EXTERNAL MORPHOLOGY OF THE WAX GLANDS OF *EPIPTERA WOODWORTHI* (HEMIPTERA: FULGOROMORPHA: ACHILIDAE)

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ABSTRACT

External morphology of the wax gland plates and wax gland pores of the fourth-instar nymph of the achilid planthopper, *Epiptera woodworthi* (Van Duzee) (Hemiptera: Fulgoromorpha: Achilidae), is described for the first time, based on scanning electron microscope observations. Six large, oblong wax gland plates are located on lateral regions of the 6th-8th abdominal tergites. Each wax gland plate has numerous, very small, disc-shaped wax gland pores, each of which is composed of a middle disc (3.94-4.25 μm in diameter) surrounded by 5-7 microtubules (six being the most common number encountered) that are separated by 4-6 ridges (five being the most common number encountered). Wax gland pores are separated by numerous rounded papillae located in shallow cavities which have smooth rims with the side adjacent to the wax pore being distinctly ridged. Wax gland pores observed in *Epiptera woodworthi* are externally very similar to those found in nymphs of species of Cixiidae and Dictyopharidae.

INTRODUCTION

The achilid planthopper *Epiptera woodworthi* (Van Duzee), was originally described under *Elidiptera* Spinola by Van Duzee in 1916 from California. It was later listed in Van Duzee's (1917) Catalogue of Hemiptera North of Mexico. Muir (1922) questioned the generic placement of this species. Ball (1933) transferred it to *Epiptera* Metcalf. Since then, the species has not been reported in the literature, except in Metcalf's (1948) catalog of the world Achilidae. The species appears endemic to California.

Epiptera is a northern genus with nymphs and adults usually associated with conifers (O'Brien et al. 1991). Emeljanov (1991) indicated that the New World *Epiptera* Metcalf are actually Old World *Cixidia* Fieber. However, this has not been formally accepted by American hemipterists and *Epiptera* is still widely used in North America. Nymphs of *Epiptera* are the most frequently seen achilid nymphs in the U.S. and Canada. They are usually found under bark of fallen trees (O'Brien and Wilson 1985). Based on observations of *E. fusca* (Walker), Hepburn (1967) believed that nymphs of *Epiptera* species probably feed on fungi, either under the loose bark of dead trees or in leaf litter. Van Duzee (1916) noted

that adults of *Epiptera woodworthi* were collected on Jeffrey pine, but that nymphs as well as adults were beaten from cypress bushes growing on the same slope.

Nymphs and female adults of most fulgoromorphan species secrete wax through distinct sclerotized structures that act as molds to produce structurally different forms 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 useful characters for taxonomic identifications and phylogenetic inferences (O'Brien et al. 1991; Liang, unpublished data). The wax can function as protection from predators and parasites in nymphs, adults, and eggs (Eisner et al. 1978) or from flooding for underground species (Cumber 1953).

Nymphs of *Epiptera* are unique in having large, distinctive wax gland plates, covered with many small wax gland pores which secrete wax, present on the 6th-8th abdominal tergites Fennah (1950) illustrated a fifth-instar nymph of *E. fusca* (Walker) with white, filamentous wax threads on the 6th-8th abdominal tergites but provided no description. Abdominal wax glands are usually absent from adult female Achilidae.

Very few descriptions or illustrations of wax glands of Achilidae nymphs have been published. Previous investigations of wax plates and wax glands of *Epiptera* have only utilized light microscopy (Osborn 1922, Fennah 1950, Yang and Yeh 1994); there have been no scanning electron microscopy studies. During morphological studies of fulgoromorphan immatures, we made scanning electron microscopic observations of the wax gland plates and wax gland pores of nymphs of *Epiptera woodworthi*. Herein, we present a description of the external morphology and distribution of the wax plates and wax pores found on the 6th-8th abdominal tergites of this species.

MATERIALS AND METHODS

Dry, pinned museum specimens were examined from the California Academy of Sciences, San Francisco. The nymphs were collected at Cazadero, California, USA. For scanning electron microscopy (SEM) study of wax gland ultrastructure, the whole nymph or abdomen was first cleaned and dewaxed with 10% KOH, then 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 5 kV. Morphological terminology largely follows that of Foldi (1997).

OBSERVATIONS AND DISCUSSION

Gross morphology of nymph. General morphology (Figs. 1, 2) as in *Epiptera opaca* (Say), as described by Wilson (1983), but differs from the latter in abdominal segments with distinct median ridges and in having distinct lateral sensory pits in columns beyond abdominal median ridges.

Wax gland plates. As in other *Epiptera* species, six large, distinct wax gland plates are present on lateral regions of abdominal tergites 6-8 of the fourth-instar *Epiptera woodworthi* nymph (Figs. 1-3). The wax plates are large and transversely oblong, occupying approximately one-half the area to almost all of the tergite, and are covered with numerous small cuticular structures for wax molding, the wax pores (Figs. 4-11).

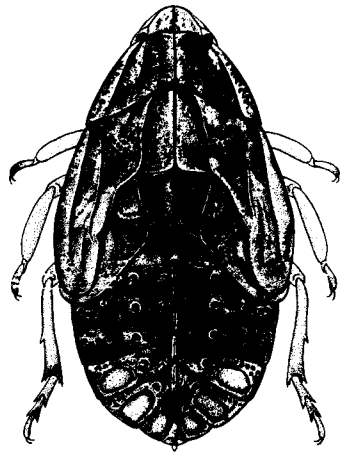

FIG. 1. *Epiptera woodworthi* (Van Duzee), fourth-instar nymph, California: Cazadero, dorsal view.

Some differences in size, shape, and position exist among the wax gland plates on the 6-8th abdominal tergites (Figs. 1-3). Wax gland plates on the 6th abdominal tergite are shortest, narrowest and smallest, being less than one-half the area of the 6th tergite, and being nearer to its posterior margin; those on the 7th abdominal tergite are largest and longest, being greater than one-half the area of the entire tergite, with the inner part relatively narrow and the outer part relatively broad. Wax gland plates on the 8th abdominal tergite are intermediate in size, occupying almost all of the tergite, being close to the anterior and posterior margins of the tergite, with the inner part relatively narrow and the outer part relatively broad.

Wax gland pores. Wax gland pores in nymphs of *Epiptera woodworthi* are disc-shaped (Figs. 4-11). Each glandular pore unit consists of a main circular disc surrounded by 5-7 microtubules which are separated by 4-6 cuticular ridges (Figs. 5-11). The discs are rounded and elevated and measure approximately 3.94-4.25 μm in diameter and about 1.22 μm in height. Each disc has a raised circle in the center which is probably the site of wax secretion emission. Each disc is surrounded by 5-7 microtubules (six being the most common number encountered), which are separated by 4-6 cuticular ridges (1.52-2.12 μm long) (five being the most common number encountered) (Figs. 5-11).

The microtubules are very slender and short, about 0.86 μm in length and about 0.50-0.60 μm in diameter. They are hollow centrally with the apex slightly expanded (Figs. 5-11). Their function is unknown, but they may secrete the fluid material to strengthen or solidify the wax threads arising from the central raised circle of the disc. The number of microtubules varies slightly. Six and seven microtubules (seven being the more common number encountered) are observed in the wax plates on tergite 6 (Figs. 5-7), while 5-7 microtubules (six being the most and five being the least common number) are observed in tergites 7 and 8, respectively (Figs. 8-11).

FIG. 2-7. *Epiptera woodworthi* (Van Duzee): 2. Fourth-instar nymph, California: Cazadero; 3. Abdominal tergites 6-8, showing wax gland plates; 4. Wax gland plates on right abdominal tergites 6-8; 5-7. Wax gland pores in wax gland plates of abdominal tergite 6.

The disc-shaped wax gland pores are surrounded by many small, rounded papillae (1.21-1.82 μm in diameter) located in shallow cavities (2.16-2.61 μm in diameter) (Figs. 5-11). The rim of each cavity is smooth but the side of the rim adjacent to the wax gland pore is distinctly ridged. The length of these elevated ridges is about 2.12-3.03 μm. The function of these papillae is unknown.

Wax gland plates and wax glands are morphologically very diverse within Fulgoromorpha but only a few have been studied with scanning electron microscopy [e.g., Cixiidae (Pope 1985, Sforza et al. 1999), Lophopidae (Liang 1997, 2000), Meenoplidae

(Bourgoin 1997) and Kinnaridae (Liang 2001)]. The present study shows that the wax gland plates and wax gland pores of *Epiptera woodworthi* provide many potentially informative characters for identification and phylogenetic study. Nymphs of the *Epiptera* species have the largest wax gland plates within the Achilidae. The number (six), shape (oblong or ovoid), and position (lateral regions of the 6th-8th abdominal tergites) of the wax gland plates in *Epiptera* differ from those in the nymphs of the Cixiidae, Dictyopharidae, and other fulgoromorphan families.

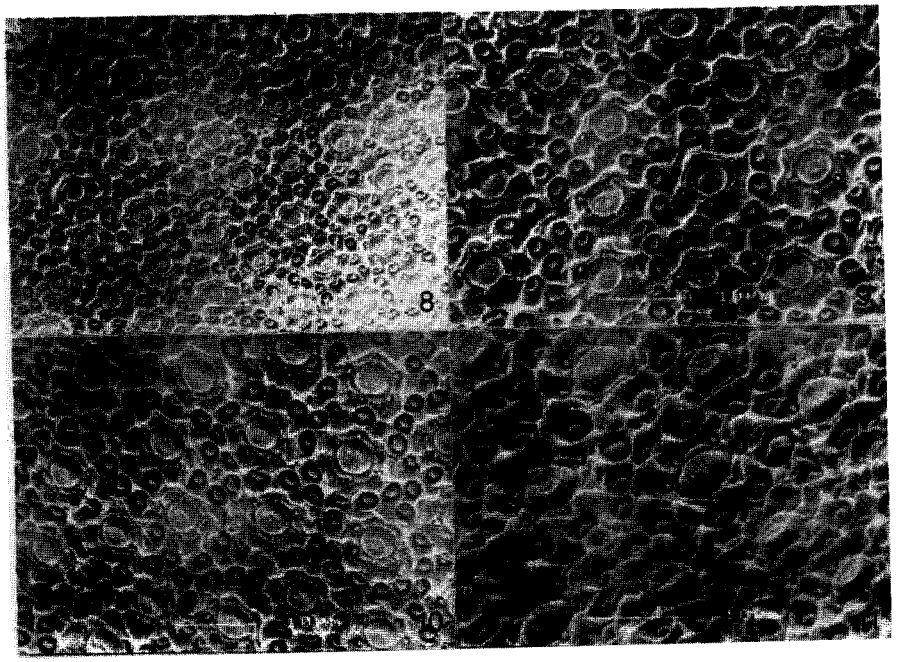

FIG. 8-11. *Epiptera woodworthi* (Van Duzee): 8-9. Wax gland pores in wax gland plates of right abdominal tergite 7; 10-11. wax gland pores in wax gland plates of right abdominal tergite 8.

Wax gland pores in *Epiptera woodworthi* are externally very similar to those in nymphs of species of Cixiidae (Pope 1985, Sforza et al. 1999) and Dictyopharidae, with all having a central rounded disc surrounded by several microtubules and cuticular ridges, and separated by a series of small rounded papillae situated in shallow cavities, but distinctly different from those seen in nymphs of other families (e.g., Fulgoridae, Issidae, Tropiduchidae, Flatidae, Lophopidae, and Eurybrachidae) (Liang, unpublished data).

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