

HOW CONTACT FORAGING EXPERIENCES AFFECT PREFERENCES FOR HOST-RELATED ODORS IN THE LARVAL PARASITOID *Cotesia marginiventris* (CRESSON) (HYMENOPTERA: BRACONIDAE)¹

TED C.J. TURLINGS, J.W.A. SCHEEPMAKER,² L.E.M. VET,²
J.H. TUMLINSON, and W.J. LEWIS³

*Insect Attractants, Behavior, and Basic Biology Research Laboratory
Agricultural Research Service, U.S. Department of Agriculture
Gainesville, Florida 32604*

Abstract—Responses of individual females of the parasitoid *Cotesia marginiventris* to the odors of four different complexes of host larvae feeding on leaves were observed in a four-arm olfactometer. The plant–host complexes were composed of fall armyworm (FAW) larvae or cabbage looper (CL) larvae feeding on either corn or cotton seedlings. Prior to testing, each female was given a brief foraging experience on a plant–host complex and was then exposed to the odors of the same complex in the olfactometer. The experienced females responded to familiar odors in a dose-related manner, and these responses were virtually identical to all four complexes. Preferences for the odors of one of two plant–host complexes were tested in dual choice situations. Generally, FAW odors were preferred over CL odors and corn odors over cotton odors. A short foraging experience significantly affected the females' odor preferences in favor of the odors released by the experienced complex. Additional experiments revealed that neither longer bouts of experience nor bouts that included ovipositions resulted in a stronger change in preference. Experience affected preference in combinations where only the host species was varied as well as in combinations where only the plant species was varied. The results, therefore, strongly indicate that both the plants and the hosts somehow are involved in the production and/or release of the semiochemicals that attract *C. marginiventris*.

¹Mention of a proprietary product does not constitute an endorsement or the recommendation for its use by the USDA.

²Present address: Agricultural University of Wageningen, Department of Entomology, P.O. Box 8031, 6700 EH Wageningen, The Netherlands.

³Mailing address: P.O. Box 748, Tifton, Georgia 31793-0748.

Key Words—Hymenoptera, Braconidae, *Cotesia marginiventris*, host-finding, semiochemicals, conditioning.

INTRODUCTION

Females of many insect parasitoids rely on host and host-habitat related chemicals as cues in their search for hosts (for reviews see Vinson, 1976, 1981, 1984; Weseloh, 1981; van Alphen and Vet, 1986). Several studies have demonstrated that the response to these semiochemicals is flexible and can be influenced by learning (Thorpe and Jones, 1937; Monteith, 1963; Arthur, 1971; Taylor, 1974; Vinson et al., 1977; Sandlan, 1980; Strand and Vinson, 1982; Vet, 1983, 1988; Vet and van Opzeeland, 1984, 1985; Wardle and Borden, 1985; Dmoch et al., 1985; Drost et al., 1986; Lewis and Tumlinson, 1988). These studies show that experiences with hosts and/or their microhabitats, both by immature and mature stages, may influence an adult parasitoid's response to semiochemicals. *Cotesia marginiventris* (Cresson), a solitary larval parasitoid of many Lepidoptera, shows a significant increase in response to host-related odors after only a brief contact experience with host damaged leaves contaminated with host by-products (Turlings et al., 1989). After females receive a contact experience with a particular plant-host complex, they respond significantly better when they are exposed to the odors of that plant-host complex than when they are exposed to the odors of an alternative plant-host complex (Turlings et al., 1989). This suggests that the experience effect is not merely the result of a general increase in response to semiochemicals, but that the insects actually learn to respond to the odors that they encounter during their experience.

This phenomenon of conditioning through experience has been suggested as a useful method for biological control programs in which parasitoids could be stimulated to respond to host-related odors prior to their release in a target area (e.g., Lewis and Nordlund, 1985). This would be particularly helpful if the wasps would not just increase their responses to the experienced odors, but would actually prefer these odors over those released by alternative plant-host complexes when given a choice.

Here we report on a study in which the effect of experience on odor preferences by *C. marginiventris* was tested. Shifts in preference in favor of an experienced odor were studied in situations where only the host species was varied and in situations where only the plant was varied. Thus, we obtained information on the specific roles played by both host larvae and plants in the production and release of semiochemicals essential for host-habitat location.

METHODS AND MATERIALS

Population of C. marginiventris. Parasitoids of the '85 Mississippi strain were reared on fall armyworm larvae at the USDA-ARS, Insect Biology and Population Management Research Laboratory, Tifton, Georgia, according to the procedure described by Lewis and Burton (1970) for the parasitoid *Microplitis croceipes*. Cocoons were collected a few days prior to emergence and shipped to Gainesville where they were kept in 25 × 25 × 25-cm Plexiglas cages, each with one side of fine mesh nylon screen. Parasitoids that emerged on the same day were kept in the same cage, and all cages were stored in cabinets at 26°C, 50–60% relative humidity, and a 15-hr photophase. Males were removed after two days, allowing sufficient time for all females to be mated. All experiments were conducted with 3- to 5-day-old mated females, 6–10 hr into the photophase.

Hosts. The hosts used in the experiments were second-instar larvae of the fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), and of the cabbage looper (CL), *Trichoplusia ni* (Hübner). They were reared according to the procedure described by King and Leppla (1981).

Olfactometer. Individual females were exposed to host-related odors and observed in a four-arm olfactometer similar to the one described by Vet et al. (1983) with some modifications described by Eller et al. (1988). This device is designed so that four well-defined odor fields, each associated with one of the arms, are created in a square central arena. The fraction of an odor-containing flow that actually reached a parasitoid in the olfactometer could be controlled by diverting part of the flow before it entered the arena. The fraction that was split off was then replaced by clean humidified air. The total flow entering the central exposure chamber through each arm was kept at 300 ml/min.

Odor Sources. The odor sources consisted of five late second- or early third-instar larvae feeding on three seedlings. The larvae of either FAW or CL were put on the seedlings of either corn (*Zea mays* L.) or cotton (*Gossypium hirsutum* L.) 1.5 hr prior to the actual bioassays.

Data Recording. The behavior of the females in the olfactometer was recorded with the use of an Epson Geneva PX-8 portable computer. After a female was introduced into the olfactometer, the time it spent in each odor quadrant was recorded during a 5-min period. If the parasitoid walked into one of the arms and did not return within 15 sec, this was recorded as a final choice for that arm. The remaining time was added to the time spent in the quadrant of the final choice. For the dual choice tests, the odor quadrant in which a female spent the greatest amount of time was recorded as her odor field preference.

RESULTS

Dose-Response Experiments. Before actual odor preferences were tested; the responses to different odor doses were tested for each plant-host complex separately. Thus, dose-response curves could be generated to determine which concentrations of the different plant-host complexes evoke similar response levels. These concentrations were then used in the preference experiments to reduce the possibility that preferences were influenced by concentration differences.

The responses of female parasitoids were observed to the odors of FAW on corn, FAW on cotton, CL on corn, or CL on cotton. During each test the odor of one of these complexes was offered through one of the four flows, while the other flows contained humidified air and served as controls. For each of the four odor sources three concentrations were tested: 25, 50, and 100% of the original odor flow.

Just prior to being tested, a female was placed, for 20 sec, on a plant-host complex like the one used as the odor source. The parasitoid was prevented from actually encountering hosts. This type of experience significantly increases a female's response to host-related odors (Turlings et al., 1989). The female was then introduced into the olfactometer. Odor sources were rotated to the next air flow after six females were tested for each of the three concentrations of a particular odor. A total of 24 females were tested for each concentration of all odor sources.

Figure 1 shows that the wasps responded in a dose-related manner to all four complexes. Regression analyses of the time spent in the odor quadrant (Figure 1b) and of the time it took the females to make a final choice (Figure 1c) show a significant increase in responsiveness to the odors with increasing odor dose. The total number of final choices made for the odor arms was also found to be significantly dose related, with the exception of CL on cotton (Figure 1a).

No significant differences were found between the same doses of the four odor sources. In all of the following preference tests, 50% doses were used.

Effect of Short Contact Experience on Odor Preference. The effect of a short-term contact experience on a female's preference for the odors emitted by

FIG. 1. Responses of experienced *C. marginiventris* females to three doses of odors emitted by larvae feeding on leaves. Responses were measured as: (a) average percentage of the females that made a final choice for the odor arm; (b) average percentage of time that the females spend in the quadrant with the odor; (c) average time it took a female to make a final choice. The lines connect the average values, while the equations for the actual linear regressions are given with each graph.

