Wax-Exuding Cuticular Pores in *Oeclidius nanus* Van Duzee (Hemiptera: Fulgoromorpha: Kinnaridae)[1]

Ai-Ping Liang[2] and Guo-Mei Jiang

Department of Entomology, Institute of Zoology, Chinese Academy of Sciences, 19 Zhongguancun Road, Beijing 100080, P. R. China

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Abstract The fine cuticular structures of the wax-secreting pores in the female adults of the kinnarid planthopper, *Oeclidius nanus* Van Duzee (Hemiptera: Fulgoromorpha: Kinnaridae), are described for the first time, based on scanning electron microscope observations. Abdominal tergites 6 to 8 in the female adults of *O. nanus* are modified into wax-secreting plates and are elevated, chevron-shaped, and divided medially into two plates, bearing a large amount of whitish and filamentous wax threads (0.78 to 1.0 μm in diam) on dorsal surface. The whole cuticular surface of abdominal tergites 6 to 8 is covered with numerous, small, rounded wax gland pores. They are shallow cuticular depressions delimited by cuticle rims. The wax comes from the bottom walls of these depressions. The wax gland pores on the tergites 6 and 7 are externally similar to each other, having a density of 0.20 to 0.23 pores and 0.21 to 0.22 pores per μm^2, respectively, and measuring 1.43 to 1.95 μm and 1.33 to 2.11 μm in diam, and 0.52 to 0.86 μm and 0.46 to 0.64 μm in cuticle rim width, respectively. There are no distinct modifications on the bottom of the wax gland pores on tergites 6 and 7. The wax gland pores found on tergite 8 are different from those found on tergites 6 and 7 and are generally larger, sparser, and have a much narrower cuticle rim (cuticle rim width 0.35 to 0.48 μm) and specialized bottom. The pores on tergite 8 have a density of 0.09 to 0.10 pores per μm^2 and most pores range in diam from 2.75 to 3.58 μm, but the smallest ones (few in number) range from 1.60 to 2.10 μm. The bottom of the pores is modified and is plate-like (1.66 to 1.86 μm in diam) with a central, round, depressed disc (0.82 to 0.93 μm in diam). The wax gland pores found in *O. nanus* are similar to those found in the kinnarid *Adolenda fuscofasciata* Liang and species of Meenoplidae but differ from those seen in species of *Kinnara* Distant and in species of other fulgoromorphan families, e.g., Cixiidae, Delphacidae, Derbidae, Flatidae, Lophopidae and Eurybrachidae.

Key Words *Oeclidius nanus,* wax, wax gland plate, wax gland pores, ultrastructure, planthopper, Kinnaridae

The planthopper family Kinnaridae was established by Muir in 1925 and is one of the smallest of the 20 Fulgoroidea families currently recognized, including about 17 genera and over 80 described species (Metcalf 1945, Emeljanov 1984). The family is essentially distributed in the Oriental and Neotropical regions (mainly in the West Indies), with some species in the Nearctic Region (southwestern U.S.) and south Palaearctic Region. Members of the Kinnaridae can be recognized by the following combination of characters: frons with median ocellus; forewings with Sc and R usually

[1]Received 02 November 2001; accepted for publication 25 July 2002.
[2]To whom all inquiries are to be addressed (email: liangap@panda.ioz.ac.cn).

forking near middle of wing, without granulation; hind tibiae without lateral spines, hind tarsomere II with apical spines; and female adults with abdominal tergites 6-8 modified into large wax-secreting plates.

Like most other fulgoromorphans, female adults of most kinnarid species secrete wax. The wax is secreted through distinct sclerotized cuticular structures that act as moulds to produce structurally different forms of wax at different positions on the body. These wax-producing structures have been termed pores and ducts, and the types and distributions of these structures are very useful characters for taxonomic identifications and phylogenetic inferences (Pope 1985, O'Brien et al. 1991, Liang and Wilson 1999, Liang and O'Brien 2002). The wax can function as protection from predators and parasites in nymphs, adults, and eggs (Eisner et al. 1978) or protection from flooding for underground species (Cumber 1953).

Few descriptions or illustrations of the surface cuticular modifications associated with wax secretion in Kinnaridae have been published. Previous work on the wax plates and wax glands of kinnarid female adults has only been based on light microscope work. There are only two scanning electron microscopy studies of the wax gland pores in Kinnaridae: *Adolenda fuscofasciata* Liang (Kinnarinae: Adolendini) from southwestern China (Liang 2001) and several species of *Kinnara* Distant (Kinnarinae: Kinnarini) from the Oriental region (Liang 2002).

The genus *Oeclidius* was established by Van Duzee in 1914 for *O. nanus* Van Duzee, 1914 from southern California and is a major kinnarid genus endemic to southern U.S., Mexico, Cuba and Jamaica (Metcalf 1945). Ball (1934) provided a brief review of the genus and its included species. Six species of *Oeclidius* are currently recorded in the southwestern U.S. (Ball 1934, Metcalf 1945, O'Brien et al. 1991). Species of the genus can be easily identified by their very delicate body form with long narrow trough-like vertex; antennae with scape longer than wide, papillose; pronotum angularly emarginated posteriorly; and forewings with veins not dotted and with distinct venation (Van Duzee 1914, Ball 1934). The only genus in the U.S. fauna that might be confused with *Oeclidius* is the cixiid genus *Oecleus* Stål. *Oeclidius* differs from *Oecleus* in having the vertex broadest basally and then tapered to a narrow or closed apex, in the presence of a distinct central, longitudinal carina on the pronotum, and in the lack of an aedeagal flagellum in the male adults (Kramer 1977). Nymphs of two species of *Oeclidius* have been found feeding on roots (Fennah 1948, 1980). Most kinnarid adults are generally collected from the upper portions of plants, but the adults of *Oeclidius* also have been found on the roots of their hosts (Fennah 1980). The monophyly of *Oeclidius* has not been tested (Bourgoin 1993).

During morphological studies of Kinnaridae, we made scanning electron microscopic observations of the wax plates and wax gland pores in female adults of *Oeclidius nanus* Van Duzee. It was originally described by Van Duzee in 1914 from California. Metcalf (1923) redescribed and illustrated this species. Several authors made notes or listed this species in local faunal work (e.g., Ball 1934, Metcalf 1945). *Oeclidius nanus* can be recognized by its small size (less than 3.5 mm), pale tawny color, mesonotum with three carinae, and forewings with four apical cells (including nodal) in a row along costa and without spots on stigma. The species appears endemic to California. Currently no biological data are available for *O. nanus,* but Van Duzee (1914) noted that the species was described from numerous specimens swept from weeds, grasses and low bushes at East San Diego, La Mesa, Lemon Grove, Lakeside and Alpine in San Diego Co., CA, during April and May 1913. Here, we present a description of the external morphology and distribution of the wax plates

and wax gland pores that are found in the female adults of *Oeclidius nanus* Van Duzee.

Materials and Methods

Two dry, pinned female adult specimens were examined. Both were borrowed from the National Museum of Natural History, Smithsonian Institution, Washington, DC, USA and were collected at Three Rivers, CA, USA.

For scanning electron microscopy (SEM) study of wax gland ultrastructure, the abdomen of the female adult was first removed from the body, then cleaned and dewaxed with 10% KOH, washed with distilled water, mounted on aluminum stubs with double-sided sticky tape, air-dried at room temperature, and coated with gold-palladium using a sputter coater. Observations were made with a JEOL JSM-6301F (Japanese Electronic and Optical Ltd., Tokyo, Japan) scanning electron microscope, operated at accelerating voltage of 15 kV.

Morphological terminology largely follows that of Foldi (1997) and Liang and O'Brien (2002).

Results and Discussion

Wax. Distinct wax coatings can usually be seen on abdominal tergites 6-8 in female adults of *O. nanus* (Fig. 1). The wax secreted by the female adults is whitish in color and is filamentous in shape (Figs. 2, 3). Each wax thread measures about 0.78 to 1.00 μm in diam. They usually gather together to form a wax skein or wax bundle on the dorsal surface of the abdominal tergites 6-8.

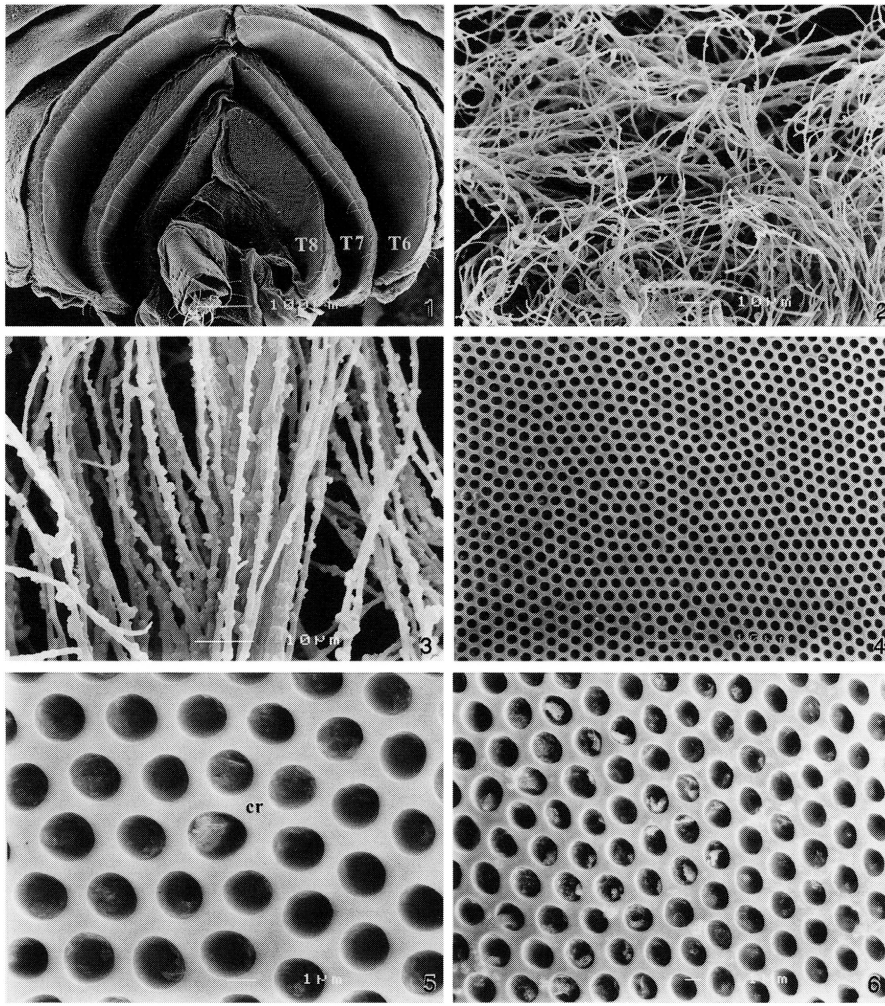
Wax gland plates. As in most other kinnarids (O'Brien and Wilson 1985), abdominal tergites 6-8 in female adults of *O. nanus* (Fig. 1) are elevated, chevron-shaped, and divided medially into two plates, bearing a large amount of white filamentous wax threads. Tergites 6, 7 and 8 form the largest, intermediate and smallest wax-secreting plates, respectively. The whole surface of the wax-secreting plates is covered with numerous small cuticular structures for wax molding, the wax gland pores (Figs. 4-10).

Wax gland pores. The wax gland pores in the female adults of *O. nanus* are typically porous-shaped (Figs. 4-10). They are shallow cuticular depressions delimited by a reticulate cuticle rim (designated as cuticle rim, CR in Figs. 5, 7). It is from the bottom walls of these depressions that the wax is extruded as fine threads. The wax gland pore features in *O. nanus* are summarized in Table 1.

The wax gland pore density on tergite (Figs. 4, 5) is 0.20 to 0.23 pores per μm^2. The pores measure 1.43 to 1.95 μm in diam and 0.52 to 0.62 μm in depth. The rims surrounding the wax gland pores are relatively wide and measure 0.52 to 0.86 μm in width (the widest rims measuring 0.97 to 1.78 μm). There are no modifications on the bottom of the wax pores.

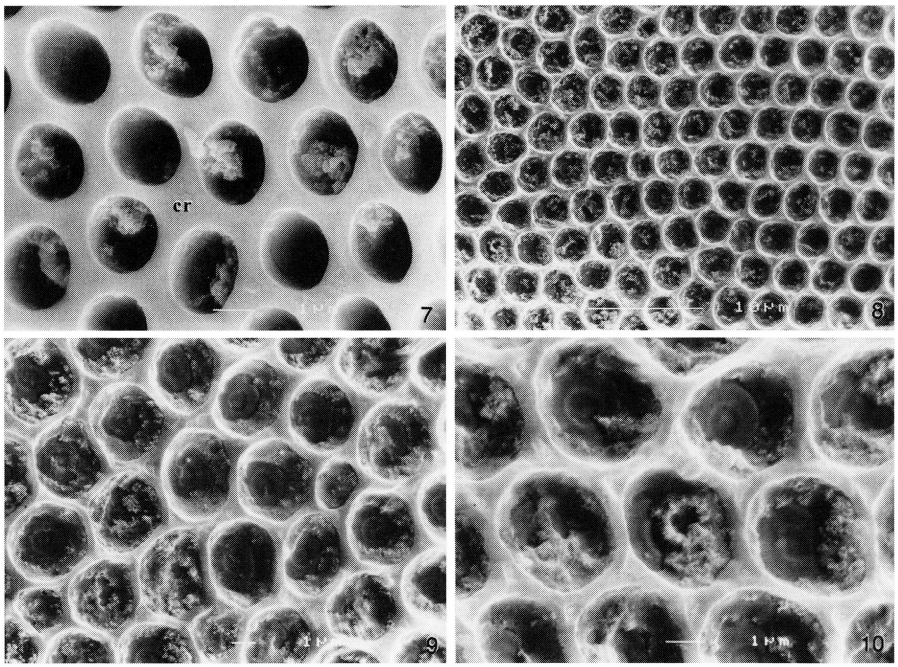
The general shape, density, and distribution of the wax gland pores found on tergite 7 (Figs. 6, 7) are externally similar to those found on tergite 6. Tergite 7 has 0.21-0.22 pores per μm^2, each 1.33 to 2.11 μm in diam. The width of the rims surrounding the pores ranges from 0.46 to 0.64 μm (the widest rim measuring 0.89 μm).

The wax gland pores found on tergite 8 (Figs. 8-10) are externally different from those found on tergites 6 and 7. They are relatively large in size, most measure 2.75



Figs. 1-6. Scanning electron micrographs of *Oeclidius nanus* Van Duzee: 1. abdominal tergites 6-8, showing wax-secreting plates; 2, 3. filamentous wax threads secreted by female adults; 4, 5. wax gland pores in wax plates on abdominal tergite 6, cr, cuticle rim; 6. wax gland pores in wax plates on abdominal tergite 7, cr, cuticle rim.

to 3.58 μm in diam (the smallest pores [few in number] measuring 1.60 to 2.10 μm in diam), about 0.70 μm in depth, and are relatively sparse with a density of 0.09 to 0.10 pores per μm^2. The cuticle rims surrounding the pores are much narrower and are somewhat ridge-like, measuring 0.35 to 0.48 μm in width. The bottom of the wax gland pore is distinctly specialized and is nearly plate-shaped, with a distinct, depressed circle in the center (the central disc) which is probably the site of wax se-



Figs. 7-10. Scanning electron micrographs of *Oeclidius nanus* Van Duzee: 7. wax gland pores in wax plates on abdominal tergite 7, cr, cuticle rim; 8-10. wax gland pores in wax plates on abdominal tergite 8.

Table 1. Wax gland pore features in *Oeclidius nanus*

Wax gland plates	Characters			
	Size of wax plate	Pore density (μm^2)	Pore diam (μm)	Cuticle rim width (μm)
VI	largest	0.20-0.23	1.43-1.95	0.52-0.86
VII	intermediate	0.21-0.22	1.33-2.11	0.46-0.64
VIII	smallest	0.09-0.10	2.75-3.58	0.35-0.48

cretion emission. The diam of the bottom plate is 1.66 to 1.86 μm, and that of the central disc of the plate is 0.82 to 0.93 μm.

The wax gland pores in the female adults of *O. nanus* found in this current study are externally very similar to those found in the kinnarid *A. fuscofasciata* (Liang 2001) and in species of Meenoplidae (Bourgoin 1997) but greatly differ from those seen in species of *Kinnara* Distant (Kinnarinae: Kinnarini) (Liang 2002) and in species of other fulgoromorphan families, e.g., Cixiidae (Sforza et al. 1999), Delphacidae, Derbidae

(Fang et al. 1999), Lophopidae (Liang 1997, 2000) and Eurybrachidae (Fang et al. 1999). *Oeclidius* may represent a relatively primitive kinnarid genus since the typical porous wax gland pores seen in *A. fuscofasciata* and *O. nanus* revealed in this study were regarded as plesiomorphic wax gland features within the Kinnaridae (Liang 2002).

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