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Sexual dimorphism of antenna of the scale insect *Drosicha corpulenta* (Kuwana) (Hemiptera: Coccoidae: Monophlebidae)

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ABSTRACT

The scale insect *Drosicha corpulenta* is a serious pest of various garden trees. A comprehensive knowledge of the insect olfactory system is essential for the design and implementation of efficient semiochemical-based control strategies. Antennae are the primary olfactory organs in insect. To date, the antenna features of *D. corpulenta* have not been investigated in great detail. In this study, we used scanning electron microscopy to investigate the antennal morphology and sensilla distribution of both sexes of *D. corpulenta* in detail. The antenna of *D. corpulenta* exhibit obvious sexual dimorphism: antennae of the male are markedly longer than those of the female. Furthermore, each male flagellomere consists of three globular nodes, in female, however, the flagellomeres one to three are cylindrical, and the following flagellomeres exhibit an asymmetrical swelling at the distal parts except the last flagellomere which is dumbbell-shaped with distal narrowly. Seven types of sensilla were found on the antennae, including three types of sensilla trichodea (ST1, ST2, ST3), three types of sensilla chaetica (SC1, SC2, SC3), and sensilla basiconica (SB). Remarkable sex dimorphism in the sensilla composition of *D. corpulenta* was also observed. Major differences between the both sexes were found in the type, distribution, number and size of the identified sensilla. We also discuss on the possible functions of these sensilla based on their characteristics. The results of this study provide an important foundation for the studies that link morphological characteristics to insect behavior and should stimulate the development of efficient semiochemial-based control strategies against *D. corpulenta.*

1. Introduction

The scale insect, *Drosicha corpulenta* (Kuwana), is a serious pest of garden trees in many parts of the eastern Asia. It is mainly found in China, Japan, and Korea (Li, 2010). They are small sap-feeding insects, with the female adults and nymphs sucking the phloem sap and affecting plant growth and development, frequently causing significant damage. They can attack a diverse variety of horticultural plant hosts, including economically valuable fruit trees such as persimmon (Li, 2010; Xue et al., 2013). The persimmon, *Diospyros kaki* L. (Ericales: Ebenaceae), an important fruit tree, has been plant in 73.400 ha in northern China. However, almost one-third of the persimmon tree orchards are frequently damaged by *D. corpulenta* (Xie, 1998; Xue et al., 2013).

The *D. corpulenta* is difficult to control, because the adult female inset secretes a white powdery wax on her body surface. Its function is to protect the insect from pesticides and also predators (Tulloch, 1970; Hashimoto and Kitaoka, 1982). Therefore, chemical pesticides have little effect on *D. corpulenta*. The difficulty in controlling *D. corpulenta* by conventional measures has promoted scientists to develop new control strategies.

The olfactory system is essential for the survival and reproduction of insects. They rely on the variety of sensilla in this system for the reception of environmental chemical signals to locate mates, food sources, and oviposition sites, as well as to avoid predators and other threats (Allison et al., 2004; De Bruyne and Baker, 2008; Landolt and Phillips, 1997). According to the function of the sensilla, semiochemical-based control methods have been successfully applied in many cases (Nemoto et al., 1980; Stelinski et al., 2007; Wakamura and Takai, 1995). Sensilla are specialized components of the body wall and are crucial sensory organs that detect both external and internal stimuli. They function as information-receiving

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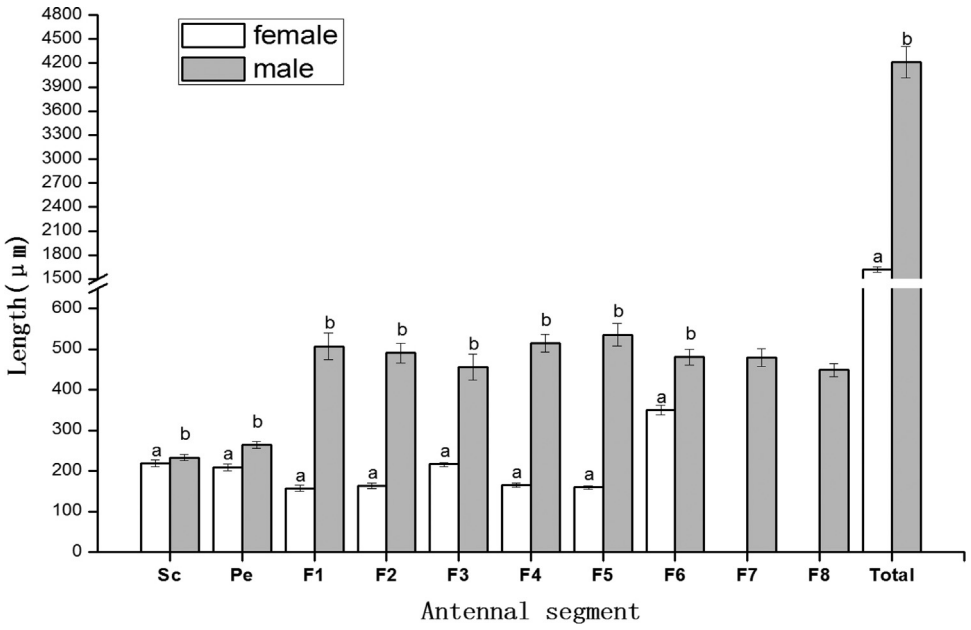

Fig. 1. Length of each segment of the male and female *D. corpulenta* antennae. The length are mean (±standard deviation) of ten antennae per sex. Different letters on the error bars in the same group indicate significant differences between sexes by the independent sample *t*-test ($P < .05$). Sc, scape. Pe, pedicel. F1-F8, flagellomeres 1–8.

apparatus and regulate a variety of insect behaviors via the nervous system (Ma and Du, 2000; Schneider, 1964). Identification and characterization of sensilla, especially antennal sensilla, is a prerequisite for the development of new control methods based on the chemical communication of insect.

Until now, the antenna features of *D. corpulenta* have not been investigated in great detail. In this article, we described and analyzed the type, quantity and distribution of *D. corpulenta* antennal sensilla using scanning electron microscopy (SEM). Both sexes were observed and compared. These data presented here could provide an important foundation for the studies that link morphological characteristics to insect behavior. Moreover, comprehensive knowledge of *D. corpulenta* olfactory system is essential for the development of efficient semiochemial-based control strategies.

2. Materials and methods

2.1. Insect collection and preparation

Adults of *D. corpulenta* were collected from the infested pear trees in Handan in northern China's Hebei province during may, 2014 and fixed in carnoy's fixative solution (95% ethanol: glacial acetic acid = 3:1, v/v) for 24 h before being stored in 75% ethanol.

2.2. Scanning electron microscopy

For scanning electron microscopy (SEM), the antennae were cleaned with an ultrasonic cleaner (KQ118, Kunshan, China) for 30s. After cleaning, the samples were dehydrated using an ascending series of ethanol (70%, 80%, 85%, 90%, 95%, 100% and 100%, for 25 min per concentration). After air-drying for 24 h, the specimens were then mounted onto SEM stubs using a double graphite adhesive tape, coated with gold in a sputter coater, and examined in a HitachiS-3400N scanning electron microscopy (Hitachi, Tokyo, Japan) at 15 kV. The types of sensilla were classified according to the terminology of Schneider (1964), Koteja (1980) and Porcelli (1995).

2.3. Data analysis

The length and diameter of each antennal segment of both sexes was calculated as the mean values for 20 individuals (ten females and ten males). The size of each sensillum was measured as the mean values of ten sensilla. The frequency of each type of sensillum was counted directly. Six antennae were evaluated on the males and females. Differences were evaluated statistically using a *t*-test to compare means in SPSS 16.0 soft ware (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Gross morphology of antenna

Antennae of both male and female *D. corpulenta* are filiform, composed of a scape, a pedicel, and a flagellum (Fig. 3A and B). The antennae are greatly elongated in the male, 4210.6 ± 195.0 μm in length, significantly longer than (or 2.6 times as long as) those in the female (1616.6 ± 35.7 μm) (Figs. 1 , 3A and B). The scape is the widest antennal segment in both sexes of *D. corpulenta* (Figs. 2 , 3A and B). Males have a scapula-shaped scape (Fig. 4B) which is 233.2 ± 7.9 μm in length, longer than those of the females (219.0 ± 7.8 μm) (Fig. 1). However, the scape width is significantly smaller in mlaes (217.0 ± 15.4 μm) compared with females (327.4 ± 15.0 μm) (Fig. 2). Males also have a longer pedicel (264.6 ± 8.6 μm) than females (209.8 ± 8.6 μm) (Fig. 1), although their pedicel is narrower (150.6 ± 3.9 μm) than in femaels (208.0 ± 13.6 μm) (Fig. 2). The flagellum is the longest antennal segment in both sexes of *D. corpulenta*, while the flagellum is six-segmented in the female and eight-segmented in the male (Fig. 3A and B). Each male flagellomere possessed three globular nodes, separated by a strong internode (Fig. 1C). They are connected via movable cuticular joint membranes. In female, the flagellomeres one to three appear nearly cylindrical in cross-section, whereas the distal part of flagellomeres four and five exhibit an asymmetrical swelling (Fig. 3B). Flagellomere six appears dumbbell-shaped with distal narrowly (Fig. 3D). All flagellomeres of *D. corpulenta* are significantly longer in males than in females (Fig. 1). However, all