BEHAVIORAL MANIPULATION OF TRICHOGRAMMA (HYMENOPTERA: TRICHOGRAMMATIDAE)[1]

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ABSTRACT

The enhancement of host-seeking behaviors by entomophagous species provides at least a partial key to their successful employment against primary lepidopterous crop pests. During 1981 and 1982, a behavior--manipulation formulation that consisted of eggs, excretions, and scales of *Heliothis zea* (Boddie) moths and an extract of foliage of *Amaranthus* spp. plants were evaluated against aerially released *Trichogramma pretiosum* Riley in field plots of cotton near Portland, AR, as part of an ARS, USDA pilot test of *Trichogramma* production and release technology. The formulation increased parasitization of *Heliothis* spp. eggs by *T. pretiosum* significantly during peak density periods of *H. zea* moths. However, during periods of low moth activity, parasitization remained less than 10% in both fields that received the formulation and those that did not, despite biweekly releases of 100-125 thousand *Trichogramma pretiosum*/ha. These results indicate that a vital odor-mediated behavioral interaction exists between *T. pretiosum* and *H. zea*. The suspected mediator is the sex pheromone and/or other volatiles produced by *H. zea* moths.

INTRODUCTION

Trichogramma spp. are the most widely augmented entomophagous insects in the world today (King et al. 1984), including releases on an estimated 200,000 ha annually in the United States (Ridgway et al. 1981). Despite this extensive usage, experimental demonstration of economic levels of pest control by *Trichogramma* are very limited (Stinner 1977). Poor retention of released parasitoids in the target area and inefficient host-searching behavior have been cited among the possible reasons for the poor performance by *Trichogramma* (Beevers et al. 1981). Applications of the proper amount and distribution of host eggs and/or semiochemicals from host insects and plants have been shown to increase parasitization by *Trichogramma* significantly in greenhouse and small field plot studies (Lewis et al. 1975, Altieri et al. 1981, Nordlund et al. 1984, Gross et al. 1985).

The influence of these materials on rates of *Trichogramma* parasitization of *H. zea* and *H. virescens* (F.) eggs was evaluated in large field plots of cotton as a component of the ARS, USDA pilot project: "Management of *Heliothis* spp. in Cotton by Augmentative Releases of *Trichogramma*." Application and assessment of this component of the project was scheduled

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[1] Mention of a commercial or proprietary product does not constitute an endorsement by the USDA.

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for the 1981 and 1982 seasons. However, during 1982, early season treatments with conventional pesticides, particularly for the boll weevil, Anthonomus grandis Boheman, prevented a 2nd yr assessment of this project component. This report, therefore, is limited to data collected in the 1981 season.

MATERIALS AND METHODS

Beginning in late June, 1981, aerial releases of T. pretiosum were made one or two times/wk in six different fields in the Mississippi River Delta near Portland, AR. The effectiveness of T. pretiosum for the management of Heliothis spp. was compared with conventional management procedures and is the subject of other reports appearing simultaneously in this journal issue.

Three fields (no. 4, 5, and 6), which ranged in size from 15-25 ha, were selected for evaluation of the behavior-manipulation formulation. The formulation, designed to increase retention and host searching efficiency of Trichogramma, was applied on a 6-ha portion of each of the three fields at weekly intervals. Applications were made during the afternoons prior to a morning Trichogramma release.

The behavior-manipulation formulation consisted of the following: H. zea eggs collected and processed according to Burton (1969); H. zea scales collected from a vacuum assembly at the moth handling site of our laboratory's routine rearing program (Harrell and Perkins 1971); diatomaceous earth particles impregnated with both an ethyl acetate extract of moth excretions (Lewis et al. 1979, Lewis et al. 1982); and a hexane extract of tender foliage portions of Amaranthus spp. plants (Altieri et al. 1981, Nordlund et al. 1981). These moth scales, eggs, and impregnated particles were suspended together in a solution of Minidrift (Soil Service, Inc., Salinas, CA) and applied from a 757-l capacity Nicholson Hydra-Trac® high clearance sprayer that employed a centrifugal pump and boom mounted solenoid-controlled nozzles, which allowed the operator to spray up to 18 rows simultaneously (Gross et al. 1981). With this system, varying combinations and densities of the component package could be applied on large fields by varying the quantities of the individual ingredients. However, for this study, only one rate combination, ten scales, five eggs, and ten impregnated particles/row meter was applied. To enable distinction from natural eggs, the applied eggs were dyed with a rocket red shade of daylight fluorescent pigment (Day-Glo Corp., Cleveland, OH) prior to application. The eggs were dyed by passing them through a mist of the pigment sprayed in a solution of acetone from a chromatograph sprayer. The eggs were recycled through the mist until adequate coloration was obtained.

Applications of the formulation were made weekly beginning July 7 and continuing through August 10, except the wk of July 20 when a combination of weather and mechanical difficulties prevented application. The presence of irrigation pipes in field 5 and treatment for the boll weevil in field 6 during the wk of August 10, prevented formulation application and monitoring, respectively. Results from routine monitoring of Trichogramma parasitization by collection of naturally occurring Heliothis spp. eggs and a sampling of other beneficial insect populations are presented in the companion reports in this issue. However, to more thoroughly assess the influence of the formulation on rates of parasitization by T. pretiosum, 30-40 H. zea eggs were applied artificially according to the procedure of Nordlund et al. (1974), (1/leaf) with a camel-hair brush on marked leaves spaced at ca. 0.9-m intervals at four different locations in each of the treated and untreated portions of the three fields. To simulate natural oviposition and to enhance rates of parasitization, the substrate leaf surfaces around the applied eggs were spotsprayed with a moth scale extract as described by Lewis et al. (1972). Assessments of the level of parasitization were made for 2-3 days immediately following application of the component formulations and associated *T. pretiosum* releases. The collected eggs were examined under microscopy for parasitization by rupturing them between a glass slide and over slip. The paired *t*-test was used to test for differences in parasitization rates between the treated and control areas.

RESULTS

Figure 1 presents the overall % parasitization of the artificially applied *H. zea* eggs in the three fields during 24-h exposure periods for each evaluation date. Two peaks of parasitization appear in Figure 1, and the times of the two peaks are similar to that of naturally oviposited eggs collected from all six *Trichogramma* release fields (King et al. 1984). The report by King et al. (1984) indicated an additional minor peak occurred on July 20; however, these data were from only 23 eggs collected from all six fields. A collection of naturally oviposited eggs was made in this study from fields 5 and 6 on August 11, 13, and 15 to supplement the data from eggs applied artificially. The parasitization rates of these natural eggs and results from eggs applied artificially on those dates followed essentially parallel paths as shown in Fig. 1. The peaks in parasitization by *T. pretiosum* correspond almost exactly with the peaks in *Heliothis* moth ovipositional activity, which also are shown in Fig. 1.

Perhaps the most significant aspect of the findings depicted in Fig. 1 is that parasitization was very low except during periods of peak moth activity. These low rates of parasitization persisted despite sustained releases of 100-125,000 adult *T. pretiosum*/ha on the indicated dates in both the treated and control portions of all three fields.

The very low rates of parasitization observed on most sampling dates possibly prevented the detection of effects of the behavior-manipulation formulation. However, during periods of peak moth activity, an effect was obvious (Table 1). The data from July 8-9 provided a good basis for detailed comparison of parasitization rates in the untreated portions of the fields and those portions receiving the behavior-manipulation formulation. The rates of parasitization were significantly higher throughout the treated portions of all three fields for both dates (mean T = 18.25, mean C = 8.97). The reason for the strong drop in parasitization in field 6 on July 9 is not understood. The accumulated rates of parasitization of natural eggs during their full exposure period reached well over 50% on these dates.

DISCUSSION

During periods of peak *Heliothis* spp. moth activity, as indicated by both moth traps and egg counts (Hartstack et al. 1983), the behavior-manipulation formulation increased the rates of parasitization by *T. pretiosum* significantly. However, during periods of low moth activity, parasitization was very low in both treated and control portions of the fields (generally less than 10%). This higher parasitization obtained during the peaks of moth activity cannot be attributed only to the increased egg density during these periods, since during low moth activity the application of five host eggs/0.3 m in the treated portions of the field did not increase parasitization.

These results indicate that a vital behavioral interaction between the *T. pretiosum* and its hosts is mediated in some manner by factors associated with high moth activity. This effect can be at least partially accounted

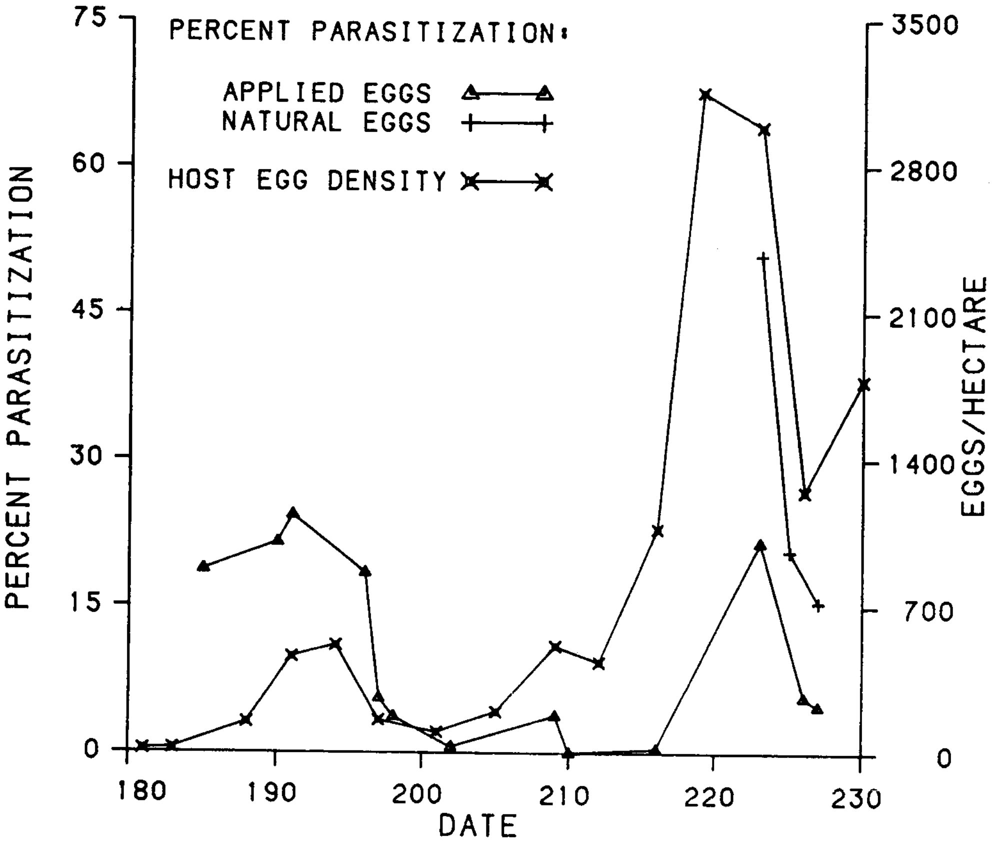

FIG. 1. Percent parasitization by <u>Trichogramma</u> spp. on indicated dates (Julian calendar) as related to egg densities of <u>Heliothis</u> spp.

for by the response of *T. pretiosum* to components of the sex pheromone and other volatile kairomones produced by *H. zea* moths (Lewis et al. 1982), a response subsequently shown in other *Trichogramma* spp. and host interactions (Noldus and Van Lenteren 1985). These sex pheromones and other volatile semiochemicals may be an important link in the behaviors that occur prior to these closerange responses, and are present in adequate amounts only during mating and ovipositional activities during the early part of the generation peaks. This relationship would explain why the applied behavior-manipulation formulation alone, which consisted of host eggs and other close range or contact cues, was ineffective in enhancing the host-seeking of *T. pretiosum* during low moth activity periods.

The data indicate that consideration of behavioral interactions is essential to effective performance of released *T. pretiosum*. In fact, it appears that direct behavioral manipulation, including the more recently discovered volatile mediators will be necessary during periods of low host populations.

Studies are underway to elucidate further the mediating factors and approaches for their utilization to enhance *Trichogramma* performance.

TABLE 1. Parasitization by *Trichogramma* of *H. zea* Eggs Applied Artificially in Behavioral Manipulation Treated *vs*. Untreated Fields (Host-Eggs Exposed 24 h).[a]

Replications	July 8		July 9	
	T	U	T	U
		Field 4		
1	27.2	8.0	36.8	28.6
2	22.2	0.0	40.8	4.2
3	26.9	3.7	23.8	11.1
4	18.5	12.5	23.5	38.1
		Field 5		
1	4.2	3.8	4.8	0.0
2	27.6	0.0	35.0	7.1
3	3.8	15.4	11.1	0.0
4	14.8	11.1	21.7	0.0
		Field 6		
1	29.2	25.9	0.0	15.8
2	20.8	10.7	0.0	0.0
3	10.0	5.6	5.3	0.0
4	24.1	13.8	5.9	0.0
Mean [b]	T = 18.25a		U = 8.97b	

[a] Based on a recovery of 90-140 eggs/field/date.

[b] Means significantly different ($P = 0.05$) as determined by paired *t*-test.

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