WIND TUNNEL STUDIES OF SEX PHEROMONE-MEDIATED BEHAVIOR OF THE HESSIAN FLY (DIPTERA: CECIDOMYIIDAE)

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Abstract—In a wind-tunnel, male Hessian flies flying toward a source of the female-produced sex pheromone exhibited flight maneuvers very similar to those described for male moths. Upwind flight, consisting of zigzagging and straight flight upwind, was initiated within seconds after flies were placed in the odor plume. This upwind flight was sometimes interrupted by casting, which consisted of wide excursions in the horizontal plane ranging 10–35 cm across the central zone of the tunnel. Comparison of the flight maneuvers of males exposed to ten female equivalents of a hexane extract of female ovi-positors and males exposed to 20 ng of (2S)-(E)-10-tridecen-2-yl acetate (SE10-13:OAc), which has been identified as a component of the Hessian fly sex pheromone, indicated that the sex pheromone probably contains additional components. However, SE10-13:OAc elicited upwind flight and source location by a significant number of males, even at dosages as low as 2 ng on filter paper. At the highest dosage of SE10-13:OAc tested (200 ng on filter paper), there was a significant decrease in net flight velocity and a slight, but not significant, reduction in the number of males contacting the odor source. The addition of increasing amounts of the R enantiomer to the S enantiomer resulted in increased inhibition of upwind flight and source contact by males.

Key Words—Hessian fly, Mayetiola destructor, Diptera, Cecidomyiidae, flight, anemotaxis, orientation, olfaction, enantiomer, mating.

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INTRODUCTION

During the last decade, scientists studying the responses of various species of Lepidoptera to sex pheromones have made significant progress toward understanding how male moths locate odor sources (Baker, 1989). By manipulating concentrations and blends of pheromone components and altering pheromonal plume characteristics, they have shown that behavioral thresholds are lowest for the natural blend of components (Linn et al., 1986, 1987) and that there are two main mechanisms for odor source location (Baker, 1986; Kennedy, 1986), optomotor anemotaxis, i.e., steering with respect to the wind, and self-steered counterturning. Most of these studies have been carried out using a sustained-flight tunnel, an arena that enables the researcher to measure flight responses under controlled conditions.

In contrast to moths, many other insects are either less tractable in the wind tunnel or exhibit a different set of responses to pheromones of conspecifics. Some species of beetles, for example, must fly for a certain time before they become responsive to aggregation and sex pheromones (Choudhury and Kennedy, 1980), whereas others must be starved (Bartelt et al., 1990). However, recent successes with beetles flying in the wind tunnel (Birch and White, 1988; Bartelt et al., 1990; Domek et al., 1990) indicate that behavioral mechanisms used in the location of odor sources by some species of Coleoptera may be similar to those used by moths.

In the Diptera, orientation to sex pheromones over long distances is more common in the so-called primitive flies (suborder Nematocera) than in the more advanced flies (Blomquist et al., 1987). Thus, in the families Sciaridae and Cecidomyiidae, males exposed to sex pheromones move upwind in y-tube olfactometers or individual glass cylinders (Kostelc et al., 1980; Alberts et al., 1981; Williams and Martin, 1986), whereas many species in the suborder Cyclorrhapha produce sex pheromones that do not appear to elicit long-range orientation but rather release short-range courtship (Shorey and Bartell, 1970) and copulatory behaviors (Carlson et al., 1984) or increase mating strike activity (Mackley and Broce, 1981). The exception to this trend within the Cyclorrhapha is the tephritid Dacus oleae (Haniotakis et al., 1977); in this species, males respond over distances of > 1 meter to the female-produced sex pheromone.

It has been known for many years that male Hessian flies, Mayetiola destructor (Say) (Diptera: Cecidomyiidae) respond to virgin females over distances of several meters by flying upwind (Cartwright, 1922). The utilization of a sex pheromone by this species was demonstrated by McKay and Hatchett (1984), who showed that males placed in a y-tube olfactometer responded to hexane extracts of ovipositors of virgin females. Recently, Foster et al. (1991) identified a chemical, (2S)-(E)-10-tridecen-2-yl acetate (SE10-13:OAc), from