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The Florida Entomologist, Vol. 66, No. 2. (Jun., 1983), pp. 215-222.

Stable URL:
http://links.jstor.org/sici?sici=0015-4040%28198306%2966%3A2%3C215%3APONLOD%3E2.0.CO%3B2-E

The Florida Entomologist is currently published by Florida Entomological Society.

PREDATION ON NEONATE LARVAE OF *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE) IN FLORIDA AND PUERTO RICO CITRUS GROVES

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ABSTRACT

Predation by ants on neonate (1st instar) larvae of *Diaprepes abbreviatus* (L.) on the soil surface in citrus groves was less in the afternoon (1200-1530 EST) in Florida (average 9.6% in 2 groves) compared with previously reported evening through morning periods (average 47% for 1 grove). Predation averaged 6.0% at Isabela, Puerto Rico from morning through afternoon and 1.5% at Adjuntas, Puerto Rico in the afternoon (1200-1600 PM AST). Researchers at the U.S. Dept. of Agriculture ARS Lab at Plymouth, FL have shown that most larvae drop from the trees and burrow into the ground from 1200-2000. It is thus concluded that in contrast to the findings of earlier researchers, surface predation by ants is probably much less important than other mortality factors, such as egg predators, subterranean ants and nematodes, and climatic conditions.

RESUMEN

La rapacidad de las hormigas sobre las larvas neonatas (1° instar) de *Diaprepes abbreviatus* (L.) en la superficie del suelo en los naranjales fue menos por la tarde (1200-1530 EST) en Florida (promedio de 9.6% en 2 naranjales) en comparasión con los períodos que se extendían de la tarde hasta la mañana, los cuales fueron reportados previamente (promedio de 47% para 1 naranjal). El promedio de la rapacidad desde la manana hasta la tarde (1200-1600 PM AST) fue 1.5%. Los investigadores del laboratorio del U.S. Department of Agriculture en Plymouth, FL han mostrado que la mayoría de las larvas caen de los arboles y entran en el suelo desde las 1200 hasta 2000 h. Se concluyen que, en contraste a lo que se han informado los investigadores anteriores, la rapacidad por las hormigas de la superficie probablemente es menos importante que otros factores de la mortalidad, tales como los predadores de los huevos, las hormigas subterraneas, los nematodos, y las condiciones climaticas.

The sugarcane rootstalk borer, *Diaprepes abbreviatus* (L.), poses a serious threat to citrus, foliage, and possibly sugarcane industries in Florida. The weevil was apparently introduced from Puerto Rico to the area around Apopka in 1964 (Woodruff 1964). Its range has since expanded within Florida (Woodruff 1968).

D. abbreviatus adults feed on foliage of citrus, mango, and many other plants. After mating, the females deposit their eggs between host plant leaves glued together with an adhesive produced by the female. The eggs hatch almost exactly in 7 days and the larvae drop to the surface of the ground and burrow into the roots of the host plant (Woodruff 1968, Whitcomb et al. 1982).

Studies of the predation on *D. abbreviatus* by arthropods have been

made for the eggs (Richman et al. unpublished data) and larvae (Whitcomb et al. 1982, Tryon and Whitcomb unpublished data). Immature stages seem to be most vulnerable to attack, although adults have been occasionally preyed on in Puerto Rico by lizards (Wolcott 1924) and birds (Wetmore 1916, Whitcomb et al., personal observations), and in Florida by spiders (Gowan and Whitcomb, personal observations) and snakes (Gowan, personal observations). The predation data of Whitcomb et al. (1982) were taken mostly in the late afternoon to early morning because the exact time the weevil larvae left the egg masses was unknown. They report very high rates for larvae artificially placed in orchards at night and in the early morning.

Recent work by Jones and Schroeder (1983) indicates that the larvae actually drop to the soil surface between 1200 and 2400 EST. The number of larvae dropping decreased considerably by 2000 EST and ended completely by midnight. Whitcomb et al. (1982) found little predation at 1100 and 1400 EST at Forest City, FL. They found high predation at the same site at 1700 and 2300 EST (40%+) and very high predation (62%) at 0600 EST. Jones and Schroeder (1983) have shown in laboratory experiments that most larvae burrow into the soil within 3 h of dropping. Thus it appears that neonate larvae may be escaping many of the natural surface predators. To test this hypothesis further, data on the importance of predators during the afternoon was collected in Florida during the summer of 1981 and in Puerto Rico in May 1982.

Materials and Methods

Two citrus groves within the quarantine area for *D. abbreviatus*, in Florida were chosen for comparative observations. They each had trees with uniform canopies that had not been heavily frost damaged and had a diverse arthropod fauna. These groves were at Forest City, Seminole Co., and Lockhart, Orange Co. Weevil larvae were obtained from the U.S. Department of Agriculture ARS Laboratory at Plymouth. Initially 50 larvae were placed in plastic petri dishes (Whitcomb et al. 1982) and starting at 1200-1230 EST 2 dishes were placed on the ground beneath each of 3 arbitrarily selected trees within the grove. An observer at each tree watched the larvae constantly for a 20-minute period. Dishes with fresh larvae were then placed under new trees after each 20-minute period. This was repeated so that a total of 1 h of observations per observer was completed for each series. A second set of observations was conducted starting at 1400-1430 and continued to 1500-1530. A total of 1800 larvae were observed per day under this system. This method was used during July 1981.

After late July there were 2 observers. Also, since plain petri dishes did not simulate natural surfaces enough to keep the larvae from escaping completely during hot afternoons, petri dishes filled with a mixture of plaster of Paris and sterile soil were used. In this case 6, 1-h observation periods were conducted in each grove for a total of 24 h of observation on 7200 larvae. No attempt was made to keep larvae from leaving the dishes. However, they were more likely to remain within the dish than when unaltered dishes were used. Predation was recorded by direct visual observation of each event. Samples of each species of predator observed were taken to the laboratory for identification. Direct visual observation was used in this study because early attempts to check observation after 20 minutes

gave less accurate predation rates and allowed larvae to escape at a much higher rate (50% or more than plain dishes were used) during the hot afternoon periods than was observed by Whitcomb et al. (1982) during the evening and morning. Observations utilizing this method were made from 31 August to 2 October 1981.

Weevils were present at Forest City from June through October and field-caught females were mating and laying eggs at the U.S. Department of Agriculture ARS Lab at Plymouth, during this time. Temperature, relative humidity, cloud cover and general conditions were recorded at the beginning and end of each hour period. The observations were made from 1200-1330 and from 1400-1530 EST in Florida. The Florida groves were sprayed with ethion and oil during the summer and fall and dicofol for mites at various times. The Forest City grove also had been treated with heptachlor as recently as 1975 and with benomyl, wettable sulphur and malation prior to 1980. Both Florida groves had a high population of ants and spiders on the surface of the soil. The weather at Forest City and Lockhart was quite variable during the afternoon, but the temperature was often above 30°C and the relative humidity was 60% or higher.

Observations in Puerto Rico were based on the same technique, except that 3 observers with 1 dish each were utilized and observations were conducted in the morning, at night and in the afternoon, for comparison with earlier work in Florida. A total of 7.5 h of observations (3 observers, 2.5 h of observation each) from 1200 to 1520 AST were made at Adjuntas on 28 May 1982. At Isabela a total of 20 h of observation (3 observers, 6.7 h of observation each) was conducted, with a total of 15 h in the morning (0700-1020 AST), 3 h in the afternoon (1340-1500 AST), and 2 h at night (1940-2030 AST). Night and afternoon observations were difficult because of heavy rain during this period (27-29 May 1982). Weevils were present both at Isabela and Adjuntas and at Isabela they were so numerous that they had defoliated several papayas near the citrus grove. Larvae were obtained from the U. S. Dept. of Agriculture Laboratory in Mayagüez. The source for their laboratory population was the Isabela infestation. At Isabela and Adjuntas malathion, dicofol, and methomyl were applied once a year or when pests built up. Insects and spiders were quite abundant at all locations in Puerto Rico.

Both Isabela and Adjuntas had high humidity and temperatures near 25°C or slightly higher during the afternoon, cooling to no lower than 20°C at night. Heavy rains fell in Puerto Rico during the late May observations, whereas conditions were unusually dry in Florida during summer and early fall 1981.

Surveys of surface ants were conducted at Forest City on 9 September 1982 and at Isabela on 29 May 1982 with tuna fish placed around flags at 20 stations within the groves. The stations were arranged in two crossing lines of 10 stations each. After a half hour the baits were checked and ant samples collected with an aspirator. The ants were then placed in alcohol and transported to Gainesville, FL for identification.

Results and Discussion

The dominant predators found in all of the groves were ants (Table 1) and these accounted for 99% of the predation. The major ant species in-

volved were *Tetramorium simillimum* Roger, *Pheidole dentata* Mayr, *P. floridana* Emery, and *Paratrechina bourbonica* (Forel) in Florida (Table 1) and *Pheidole fallax antillensis* Forel, *T. bicarinatum* (Nylander), and *Pheidole subarmata borenquensis* Wheeler in Puerto Rico (Table 2). *P. fallax antillensis* was by far the most important of the predators at Isabela, accounting for 88.4% of the 215 predation events observed. The Florida list varies from that of Whitcomb et al. (1982) only in the order of importance of a few species and in rates of predation.

The only non-ant predators observed were an earwig, *Labidura riparia* (Pallas) (Dermaptera: Labiduridae) and a jumping spider, *Corythalia canosa* (Walckenaer) (Araneae: Salticidae). All the Puerto Rican predation records were for ants. The predation rate was much lower at Lockhart than at Forest City, with the Puerto Rican groves being closer to Lockhart for afternoon periods (Forest City 17.1%, Isabela 6.2%, Adjuntas 3.7%, Lockhart 2.1%). Whitcomb et al. (1982) found that an average of 47% of the larvae were consumed by predators at Forest City from 1700 to 0600 EST, with 62% being consumed in the early morning. At Isabela, Puerto Rico, 8.4% of the larvae (total 2250) that were placed out in the morning were consumed and 0.0% of the larvae (total 300) placed out at night were consumed. At night the ground, grass and trees were very wet and droplets of water were everywhere. The arboreal ant *Camponotus ustus* Forel was quite active at night on the trunks of citrus on 27 May, but surface ant activity was very low.

Predation by ants in the Florida groves varied from 53% during a 20-min period at Forest City (15 Sept. 1981, 1430-1450 EST, cloudy and 32°C with 60% RH) to 0 at Lockhart on several occasions during the study. This was most pronounced on 2 Oct. 1981 with 7 20-min observations of 0 under

TABLE 1. MEAN TOTAL PREDATION EVENTS FOR 3 OBSERVATION DAYS OF *Diaprepes abbreviatus* NEONATE LARVAE[1] AT FOREST CITY AND LOCKHART, FL, DURING THE AFTERNOON (1200-1530 EST, BETWEEN 31 AUGUST-3 OCTOBER 1981).

Predator species	Observed predation events per 2 h observation/day (1200 larvae)			
	Forest City		Lockhart	
	$\bar{X}$	SE	$\bar{X}$	SE
Tetramorium simillimum Roger	69.3	39.9	2.0	1.4
Pheidole floridana Emery	59.7	18.6	4.3	5.4
Pheidole dentata Mayr	58.3	41.0	0.7	0.9
Paratrechina bourbonica (Forel)	5.3	6.8	14.0	0.3
Pheidole moerens Wheeler	3.7	4.5	2.0	2.8
Conomyrma flavopecta (M. R. Smith)	3.7	2.6	0.0	0.0
Labidura riparia (Pallas)	2.0	1.6	0.0	0.0
Pheidole dentigula M. R. Smith	0.7	0.9	0.0	0.0
Brachymyrmex obscurior Forel	1.0	1.4	0.3	0.5
Pheidole morrisi Forel	0.0	0.0	0.3	0.5
Corythalia canosa (Walckenaer)	0.0	0.0	0.3	0.5
Total	203.7		23.9	

TABLE 2. TOTAL PREDATION EVENTS ON *Diaprepes abbreviatus* NEONATE LARVAE FOR MORNING, AFTERNOON AND NIGHT PERIODS AT ISABELA AND AFTERNOON PERIODS AT ADJUNTAS, PUERTO RICO IN LATE MAY, 1982. CORRECTED FOR 2 H/DAY (FOR 900 LARVAE).

Predator species	Isabela			Adjuntas
	Morning	Afternoon	Night[1]	(Afternoon)
Pheidole fallax antillensis Forel	25.3	27.0	0.0	6.8
Pheidole subarmata borenquensis Wheeler	0.4	0.0	0.0	2.6
Tetramorium bicarinatum (Nylander)	0.5	0.0	0.0	2.6
Cardiocondyla nuda (Mayr)	1.3	1.0	0.0	0.0
Camponotus ustus Forel	0.9	0.0	0.0	0.0
Solenopsis geminata (Fab.)	0.0	0.0	0.0	0.0
Hypopenera opaciceps (Mayr)	0.0	0.0	0.0	1.7
Brachymymex obscurior Forel	0.0	0.0	0.0	0.9
Ochaetomyrmex auropunctata (Roger)	0.0	0.0	0.0	1.7
Odontomachus bauri Emery	0.0	0.0	0.0	0.9
Cyphomyrmex rimosus (Spinola)	0.0	0.0	0.0	0.9
Total	28.4	28.0	0.0	18.1

[1]Very wet in grove. Based on only 120 min observation (3 observers 90 min each).

sunny, warm (27°C or higher), and dry (RH ca. 40%) conditions. Although there was some increase of ant activity toward the late afternoon, differences in humidity and cloud cover often masked this effect. Predation was usually higher during cloudy, humid periods than during sunny and dry, or rainy periods at both Forest City and Lockhart. A chi square analysis of differences between early and late afternoon periods at Forest City showed significance at the 0.05 level, with late afternoon having the higher level of predation. A similar analysis among 20-min observation subperiods within each of the 1 h periods and among days of observation also showed some significance, some of the 20-min observation subperiods having significantly higher predation on the same day and/or on different days. Variation among time periods and among days was thus quite high. The Puerto Rican data were not easily compared in this manner.

The major difference between our study at Forest City and that of Whitcomb et al. (1982) is that during part of the time (afternoon) in which many of the larvae of *D. abbreviatus* apparently drop from the trees, the predation rates were less than 1/2 as high as they were in evening to morning (Table 3). For the most part, the same species of predators were involved, but these were less active during the afternoon. Because of the slightly different techniques involved it was not possible to compare these data statistically.

The earlier observations using plain petri dishes are somewhat comparable to the technique employed by Whitcomb et al. (1982), and these

TABLE 3. PERCENT PREDATION OF NEONATE LARVAE OF *Diaprepes abbreviatus* AT FOREST CITY, FL, DURING THE AFTERNOON THROUGH THE MORNING HOURS 1220 TO 1530 (SUMMER AND EARLY FALL 1981) AND 1700 TO 0600 EST (SUMMER AND EARLY FALL 1979).

Predator species	Time period: 1200-1530[1] (% of 3600 larvae)	Time period: 1700-0600[2] (% of ca. 5560 larvae)
Tetramorium simillimum Roger	5.8	9.8
Pheidole floridana Emery	5.0	11.3
Pheidole dentata Mayr	4.9	14.6
Paratrechina bourbonica (Forel)	0.4	3.0
Pheidole moerens Wheeler	0.3	0.9
Conomyrma flavopecta M. R. Smith	0.3	1.8
Labidura riparia (Pallas)	0.2	less than 0.1
Pheidole dentigula M. R. Smith	0.2	0.0
Brachymyrmex obscurior Forel	less than 0.1	0.0
Pheidole morrisi Forel	0.0	3.0
Corythalia canosa (Walckenaer)	0.0	less than 0.1
Solenopsis invicta Buren	0.0	2.3
Paratrechina vividula (Nylander)	0.0	0.4
Total	17.1+	47.1+

[1]Current study.
[2]Converted from data in Whitcomb, Gowan and Buren, 1982.

resulted in a 1.1% predation rate at Forest City for 30 July 1981 (1200 larvae, interrupted by rain).

The observations in Puerto Rico did not produce the expected large number of predation events for night and morning. Because of extreme wet conditions at night, few ants were seen on the surface of the soil. By mid to late morning the soil and grass had dried sufficiently for numerous ants to be active on the soil. A comparison between the soil ants trapped at 20 flagged bait stations at Isabela, Puerto Rico (29 May 1982), and at Forest City, FL (9 Sept. 1982) is shown in Table 4. Only 2 ant species were shared (*Tetramorium bicarinatum* and *Brachymyrmex obscurior* Forel). However, both faunas were characterized by *Pheidole*, *Tetramorium*, and *Solenopsis* species. The Forest City grove contained a very large number of colonies of *Conomyrma flavopecta* (M. R. Smith), and 70% of the bait stations attracted this species. The ant was, however, not an efficient predator of *Diaprepes* larvae and accounted for only 1.8% of the predation events observed at Forest City in the current study and 3.8% of the predation events recorded by Whitcomb et al. (1982). At Isabela *Pheidole fallax antillensis* and *Tetramorium bicarinatum* were attracted to equal numbers of bait stations (65%).

CONCLUSIONS

Since it appears that larvae drop from egg masses in the afternoon and evening (Jones and Schroeder, in press) the data presented in this report indicate that the predation of neonate larvae of *Diaprepes abbreviatus* on

TABLE 4. ANTS ATTRACTED TO SURFACE TUNA FISH BAIT (IN LATE MORNING-EARLY AFTERNOON) AT ISABELA, PUERTO RICO, 29 MAY 1982 AND FOREST CITY FLORIDA, 9 SEPTEMBER 1982.

Ant species	% of baits visited[1]	
	Isabela	Forest City
Pheidole fallax antillensis Forel	65	0
Pheidole subarmata borenquensis Wheeler	30	0
Tetramorium bicarinatum (Nylander)	65	5
Solenopsis geminata (Fab.)	25	0
Brachymyrmex obscurior Forel	15	20
Conomyrma flavopecta (M. R. Smith)	0	70
Pheidole dentata Mayr	0	35
Pheidole floridana Emery	0	30
Tetramorium simillimum Roger	0	10
Solenopsis invicta Buren	0	10
Crematogaster ashmeadi Mayr	0	5

[1]Sums to more than 100% because baits were often visited by more than 1 species.

the soil surface in Florida may not be as important as previously reported for late afternoon through morning (Whitcomb et al. 1982). Soil surface predation was relatively low in the Puerto Rican citrus groves utilized in this study regardless of the time of day. Recent studies on egg predation (Richman, Buren, and Whitcomb, unpublished data) and parasitism and predation on subterranean larvae (Roman and Beavers in press; Beavers, McCoy and Kaplan unpublished data; Klein and Buren unpublished data) indicated that eggs and subterranean larvae may be more vulnerable to attack than freshly dropped larvae on the soil surface. The predators include various ants and the parasites are primarily nematodes. Weather conditions may also cause heavy mortality among neonates falling on dry soil (D. Richman pers. obs.). The egg parasite *Tetrastichus haitensis* Gehan is apparently not an effective control agent (Schroeder and Beavers 1977).

ACKNOWLEDGEMENTS

We would like to thank Drs. William J. Schroeder, J. B. Beavers, and Ira Jones (U.S. Dept. of Agric., ARS Plymouth, FL) for their help. We would also like to thank Drs. Deborah Green and Agripino Perez of the Isabela Agricultural Research Station, University of Puerto Rico, for their help with our work in Puerto Rico. Takuji Hayakawa, Anne Trambarulo, James Trager and Mary K. Elvin of the University of Florida, Dept. of Entomology and Nematology, helped with the field work or analysis of data.

This study was partially supported by P.L. 89-108, Section 406 Grant TAD 124914329 entitled "Control of *Diaprepes* and other root weevils". Florida Agric. Exp. Sta. Journal Series No. 3797.

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VERTICAL AND TEMPORAL ASPECTS OF ALSYNITE® PANEL SAMPLING FOR ADULT *STOMOXYS CALCITRANS* (L.) (DIPTERA: MUSCIDAE)

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ABSTRACT

A 45 cm X 3 m vertical Alsynite® panel coated with Tack Trap® was used to study adult flight behavior of *Stomoxys calcitrans* (L.) at 3 different land use areas in Michigan. Data indicated 2 daily plateaus of stable fly activity at 1000 to 1300 h and 1500 to 1800 h. Ninety-five percent of the total trap catch occurred below 180 cm and between 0800 and 2000 h. More females than males were trapped closer to the ground. The largest number of both male and female flies were captured where equine host activity was greatest.

RESUMEN

Para estudiar el comportamiento de vuelo de adultos de *Stomoxys calcitrans* en Michigan en tres areas donde el uso de la tierra era diferente, se usaron paneles verticales de Alsynite® de 45 cm x 3 m en tomaño cubiertos con Tack Trap.® Los datos indicaron altiplanos diarios de actividad de *S. calcitrans* a las 1000-1300 h y a las 1500-1800 h. Noventa y cinco % de las moscas que se encontraron en las trampas fueron capturadas debajo de 180 cm y entre 0800 y 2000 h. Más cerca del suelo más hembras que machos fueron capturadas. El numero más grande de machos y hembras fue capturadas debajo de 180 cm y entre 0800 y 2000 h. Más cerca del suelo

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