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KAIROMONES AND THEIR USE FOR MANAGEMENT OF ENTOMOPHAGOUS INSECTS: I. EVALUATION FOR INCREASING RATES OF PARASITIZATION BY *Trichogramma* spp. IN THE FIELD[1,2,3]

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Abstract—Kairomones for *Trichogramma* spp. were evaluated in the field on soybeans and crimson clover. Blanket (complete coverage) spraying of plots (either a synthetic tricosane or an eluate from a hexane extract of moth scales, depending on the responsiveness of the *Trichogramma* spp. present) resulted in increased parasitization by released and wild *Trichogramma* populations. The increased parasitization resulted for both natural and artificially applied eggs.

Key Words—kairomones, *Trichogramma evanescens*, *Trichogramma achaeae*, biological control, pest management, *Heliothis zea*, *Anticarsia gemmatalis*, pheromones, insect behavior, host finding, parasitoids, behavior chemicals.

INTRODUCTION

Numerous investigations, beginning with an observation by Thorpe and Jones (1937), have demonstrated that the behavior of entomophagous insects is influenced in various ways by chemicals produced by their host or prey. In the studies of entomophagous insects at our laboratory, we have

[1] Hymenoptera: Trichogrammatidae.
[2] In cooperation with University of Georgia College of Agriculture Experiment Station, Coastal Plain Station, Tifton, Georgia.
[3] Mention of a proprietary product does not necessarily imply endorsement by the USDA.

placed a great deal of emphasis on investigations of kairomones as defined by Brown, Eisner, and Wittaker (1970), because we are of the opinion that they may offer considerable potential in the management of insect pests. Lewis and Jones (1971) demonstrated that feces from *Heliothis zea* (Boddie), as well as hexane extracts of the feces, elicited a host-seeking response by *Microplitis croceipes* (Cresson). The active material was later identified by Jones et al. (1971) as 13-methylhentriacontane. Moth scales left by ovipositing moths were determined to be the source of a kairomone that elicited a host-seeking response by *Trichogramma evanescens* Westwood, and the active components were obtained in hexane extracts of the scales (Lewis, Jones and Sparks, 1972). In this same article an initial appraisal of the usefulness of these kairomones in the field for increasing the parasitization by *Trichogramma* was made. The incidence of parasitization of eggs artifically applied on alternating treated and control leaves was compared within an area of release of *T. evanescens* in a 0.5-hectare cotton field. The treatment applied was a hexane extract of *H. zea* moth scales. In this and other related tests, 1.5–2.0 times more parasitization was obtained on the treated leaves than on untreated leaves. Jones et al. (1973) used the same technique to evaluate various fractions extracted from *H. zea* moth scales and determined that tricosane was the most active component.

The reports to be presented in this series will deal with more extended studies of the potential uses of kairomones, their occurrence among various entomophagous insects, and the interrelated behaviors involved.

The studies reported here were designed to determine whether these kairomones, either extracts from moth scales or synthetic tricosane, were active when they were applied in a solid pattern over the leaf surfaces of larger plots, whether they would increase parasitization of naturally deposited eggs that would have natural kairomones present, and whether they could be used to manipulate the behavior of wild *Trichogramma.*

METHODS AND MATERIALS

The hexane extracts of the corn earworm moth scales were formulated according to the procedure described by Jones et al. (1973). The extract formulations and synthetic tricosane were applied with hexane as a carrier solution using the pneumatic spray system described by Nordlund et al. (1974). *Trichogramma* for release were reared according to the procedure used by Lewis and Redlinger (1969). *Heliothis zea* eggs placed in plots to monitor parasitization were applied to the plants with a brush by using Plantgard® as an adhesive according to the procedure described by Nordlund et al. (1974). The procedure for dissecting the eggs was described by Lewis and

Redlinger (1969). The *t* test and analysis of variance were used to determine whether differences between treatments were significant. Arcsin transformations were conducted on percentages prior to analysis.

PROCEDURES AND RESULTS

Experiment 1

Experiment 1 was conducted to determine whether applications of the tricosane in a blanket pattern over an entire plot would result in improved parasitization similar to that obtained in earlier studies by treating single leaves on which eggs were applied (Lewis, Jones, and Sparks, 1972). 12 soybean plots, 6.1 × 7.3 m (8 rows) in size and having 3.5 m of separation on all sides were selected for the study. The plots were arranged in 6 pairs with 1 of each pair selected at random for treatment with tricosane at the rate of 395 mg/hectare, and the other plot of each pair served as a control. Eggs of *H. zea* were placed on the plants at a rate of 64/plot. Plastic cups, 0.5 oz in size, each containing 200 adult *T. achaeae* Nagaraja and Nagarkatti[4] were opened and placed in the furrows throughout each plot at the rate of 8 cups/plot. After a 4-h exposure, the mean level of parasitization was 21% in the treated plot and 8% in the control plots. The difference was significant at the 1% level of probability.

Experiment 2

A study was conducted to determine whether the kairomone would function to improve parasitization of naturally deposited eggs that already must contain some amount of the kairomone. 5 pairs (1 treated and 1 control) of plots 7.6 × 3.7 m in size were selected at random through the field. The treated plots were sprayed with tricosane at a rate of 395 mg/hectare. Equal numbers of *T. achaeae* (ca. 800 adults) were released in each of the plots. Sample collections of eggs were made at random in each of the plots ca. 4 h later. Eggs of *H. zea* and the velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, were sufficiently abundant so that 40 eggs were available from each plot. Egg samples were predominately *A. gemmatalis*. The eggs were dissected,

[4] Based on the morphological characteristics of the genitalia, the *Trichogramma* colony used for the study fits the description of *T. achaea* as described by Nagaraja and Nagarkatti (1969). This colony (obtained from India) had earlier been accidentally mixed with the *T. evanescens* Westwood used in our previous studies of kairomones, and a loss of the *T. evanescens* colony resulted. Our colony of *T. achaeae* are quite responsive to tricosane. However, since some interchange of genetic material with *T. evanescens* may have occurred, this response is not necessarily representative of the species.

and the percent parasitization in each plot was determined. The parasitization in the treated plots (78%) was significantly higher than in the control plots (58%).

Experiment 3

This experiment and the subsequent experiment were conducted to determine whether the kairomone could be used to increase parasitization by wild *Trichogramma* spp. This appraisal was made in crimson clover. 10 pairs of plots 3.5 × 3.5 m were selected. One of each pair was sprayed with tricosane at a rate of 2965 mg/hectare. 75 eggs were placed in each plot and re-collected after a 24-hr exposure. The parasitization, all the result of naturally occurring *Trichogramma* spp., was significantly higher in the treated plots (14%) than in the control plots (4%).

Experiment 4

The influence of kairomones on parasitization rates of wild parasites on a larger scale was appraised. The study was conducted in a 2.83-hectare soybean field. 8 plots, 15.2 × 38.6 m with 7.6 m between the plots, were selected in a linear pattern across the field. Every second plot was sprayed with a hexane eluate of moth scale extract [this eluate was obtained as described by Jones et al. (1973) and was used in this experiment because a preliminary test indicated that the wild *Trichogramma* in this field were not very responsive to tricosane]. 10 subsample plots consisting of 1 row 3.5 m long were selected in each plot. 40 *H. zea* eggs were placed on each subsample plot, left for 24 h, then re-collected on the first and fifth days after treatment. The mean parasitization for both days was significantly higher in the treated plots (22%) than in the control plots (13%). Assessments of parasitization were not made on the second, third, and fourth days because of adverse weather conditions. There was a long and heavy rain on the second day. Also, there was brief, moderate rainfall ca. 1 hr after treatment and before the first day's evaluation. These data demonstrate that the kairomone treatment is durable and lasts for at least 5 days.

DISCUSSION

The results demonstrate that kairomones can be used, by applying them on the plant surfaces of crops, to increase the rate of parasitization by released or wild *Trichogramma* populations. Increased parasitization resulted for both natural and artificially applied host eggs. These results are highly

encouraging because they are evidence that kairomones offer a variety of possible uses in pest management, both with naturally occurring and released parasites.

Since the distribution of the kairomones does not have to be limited to the immediate vicinity of the host eggs, but functions to increase parasitization when applied in a complete coverage pattern throughout the target area, the possible uses of the materials are enhanced. This fact also indicates that the kairomones function primarily as a releaser to elicit a more intensified search pattern in the areas where they occur rather than as a guidance trail directing the parasite to the egg.

The factor(s) causing the higher rates of parasitization and the various interrelated behavioral patterns could have an important bearing on their utility. Studies on this subject are presently underway and results of these studies will be presented in subsequent reports of this series.

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