Attraction, Mating, and Oviposition Behavior in Field Populations of *Diaprepes abbreviatus*[1] on Citrus[2]

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ABSTRACT

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In a field bioassay, significantly more male and female *Diaprepes abbreviatus* (L.) weevils congregated on trees which had been exposed overnight to weevils of the opposite sex compared with numbers on check trees and trees exposed to weevils of the same sex. The number of weevils of the opposite sex per treated tree increased from 0900 h until midafternoon, whereas the number of weevils present on trees exposed to weevils of the same sex and on check trees remained constant (from 0900 to 1600 h). Mating and oviposition were found to be primarily diurnal and nocturnal functions, respectively. The number of mating pairs in a sample at 1400 to 1600 h was significantly greater than that in an 0900 to 1100 h sample or an 1800 to 2000 h sample of a field population. More than 80% of 10,090 eggs were oviposited between 2000 and 0600 h on foliage in a field cage.

Diaprepes abbreviatus (L.), an exotic root weevil, is present on 2,000 ha of citrus in central Florida. There are 324,000 ha of citrus and 120,000 ha of sugarcane in the state and in other areas of the nation that could support populations of *D. abbreviatus,* which is already a major pest of sugarcane, citrus, and certain vegetable crops in Puerto Rico. The weevil was first found in Florida in 1964, and because of the threat to agriculture, the U.S. Department of Agriculture (USDA) began to conduct research and weevil population suppression programs. Basic information concerning the reproductive biology of the weevil is needed for development of pheromones for survey purposes and to evaluate promising population suppression methods. Studies on the biology of *D. abbreviatus* were conducted by Wolcott (1922) in Puerto Rico, and its population dynamics under Florida conditions were reported by Beavers and Selhime (1975). Its reproductive behavior has not been examined. Studies were therefore conducted from 1976 through 1978 at the U.S. Horticultural Research Laboratory, Agricultural Research, Science and Education Administration (AR, SEA), USDA, Orlando, Fla., to elucidate some of the factors affecting attraction, mating, and oviposition. The results are reported here.

Materials and Methods

Weevils were obtained as adults from infested areas in central Florida. The insects were separated by sex, using morphological differences, and then held in cages containing citrus foliage in the laboratory. *D. abbreviatus* is a large weevil (average weight 230 mg, length 2 cm) that has limited flight, moves slowly, and can be maintained in the laboratory at 27°C as an adult for more than 6 months. Insects were difficult to obtain in quantity, and the weevils used for behavioral studies were the result of daily field collections. Therefore, age was variable, and female weevils were probably mated before collection. Reproductive status of females in the field-collected colony was determined by examination of the spermathecae of 126 female adults not engaged in copulation. The July, August, and September field sample consisted of 435 female weevils, of which 309 were collected with males as mating pairs.

Attraction

Each bioassay required 2 days. Day 1 was as follows. In the morning (0800 h), 100 weevils, all of one sex, were placed in a 2.5-m^3 field cage located 100 m from the laboratory adjacent to a citrus grove. At 1600 h, 50 weevils, again all of one sex, were placed in a small cage that contained a potted Calamondin, *Citrus reticulata* Blanco var. *austera* Swingle × *Fortunella* sp. 1.5 m high. This cage was located in a screenhouse 100 m from the field cage. The weevils remained in the cage with the tree until 0800 h the next day. Day 2 was as follows. At 0800 h, all weevils were removed from the tree in the small cage, and then this tree and a check tree (unexposed) were placed in the 2.5-m^3 field cage that contained the 100 weevils. One hour after the trees were placed in the field cage and every hour thereafter, the number of weevils on the check and treated trees was determined. Weevils in the cage or on the trees were not disturbed until the attraction bioassay was terminated after eight counts were made (1600 h).

Mating

For collection of adult weevils, citrus trees with new growth and with weevil feeding damage were located, and the adults were collected by hand. In this study, the field collection day was divided into three time periods, i.e., morning (0900 to 1100 h), afternoon (1400 to 1600 h), and evening (1800 to 2000 h), and the frequency distribution for single males, single females, and mating pairs was determined. The observations were made in June, July,

[1] Coleoptera: Curculionidae.

[2] Received for publication 26 September 1980.

August, and September, when adults were abundant.

Oviposition

One hundred field-collected weevils (sex ratio 50:50) were placed in a 1-m³ field cage. Citrus foliage in the cage was replaced daily at 0600 and 1800 h, and the number of eggs on the foliage and the size of the egg mass were recorded. The data were collected for 8 consecutive days in August.

Results

Attraction experiments presented here were undertaken after preliminary studies failed to indicate insect-to-insect attraction via airborne chemical messengers. One must bear in mind, however, that these behavioral studies were performed on mated females of variable ages. (An estimated 97.5% of females entering behavior studies had sperm present in the spermathecae).

In these experiments, the mean number of weevils per tree (eight counts) was significantly higher when the tree was exposed to the opposite sex before the bioassay in the field cage (Table 1). When the treated tree was exposed to weevils of the same sex as those in the field cage, the mean number of weevils on the treated and check tree was not significantly different. The 1976 and 1978 results were similar. Since weevils were not removed from the trees after each count, weevil numbers increased on trees that had been exposed to the opposite sex (Fig. 1) until 1300 to 1400 h, when weevils began leaving the trees. The number of weevils on check trees and trees exposed to weevils of the same sex as those in the field cage did not increase significantly from the 0900 to 1600 h count, an indication that weevil activity was constant during the observation period. These data lead one to speculate that a pheromone was deposited on the plant that caused weevils of the opposite sex to increase their contact with the tree. This hypothetical pheromone had no apparent attractive or repellant effect on weevils of the same sex.

The number of mating pairs in the 1400 to 1600 h time period was significantly higher than in the morning (0900 to 1100 h) or evening (1800 to 2000 h) (Table 2). The effect was probably cumulative, since male and female weevils stay in copula for several hours. The number of mating pairs in the evening sample was significantly lower than in the 0900 to 1100 or 1400 to 1600 h sample, an indication of the end of the field mating period. Mating is apparently a diurnal behavioral phenomenon.

More than 80% of the 10,090 eggs recovered was from foliage present in the cage for the 12-h period that extended from 1800 to 0600 h (Table 3). Oviposition of an egg mass (80+ eggs) requires more than 1 h and is apparently a nocturnal behavioral phenomenon. The size of each mass was variable (range, 34 to 146 eggs).

Discussion

The role of semiochemicals in mating and aggregation has been established for a large number of insects (Shorey 1976). Many chemicals identified as insect sex or aggregation pheromones have proven to be useful tools for population survey or control. It was determined for *D. abbreviatus* that a pheromone which attracts only weevils of the opposite sex was deposited on the host plant by adult weevils. At least one other instance of a similar attraction scheme (male → female, female → male) in the Curculionidae has been described (Hedin et al. 1979).

A major drawback in establishing attraction in this insect has been the lack of a continuous supply of insects and the apparent lack of insect-to-insect attraction. Additional insect behavioral studies are planned to determine how the attractant is deposited and when the event occurs. This study to determine presence of a semiochemical and to delineate oviposition and mating periods for field weevil populations was the initial step to demonstrate existence of the pheromone.

Acknowledgment

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Table 1.—Responses of adult *D. abbreviatus* to potted citrus trees (1.5 m high) exposed to weevils of the indicated sex compared with that of weevils to an untreated check on a 2.5-m³ field cage located adjacent to a citrus grove, Plymouth, Fla.

Year	Sex released[a]	2-Day bioassay (n)	Source of attraction[b]	$\bar{x}$ no. of weevils/tree per h	
				Check	Treated
1976	♂	5	♂	4.3	6.5
	♂	5	♀	3.9	12.5[c]
	♀	5	♂	4.6	9.9[c]
	♀	5	♀	3.0	2.0
1978	♂	2	♂	2.4	2.3
	♂	3	♀	2.3	7.9[c]
	♀	2	♂	2.7	10.4[c]
	♀	2	♀	2.3	2.3

[a] 100 weevils per replicate.
[b] 50 weevils per tree before bioassay.
[c] Significant increase from the untreated check ($P = 0.05$) by t test.

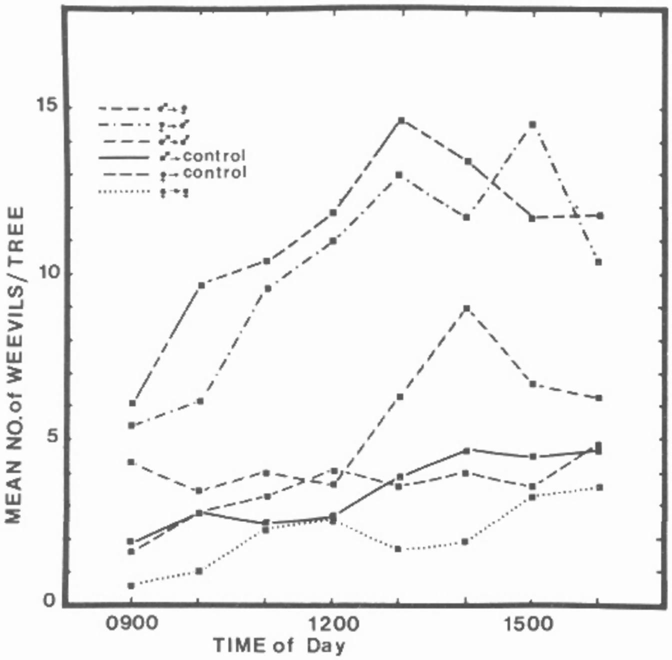

FIG. 1.—Mean number of *D. abbreviatus* per citrus tree when trees were exposed to weevils of same sex and of opposite sex, and an unexposed check before placement in field bioassay cage. Plymouth, Fla., 1976 through 1978.

Table 2.—Frequency distribution of single and paired weevils in a field population of *D. abbreviatus*, Plymouth, Fla., 1976

	Sample		Frequency distribution[a] (%)		
Time (h)	No. of weevils	Month	♂	♀	♂♀
0900–1100	570	June–July	35	22	42a
1400–1600	653	June–July	25	11	63b
1800–2000	524	June–September	37	32	31c

[a]Numbers not followed by the same letter are significantly different ($P = 0.05$) by Duncan's multiple range test.

Table 3.—Total number of *D. abbreviatus* eggs collected from a field cage containing 50 ♀♀ and 50 ♂♂ when the oviposition substrate was changed at 0600 and 1800 h, Plymouth, Fla., August 1976

	Total no. of eggs[a] collected on day:								$\bar{x}$ no. of
Time (h)	1	2	3	4	5	6	7	8	eggs/mass
0600–1800	199a	68a	33a	232a	86a	292a	744a	81a	72 ± 12.7a
1800–0600	703b	190a	1,158b	1,738b	1,268b	653b	1,659b	886b	89 ± 8.5a

[a]Numbers followed by the same letter are not significantly different ($P = 0.05$) by Duncan's multiple range test.

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Effect of Weed Covers on *En*
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Centro Internacional de Ag

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Field studies were conduc
covers on *Empoasca kraem*
vulgaris L., yields. Live sta
not have a significant effect
tochloa filiformis (Lam.) Be
This effect decreased when t
obtained with a mixture of
nymphal and adult populatio
Pure stands of *L. filiformis*
than *E. indica*. Yields of th
weed covers in unprotecte
treated weeds increased yi
susceptible variety than *L.*
leafhopper tolerant variety
or plant species with econ
beans, is suggested.

Common bean, *Phaseolus vulgaris*
in Latin America has increased by o
year over the last decade (Sander
1978). Pests and diseases are the ma
duction factors. *Empoasca kraemeri* F
is the most important insect pest; t
cause yield losses of up to 97% (Sc
Cardona 1980).

The most promising strategy in th
kraemeri is a combination of varieta
cultural practices, one of which cou
weed covers to regulate leafhopper p
rin and Phillips (1978) and Altieri
(1979) studied the interrelationship
and insects in different crops or nat
the ecological role of weeds within a
management system.

Different theories exist as to w
affect the population dynamics of in
cropping systems. Several authors,
ainen and Root (1972), Root (197
and Moody (1976), suggested that
ical, and microclimatic structure o
causes a "resistance by associatio
herbivorous pressure. In a comple
or habitat, the chemical stimulus r
attraction of a particular insect pe
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number of aphids and other pest
plots with weeds than in weed
(1973) claims that plant species
tural system lose this "resistance

Border planting of nonhost p
insect can also reduce colonizat

[1] Homoptera: Cicadellidae.

[2] Received for publication 2 October 1980.