SEX PHEROMONE CHEMISTRY OF THE FEMALE TOBACCO BUDWORM MOTH, *Heliothis virescens*

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**Abstract**—(Z)-11-Hexadecenal (77–91%), (Z)-7-hexadecenal (0.1–2%), (Z)-9-hexadecenal (0.3–2%), hexadecanal (3–19%), (Z)-11-hexadecen-1-ol (1–5%), tetradecanal (1–3%), and (Z)-9-tetradecenal (1–3%) were identified from the heptane washes of the ovipositor of female *Heliothis virescens* (F.) females. In field bioassays, a 152-μg mixture of these seven compounds deployed in an insect trap exceeded the attractiveness of 4 virgin female *H. virescens* for males and was 5–6 times more attractive than a mixture of (Z)-11-hexadecenal and (Z)-9-tetradecenal (virelure) that was previously reported as the sex pheromone of the species. Four of the seven compounds produced by *H. virescens* females are also produced by *H. zea* (Boddie). Specificity of pheromonal signals among the two species is ostensibly dependent upon one or more of the three additional compounds [tetradecanal, (Z)-9-tetradecenal, and (Z)-11-hexadecen-1-ol] produced by female *H. virescens*.

**Key Words**—*Heliothis virescens*, tobacco budworm, sex pheromones, reproductive isolation, gas open tubular capillary chromatography, mass spectrometry, insect behavior, (Z)-11-hexadecenal, (Z)-9-hexadecenal, (Z)-7-hexadecenal, (Z)-9-tetradecenal, (Z)-11-hexadecen-1-ol, tetradecanal, hexadecanal.
INTRODUCTION

The impetus for the present investigation of the sex pheromone of *Heliothis virescens* (F.) was our interest in the comparative sex pheromone chemistry of *H. virescens* and *H. zea* (Boddie). Roelofs et al. (1974) and Tumlinson et al. (1975) identified (Z)-9-tetradecenal and (Z)-11-hexadecenal as components of the sex pheromone of the female *Heliothis virescens* (F.). Klun et al. (1979) showed that *H. zea* females produce hexadecanal, (Z)-7-hexadecenal, (Z)-9-hexadecenal, and (in common with *H. virescens*) (Z)-11-hexadecenal. Initially, we wished to determine whether any of these other compounds discovered from *H. zea* were also present in *H. virescens*. We report here that *H. virescens* females do produce the four aldehydes that Klun et al. (1979) described from *H. zea*. In addition, and unlike *H. zea*, they also produce (Z)-11-hexadecen-1-ol, tetradecanal, and (Z)-9-tetradecenal. We also report evidence that the sex pheromone of *H. virescens* is not a binary combination of (Z)-11-hexadecenal and (Z)-9-tetradecenal but is a mixture that may involve as many as seven compounds.

METHODS AND MATERIALS

The glass open-tubular capillary (GOTC) chromatography, GOTC chromatography-mass spectrometry (GOTC-MS), and derivative-formation procedures used in this study were the same as those described by Klun et al. (1979). The organic synthetic methods, chemical purification procedures, and conditions of the laboratory bioassay of *H. virescens* males were also the same as described by Klun et al. (1979). All insects used in the research were obtained from artificially reared (Raulston and Lingren, 1972) cultures maintained at AR, SEA, USDA laboratories in Fargo, North Dakota, Stoneville, Mississippi, or Brownsville, Texas.

Field tests were conducted in fields near Tifton, Georgia, by evaporating chemicals from cotton dental rolls or cigarette filters that had been treated with 10-μl heptane solutions of the various mixtures of compounds. These freshly treated wicks were placed in the traps nightly. All heptane solutions contained 2,6-di-tert-butyl-4-methylphenol as antioxidant (Klun et al., 1979). Virgin females used in the tests were 24–72 hr old.

The traps used in the tests were either sticky traps constructed from plastic plates (Klun et al., 1979) or electric grid traps (Hollingsworth et al., 1963). In one test, sticky traps were deployed 1.5 m from the ground and 20 m apart at the perimeter of a cotton field and within the alleyways of a tobacco field. This test extended over 6 consecutive nights and was arranged as a randomized complete-block design with six treatments (mixtures of compounds) on cotton dental rolls, each replicated seven times. In another