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Wax of a Whitefly and Its Utilization by a Chrysopid Larva*

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A diagnostic characteristic of insects of the family Aleyrodidae (order Homoptera, suborder Sternorrhyncha) is the production of wax in the form of a particulate covering of their bodies. The substance, which is produced by special integumental glands [1] and is often applied by the insects to the leaf surfaces upon which they live, is responsible for the name "whitefly" commonly given these insects. Whiteflies include many agricultural pests. We here report on the chemical nature of the wax of a North American whitefly, and on the use that one of its predators makes of this wax.

The whitefly studied, *Metaleurodicus griseus,* is restricted to the state of Florida (USA), where it occurs on plants of the genus *Eugenia* (Myrtaceae) [2]. The population we studied was located in a patch of coastal hardwood forest on *E. myrtoides* and *E. axillaris,* near Vero Beach, Indian River County, Florida. Stages in the life cycle are shown in Fig. 1. The adults are covered with fine waxy powder, the eggs with a dense waxy fluff, and the larvae with a loose matting of waxy fibers that extends to their surroundings.

Wax for analysis was collected by swabbing the covering of eggs, and the matting on and around larvae, with a fine glass probe. A sample was analyzed by direct insertion probe on a LKB-9000 mass spectrometer at 70 eV and 20 μA ionizing current. The probe was heated from ambient to 290 °C with scans being made every ca. 20 °C. Mass measurement was checked by addition of a perfluorinated triazine standard to a second specimen of the wax.

As the probe reached 80 °C, a series of unsaturated hydrocarbons was observed. Intensities of their molecular ions at m/z 392, 418, and 420 suggested that they were present in the following proportions: $C_{28}H_{56}$ (26 %), $C_{30}H_{58}$ (27 %), and $C_{30}H_{60}$ (47 %). Further heating to 115 °C produced a saturated wax identified as triacontanyl decanoate from ions at m/z 173 (decanoic acid + H), 420 (triacontanol − H_2O), and a molecular ion at m/z 592. Further heating from 150 to 200 °C produced the much higher homolog triacontanyl octadecanoate similarly identified by ions at m/z 285 (acid + H), 420 (alcohol − H_2O), and a molecular ion at m/z 704. The main component, triacontanyl triacontanoate was detected even in the earliest scans but eluted in a broad peak maximizing at ca. 310 °C. This compound was identified by peaks at m/z 453 (triacontanoic acid + H), m/z 420 (triacontanol − H_2O), and a molecular ion at m/z 872. The approximate quantities of each were determined by integrating the areas of the corresponding total ion monitor response: unsaturated hydrocarbons 1.2 %, triacontanyl decanoate 12.8 %, triacontanyl octadecanoate 17 %, triacontanyl triacontanoate 69 %.

This wax mixture is clearly different from that reported recently for two other whiteflies, *Bemesia tabaci* and *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae) [3] where only triacylglycerols mixed with either 3 – 7 % (*B. tabaci*) or 0.6 – 1 % (*T. vaporariorum*) hydrocarbons were detected.

Comparisons are also in order with waxes characterized recently from other homopteran species. We ourselves reported the presence of the 15-ketotetratriacontanol ester of 11-ketotriacontanoic acid as the main constituent in the wax of the lantern bug *Cerogenes auricoma* (Homoptera: Fulgoridae) [4]. This wax was identical to

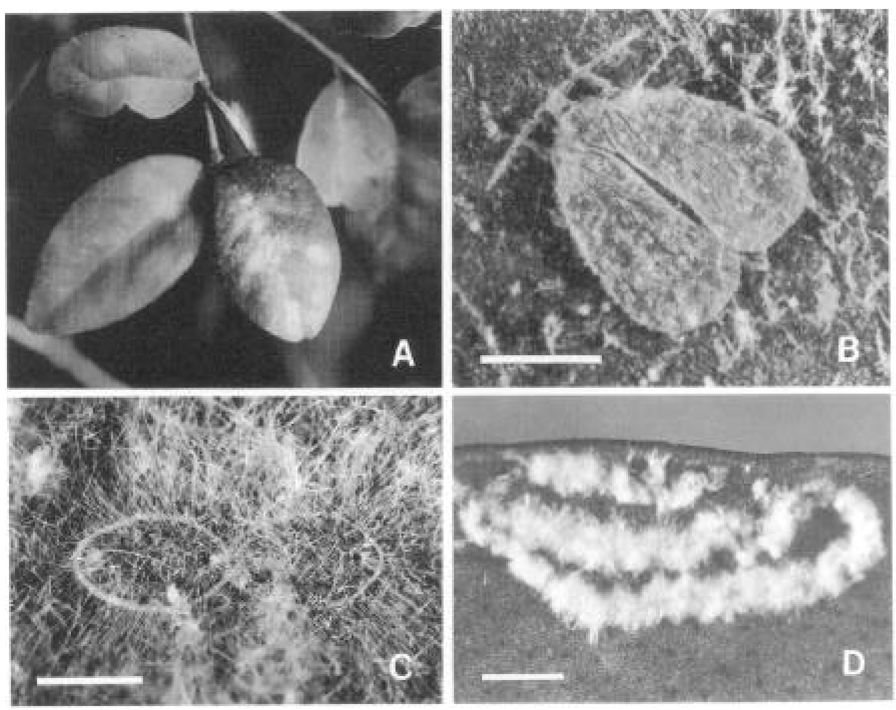

Fig. 1. The whitefly *Metaleurodicus griseus:* A) colony on *Eugenia* leaves, B) adult, C) larva, D) eggs (laid out in a convoluted row, covered over with wax). *Bars* 1 mm

* Defense Mechanisms of Arthropods, no. 96; no. 95: Eisner et al.: Chemoecology (in press)

that found previously by Meinwald et al. in *Dactylopius confusus* (Homoptera: Aphidae) [5]. Interestingly, in two other cases the wax esters were also composed of identical carbon chain length acids and alcohols. Thus, *Drosicha corpulenta* (Homoptera: Margarodidae) contained hexacosanyl hexacosanoate [6] and *Anomoneura mori* (Homoptera: Psyllidae) contained dotriacontanyl dotriacontanoate (lacceryl laccerate) [7]. Only in *Ceroplastes pseudoceriferus, C. japonicus,* and *C. rubens* (Homoptera: Coccidae) were complex mixtures noted with acids ranging from $C_{16}-C_{34}$ and alcohols from $C_{24}-C_{34}$ [8]. Use of the same carbon chain for both acid and alcohol would seem to reflect a certain biosynthetic economy in the corresponding species, while species showing little homology may find a relatively high melting point (82–86 °C in our case) advantageous.

Field observation of the *Metaleurodicus* populations revealed the presence of a green lacewing larva, *Ceraeochrysa cincta* (Chrysopidae), that actively preyed on the whiteflies. Visual inspection of some dozens of infected *Eugenia* plants produced over a dozen of these larvae, as well as a number of hatched and unhatched, typically stalked, chrysopid eggs. The larvae all bore conspicuous white packets on their backs, seemingly waxy in nature.

C. cincta belongs to a category of chrysopid larvae known as "trash carriers", which build dorsal packets from exogenous materials, including vegetable matter, arthropod remains, and general debris [9–13]. Close observation of *C. cincta* larvae that we took with *Metaleurodicus* colonies to a laboratory (Archbold Biological Station, Lake Placid, Florida) showed that the larvae construct their packet from *Metaleurodicus* wax. By use of their curved pointed mandibles, which function as a fork, they pluck wax from the covering of *Metaleurodicus* eggs and larvae, and systematically apply plucking after plucking to their back (Fig. 2F, G). Chrysopid larvae that we denuded by removing their packets with forceps, immediately engaged in such loading behavior and reconstructed their packets within 0.5–1 h. In feeding, the larvae chose both eggs and larvae (all stages) of *Metaleurodicus.* They pierced larvae with their mandibles and sucked them dry, as chrysopid larvae typically do, and fed similarly on eggs, which they exposed by first plucking away the waxy cover. As they fed, they frequently added wax pluckings from the prey to their back.

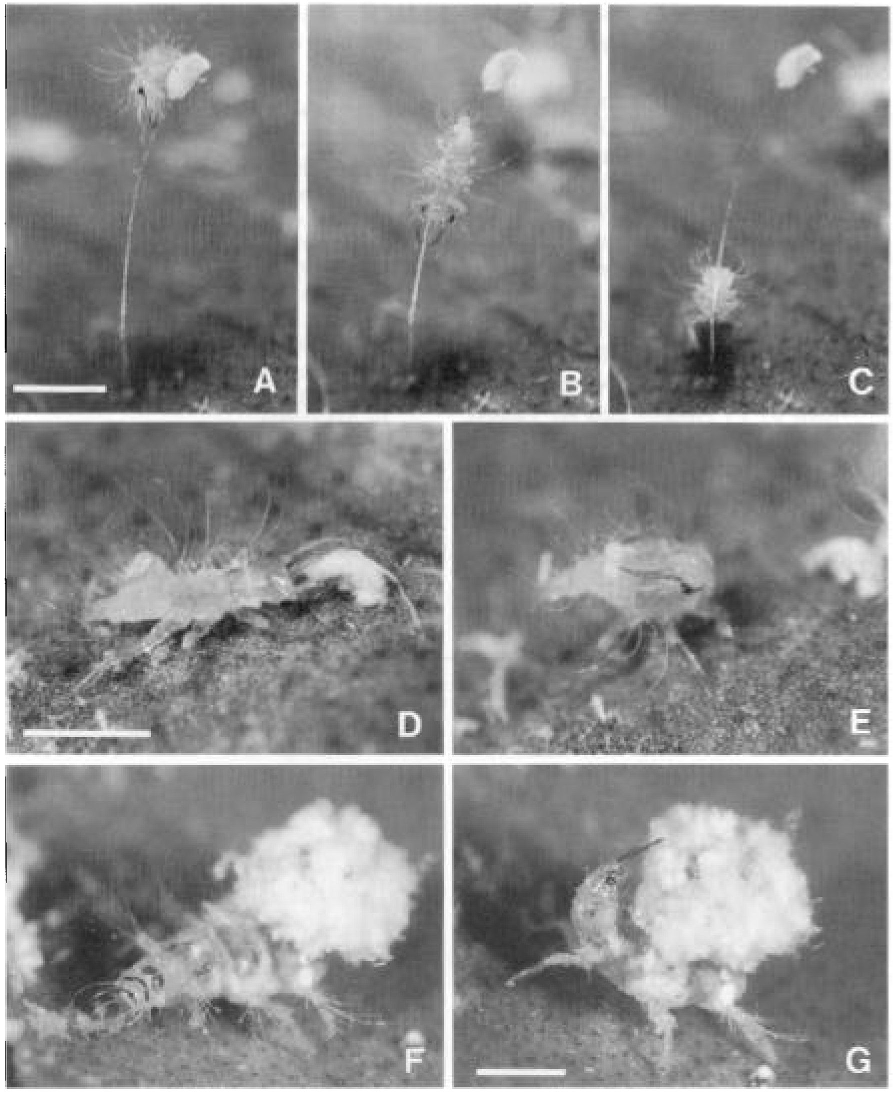

Fig. 2. The chrysopid larva *Ceraeochrysa cincta:* A–C) after emergence, descending along egg stalk, D, E) shortly after preceding, beginning to load up with wax, F, G) late instar larva, adding wax (from covering of *M. griseus* eggs) to its already well-formed dorsal packet. *Bars* 1 mm

Larvae that we monitored from the moment of hatching were noted to engage in loading behavior immediately upon their descent from the egg. The very first time they encountered a source of wax, they scooped up some of the material and applied it to their back (Fig. 2A–E).

Dorsal packets may serve chrysopids primarily as defensive shields against ants. Ants commonly tend homopteran insects that chrysopid larvae favor as prey, "milking" these insects of their honeydew and protecting them against enemies. In another chrysopid that also constructs a waxy packet, *Prociphilus tesselatus,* but which obtains its wax from an aphid rather than a whitefly, the packet has been shown to be an effective physical deterrent to ant attack [14]. While no actual ant attacks were witnessed upon *C. cincta,* there can be no doubt that this chrysopid is ordinarily exposed to ants. Individuals of five ant species (*Camponotus abdominalis floridanus, C. tortuganus, Pseudomyrmex cubaensis, Solenopsis invicta, Paratrechina longicornis*) were commonly noted in *Eugenia* in the immediate surround of *Metaleurodicus* colonies.

C. cincta larvae had previously been reported only once, from Lignum Vatae Key, Monroe County, Florida, where it was found in association with another wax-producing prey insect, the mealybug *Plotococcus eugeniae*. *C. cincta* was noted to construct a packet from the wax of this insect as well [15].

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