects

Male and female adults of *C. fuscipes* were collected from the nursing house of the edible fungi in Wuhan (Hubei Province, China) in September 2011. Insects were reared in plastic cages (10 cm × 6 cm × 4 cm) on the mushroom chunks as described by Choi et al. (2000). Cages were placed in controlled laboratory conditions of 25 ± 1 °C with a 16:8 (light:dark) photoperiod and 75 ± 5% relative humidity. Mushroom chunks with eggs were kept in a new cage until hatching.

Scanning electron microscopy (SEM)

Preparation for SEM was modified according to the method previously described by Chen and Fadamiro (2008). Freshly emerged adults of *C. fuscipes* (females = 6, males = 6) were killed by placing in −4 °C for 20 min. The entire antenna was cut off under a microscope and processed immediately, then carefully removed and fixed in 3% glutaraldehyde (0.1 M sodium phosphate buffer, pH 7.4) for 24 h at 4 °C. Antennae were rinsed for twice in glutaraldehyde and then dehydrated in a graded alcohol series as follows: 30, 50, 70, 80, 90 and 100%, in each case for 12 h (Zhang et al., 2012). After treatment by a graded alcohol series, antennae were critical point drying. Finally, specimens were coated with gold to be observed under a JSM-6390/LV SEM at the microscopy core facility, Huazhong Agricultural University (Wuhan, China).

Data analysis

The terminology and nomenclature of antennae were used to describe in this study follow Liu et al. (2013). The type, form, distribution and density of antennal sensilla were documented by SEM. The distribution and density of various types of sensilla were determined using the grid technique described by Kelling (2001), all results were scaled to 1000 μm^2 (Zhang et al., 2013). The density of sensilla on male or female was compared for significance ($P < 0.05$) by ANOVA (Bisotto-de-Oliveira et al., 2011). The length, width of 3 segments of antenna, and mean numbers of the different types sensilla found on male and female antenna were calculated before the Student's test was used to determine any significant sexual differences occurred (Ahmed et al., 2013).

Results

General description

As with other dipterans, antennae of adult *C. fuscipes* are situated on the frontal region of head between the large compound eyes (Fig. 1a). Each antenna consists of three segments, basal scape (Sc), pedicel (Pd), and flagellum (Fl) with 8 flagellomeres, respectively (Fig. 1b). No sexual dimorphism exists in *C. fuscipes* male and female antennae. Microscopic observations indicate that all antennal segments are composed of sensilla and microtrichia. Four types of sensilla are found on the flagellum and classified as: sensilla chaetica (SCh), sensilla trichoidea (STr), sensilla coeloconica (SCo) and sensilla basiconica (SBa). In particular, SCh are found on all antenna segments.

Scape

Scape, the most proximal and shortest antenna segment, measures approximately 43.63 ± 2.05 μm in length and 38.20 ± 2.58 μm in width of basal regions in female flies (n = 5), and 38.36 ± 1.99 μm in length and 45.28 ± 3.54 in width μm in males (n = 6) (Table 1). The length and width are no difference between sex. Sensilla on the scape are SCh and microtrichiae 1 (Mt1) (Fig. 2a). However, the surface of the base is extremely smooth. SCh is located on the median and proximal of the cuticular surface of the antennal scape (Table 2). Moreover, higher numbers are found on proximal than that on median and distal. Mt1 has

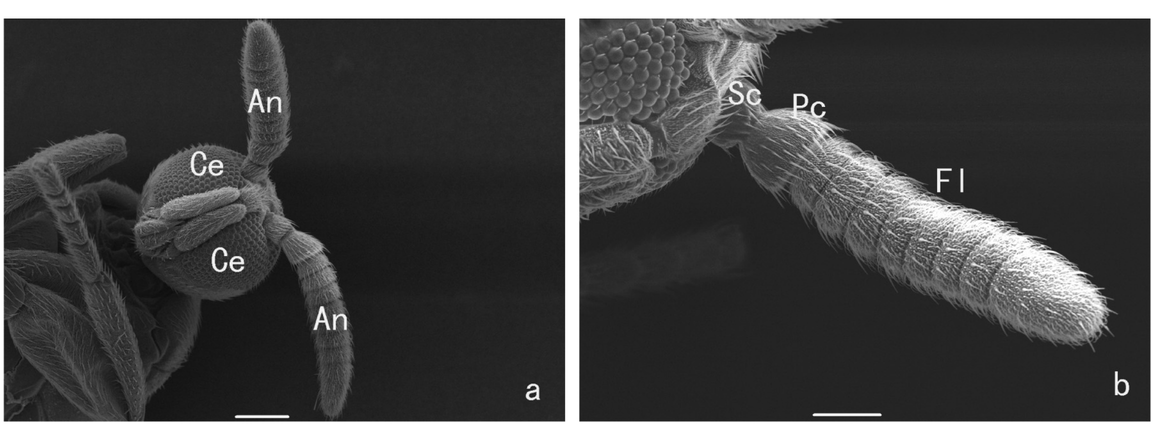

Fig. 1. SEM micrographs of *C. fuscipes* antennae. (a) The features of adult *C. fuscipes* antennae; (b) anterior surface of the whole antenna. Ce, compound eyes; An, antennae; Sc, scape; Pc, pedicel; Fl, flagellum. Scale bar = 100 μm in (a) and 50 μm in (b).