Natural Enemies of Subterranean *Diaprepes abbreviatus* (Coleoptera: Curculionidae) Larvae in Florida[1]

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ABSTRACT A monthly survey of the subterranean natural enemies of *Diaprepes abbreviatus* (L.) larvae was conducted from June 1979 through December 1980 in nine citrus groves and one ornamental nursery in central Florida. Four entomopathogenic fungi, *Metarrhizium anisopliae, Beauveria bassiana, Paecilomyces lilacinus,* and *Aspergillus ochraceous,* and two entomogenous nematodes, *Neoaplectana carpocapsae* Weiser and *Heterorhabditis* sp. Poinar, were found active in the soil and infectious to *D. abbreviatus* larvae throughout the year. Fungus-infected larvae were most prevalent from May through July, whereas nematode parasitism was most predominant from May through November. In addition, a survey conducted in 55 citrus groves throughout Florida in August 1980 and again in February 1981 showed that 27.0 and 45.0%, respectively, had detectable populations of *N. carpocapsae* or *Heterorhabditis* sp., or both species.

Diaprepes abbreviatus (L.), the so-called sugarcane rootstock borer weevil, is a major curculionid pest of citrus and sugarcane in Puerto Rico and the West Indies. A single adult of this curculionid was initially detected on citrus in Orange County, Fla., in 1964. In 1968, a high population was discovered and a quarantine area of ca. 1,000 ha was established (Woodruff 1968). This weevil is a potential threat to the citrus, ornamental, and sugarcane industries in Florida, and its quarantine area currently consists of ca. 35,000 ha in Orange, Seminole, Lake, and Broward Counties. The adult weevils feed on young, succulent foliage of citrus and other host plants and deposit their eggs in masses between mature leaves, which are held together by an adhesive secretion. The larvae drop and burrow into the soil, where they remain for 1 to 2 years (Wolcott 1936) and cause serious root injury to the host plant.

Although regulatory agencies attempted to eradicate this weevil from central Florida with soil and aerially applied insecticides in the early 1970s, today the use of these materials is greatly restricted. Only a specific exemption by the Environmental Protection Agency (EPA) for the use of granular heptachlor as a potting soil amendment for larval control has prevented the ornamental and foliage plant industry within the quarantine areas from incurring serious losses. All plant nurseries within the weevil-infested areas are required to use this treatment to make plant shipments.

Many types of pesticides have been successfully tested as foliar sprays for adult weevils (Wong et al. 1975, Schroeder et al. 1976, and Beavers and Schroeder 1981). Since the adult emergence period in Florida occurs from April through November (Beavers and Selhime 1976), the short residual action and expense of approved chemicals may not justify their use for adult weevil control.

Biological control has been investigated to reduce populations of other developmental stages of *D. abbreviatus*. An exotic hymenopterous egg parasite, *Tetrastichus haitiensis* Gahan, has been introduced from Puerto Rico and successfully established in Florida (Beavers et al. 1980). Also, Buren and Whitcomb (1977) found 1st-instar larvae vulnerable to predation by several species of ants on the soil surface. However, these biotic agents do not appear to account for the weevil population decline in citrus groves with previously high populations.

Therefore, we conducted a study from June 1979 through March 1981 to (1) identify the natural enemies present which attack the subterranean larvae of *D. abbreviatus*, (2) determine the relationship of select environmental factors on the natural enemies, and (3) determine the distribution of the predominant soil-inhabiting, natural enemies in selected citrus groves outside of the known *D. abbreviatus*-infested areas of Florida.

Materials and Methods

Two studies were conducted. In the first, within the *D. abbreviatus*-regulated area of central Florida, nine citrus groves and one ornamental nursery which have had high weevil populations in the past were selected for the natural enemy survey. Three groves were in Lakeland (thermic, coated typic quartzipsamments) and 6 in Blanton (loamy, siliceous, thermic grossarenic paleudults) soil types, the nursery was planted in Everglades (euic, hyperthermic typic medihemists) mucky-peat soil. All sites had been treated previously with chlorinated hydrocarbon soil insecticides during weevil eradication efforts in the early 1970s, but had no chemical treatment during this study.

D. abbreviatus larvae (4 to 6 months old) obtained from artificial diet (Beavers 1982) were placed individually in wire-screen cages (7.5 by 12.5 cm; 324 mesh/cm^2) and buried at 15- and 30-cm depths under the canopy of a single tree at each site on a monthly basis from June 1979 through December 1980. Six cages were bur-

[1]Received for publication 29 July 1982. This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the USDA, nor does it imply registration under FIFRA. Also, mention of a commercial or proprietary product does not constitute an endorsement by the USDA and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

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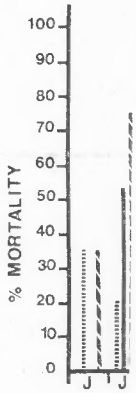

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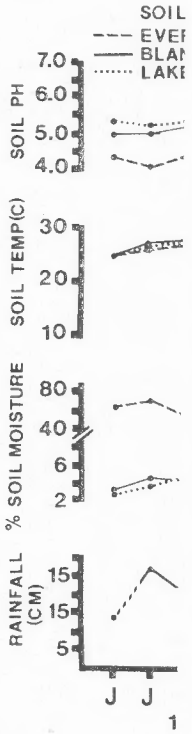

FIG. 2. Monthly variation of some ... Fla.

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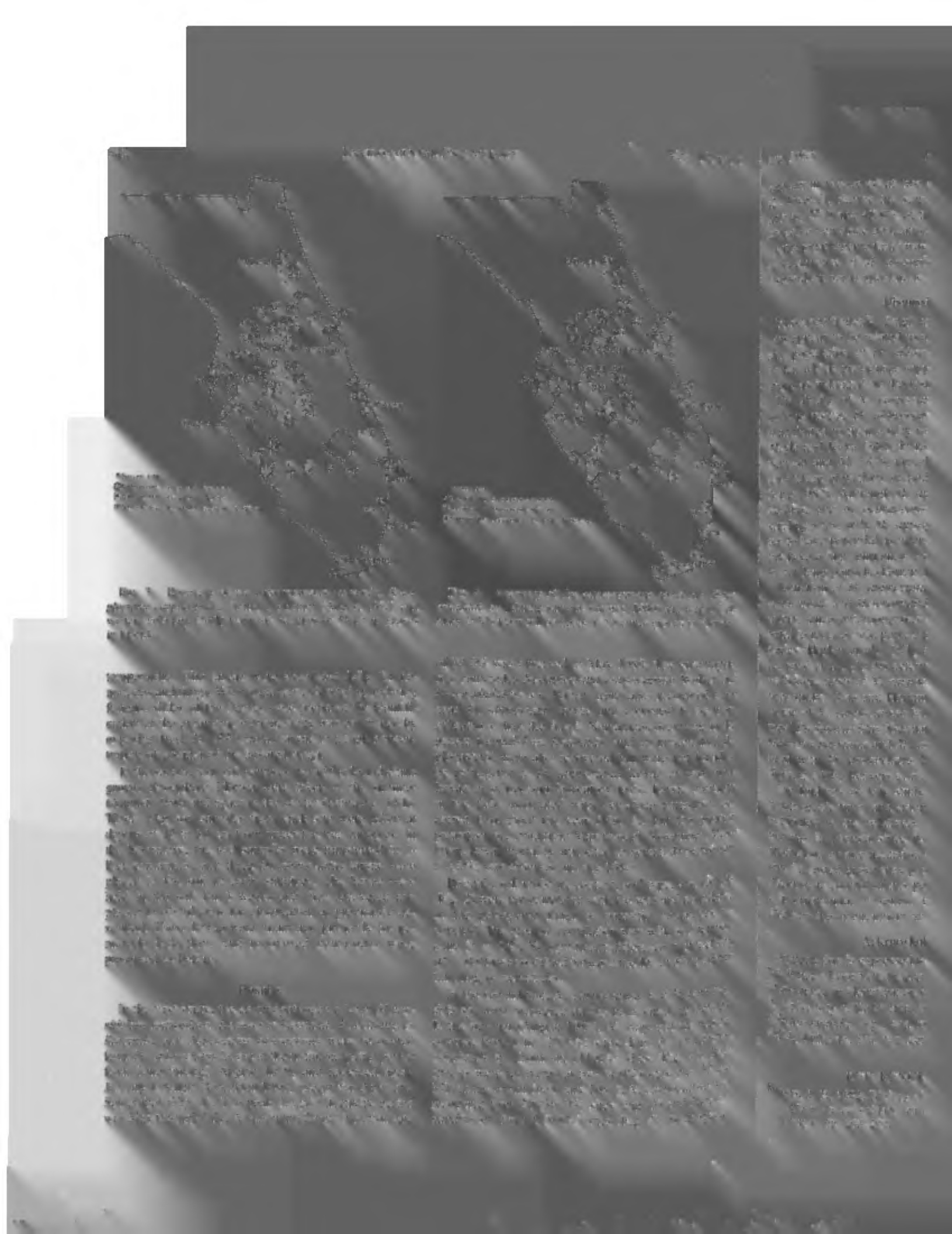

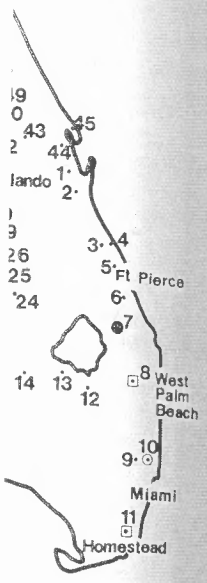

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were again recovered at two (4.0%) sites (no. 40 and 23). Overall, during the summer and winter sampling periods, 27.0 and 45.0% of the sites, respectively, had detectable nematode populations. Although mortality due to entomopathogenic fungi was not recorded in this study, the occurrence of *M. anisopliae* and *B. bassiana* was observed on some specimens.

Discussion

Entomopathogenic fungi and entomogenous nematodes appear to be related to a significant decline in the adult population of *D. abbreviatus* in areas of central Florida which previously supported large weevil populations as indicated by the results of the survey.

The ability of *N. carpocapsae* and *Heterorhabditis* sp. to parasitize *D. abbreviatus* larvae in the soil may be attributed to their ability to disperse through the soil (Moyle and Kaya 1981) in response to host karimones (Schmidt and All 1978, Gaugler et al. 1980) or to faint temperature elevations caused by the host (Byers and Poinar 1982). Although *M. anisopliae, B. bassiana, P. flavinus,* and *A. ochraceous* were detected at all 10 sampling sites, only *M. anisopliae* and *B. bassiana* appear to have potential as microbial control agents, since they have a high virulence and are able to persist in the soil for long periods (Ferron 1981).

Reduction of *D. abbreviatus* population levels by *N. carpocapsae* and *Heterorhabditis* sp. would not be surprising, since entomogenous nematodes have been reported to reduce field populations of several root weevil species (Harlan et al. 1971, and Burman et al. 1979). Laumond et al. (1979) determined that *D. abbreviatus* adults were hosts of *N. carpocapsae* in a laboratory host range study. Diaz and Hernandez (1978) have reported the use of *N. carpocapsae* for control of the citrus root weevil *Pachnaeus litus* (Germar) on bagged trees in Cuba. *Beauveria bassiana* and *M. anisopliae* have been associated with *D. abbreviatus* larval and adult mortality (Wolcott 1936, Beavers et al. 1972).

The findings of this study suggest that these entomopathogenic fungi and entomogenous nematodes have contributed to the relatively limited spread of *D. abbreviatus* in Florida since its discovery in 1964. The introduction or augmentation of these organisms into a weevil-infested grove may provide an alternative means of economic control of this pest in citrus groves as well as in ornamental nurseries, with minimal undesirable effects on the environment and public health.

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