New Record of Predation on Adult Diaprepes abbreviatus (Coleoptera: Curculionidae) by Euthyrhynchus floridanus and Podisus maculiventris (Heteroptera: Pentatomidae)

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Source: Florida Entomologist, 97(2) : 830-834

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.097.0272
NEW RECORD OF PREDATION ON ADULT DIAPREPES ABBREVIATUS (COLEOPTERA: CURCULIONIDAE) BY EUTHYRHYNCHUS FLORIDANUS AND PODISUS MACULIVENTRIS (HETEROPTERA: PENTATOMIDAE)

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Diaprepes root weevil or citrus weevil, Diaprepes abbreviatus (L.) (Coleoptera: Curculionidae), is a native of the Caribbean (Martorell 1976; Wolcott & French 1936), is an important pest of citrus, sugarcane, ornamentals and other crops in Florida (Peña & Amalin 2011). It was first reported in Florida in 1964 in Orange County (Woodruff 1968), and since has spread throughout southern and central Florida. It is estimated that citrus root weevil is responsible for more than US$ 70 million in damage to at least 40,000 ha of citrus groves in Florida (Weissling et al. 2012). This weevil is relatively large with adults ranging from 10 to 20 mm in length. There are several morphotypes with yellow or orange stripes on a black background on the elytra. In 2000, the citrus root weevil was found in a citrus grove in the Rio Grande Valley of Texas (Skaria & French 2001), where it quickly became established. This insect was first found in Orange and Los Angeles counties, California in 2005 and in fall 2006 in San Diego County. Efforts to eradicate the citrus weevil in California were unsuccessful and it is currently established in several counties presenting a high risk of spreading further (Jetter & Godfrey 2009). In its native range in the Caribbean islands, it is one of the most important crop pests, feeding on many hosts (more than 290 plant species in 59 families) including citrus, legumes, vegetables, corn, sorghum and several weeds (Simpson et al. 1996). The most significant damage is caused by the larvae feeding on the roots of host plants. Females have a great reproductive potential laying an average of 5,000 eggs during a lifetime of approximately 5 months (Wolcott & French 1936). Females lay a cluster of 30 to 264 eggs on the leaves. Larvae emerge after 7 to 10 days, crawl around for 24-48 h and then drop from the leaves to the ground to search for fine, fibrous roots, switching to larger roots as they mature. These beetles can have as many as 11 instars or as few as 6 which develop over 8 to 15 months. Typically the third to ninth instars are the most active feeders. The total life cycle of D. abbreviatus ranges from less than 1 yr to about 2 yr (Wolcott & French 1936). Larval feeding girdles the root crown area stunting growth and sometimes killing the plant. Adult citrus weevils feeding on young tender leaves produces notches similar to the feeding damage caused by other weevil species or grasshoppers but it is not as damaging as the larval root feeding.

Management tactics for D. abbreviatus in Florida are based mostly on chemical methods (McCoy et al. 2000; Bullock et al. 1988), plant resistance (Lapointe & Bowman 2002), entomopathogenic nematodes (Duncan et al. 2000; McCoy et al. 1995; Schroeder 1990) and use of egg and larval parasitoids (Peña & Amalin 2011; Peña et al. 1998; Sutton et al. 1972). However, no attempts have been made to use predatory insects in an IPM program for citrus root weevil (Peña & Amalin 2011). Control of the larval stages of the citrus root weevil using naturally occurring or commercially available entomopathogenic nematodes has been relatively successful in sandy soils. The nematodes are less effective in heavier clay and loam soils than in sandy soil conditions (Duncan & Stelinski 2013; Hall et al. 2001). Studies were conducted at the UF-Citrus Research and Education Center in Lake Alfred, Florida, to determine ‘induced response’ by citrus trees to root feeding damage by citrus root weevil larvae. The use of synthetic attractants in the field to enhance suitable habitat conditions (sandy soils) to attract beneficial nematodes in response to insect attack showed great potential as part of an IPM program (Duncan & Stelinski 2013). Several parasitoids have been introduced and released in Florida by state and federal agencies. Quadrastichus haitiensis Graham (Hymenoptera: Eulophidae), introduced from Puerto Rico, is one of the first egg-parasitoids released (more than 160,000 specimens since 1998) in untreated citrus groves in central and south areas. This parasitoid got successful established and it has been recovered from weevil eggs in Dade, Glades, Hendry, and Polk counties (Weissling et al. 2012). Ceratogramma etiennei Delvare (Hymenoptera: Trichogrammatidae) was released in Florida but its effectiveness in the field has not been determined (Peña & Amalin 2011). Generalist predators, including Euthyrhynchus floridanus (L.), the regal jumping spider, Philippus regius Koch (Araneae: Salticidae) (Jaffe et al. 1990; Tryon 1986), and several predatory ants (Whitcomb et al. 1982) have been reported attacking different stages of the citrus root weevil. Laboratory
and greenhouse experiments were conducted by Stuart et al. (2002) with 3 coccinellid species *Cycloneda sanguinea* (L.), *Harmonia axyridis* Pallas, and *Olla v-nigrum* (Mulsant) which are commonly found in the citrus canopy. Results indicated that these coccinellid species have the potential to be used for biological control of citrus root weevil eggs and neonate larvae before they drop to the ground, but their impact needs to be further studied.

Laboratory feeding experiments were conducted exposing adult and nymphal predatory stink bugs *Euthyrhynchus floridanus* and *Podi- sus maculiventris* Say (Heteroptera: Pentatomidae) (Fig. 1) to adult *Diaprepes abbreviatus* at 25° ± 3 °C, 50-55% RH and 16:8 h L:D. *Podisus maculeventris* was chosen as a comparative organism because it is a common predatory pentatomid and can be found throughout the citrus growing regions of the USA (De Clercq 2008). Both male and female stink bugs and weevils were utilized. Predators were individually housed with moistened Kimwipe® paper, bean pod, and tissue paper in a Petri dish (14.0 cm × 2.3 cm) for 24 h with no prey. Then, a single (male or female) *D. abbreviatus* was added to the testing arena as prey. A randomized design with 20 replications was used. Five *D. abbreviatus* were kept with food and water in Petri dishes with no predators as a control. After 24 h, the number of dead prey was recorded.

Results obtained indicated that *E. floridanus* males consumed on average (*P* < 0.05) more *D. abbreviatus* adults than the *E. floridanus* females or 3rd-5th instars. All *E. floridanus* life stages consumed more *Diaprepes* adults than all life stages of *P. maculiventris*. There was no significant difference (*P* > 0.05) in the percentage of *Diaprepes* male or female adults consumed by the *P. maculiventris* developmental stages tested (Table 1).

In this study *E. floridanus* was a more effective predator of *D. abbreviatus* than *P. maculiventris* in a laboratory setting (Fig. 2). With further study, *E. floridanus* may show the potential to augment biological control programs

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Fig. 1. Predators evaluated for predation of *Diaprepes abbreviatus* adults. A. *Euthyrhynchus floridanus* adult. B. *Euthyrhynchus floridanus* nymph. C. *Podisus maculiventris* adult. D. *Podisus maculiventris* nymph.
TABLE 1. LABORATORY FEEDING RESPONSES OF ADULT AND IMMATURE *EUTHYRHYNCHUS FLORIDANUS* AND *PODISUS MACULIVENTRIS* TO ADULT *DIAPREPES ABBREVIATUS*. IN A RANDOMIZED EXPERIMENT WITH 20 REPLICATIONS, A SINGLE PREDATOR IN A PETRI DISH WAS PRESENTED WITH A SINGLE (MALE OR FEMALE) *D. ABBREVIATUS*, AND WHETHER THE LATTER WAS KILLED WAS DETERMINED AFTER 24 HOURS.

| Predator stage | Prey stage | Predation by Predator Species (%) |  |
|----------------|------------|----------------------------------|---|
| Adult male     | Adult male | E. floridanus 80 a                | 15 a |
|                | Adult female | 90 a                        | 25 a |
| Adult female   | Adult male | 70 ab                       | 20 a |
|                | Adult female | 60 b                     | 10 a |
| 3th-5th instars | Adult male | 90 a                      | 15 a |
|                | Adult female | 60 b                    | 10 a |

The means within the same column followed by a different letter are significantly different from each other according to the Sign Test (*P* < 0.05).

Fig. 2. A. *Euthyrhynchus floridanus* adult male feeding on *Diaprepes abbreviatus* adult. B. *Euthyrhynchus floridanus* nymph feeding on *D. abbreviatus* adult. C. *Podisus maculiventris* adult female feeding on *D. abbreviatus* adult.
for suppressing populations of citrus root weevil. However, more testing is necessary to determine if this insect actually prefers *D. abbreviatus* when given a choice.

**ACKNOWLEDGMENTS**

The authors thank Bobbie Jo Davis, Juliaet Brambila, J. Howard Frank, Paul Skelley and Trevor Smith for reviewing this manuscript. We also thank FDACS-DPI's Biological Control Rearing Facility staff for providing the *Diaepres abbreviatus* for host feeding tests. This research was approved by the Florida Department of Agriculture and Consumer Services, Division of Plant Industry for publication as contribution #1250.

**SUMMARY**

The feeding responses of the predatory stink bugs *E. floridanus* and *P. maculiventris* to the citrus root weevil *D. abbreviatus* were studied at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry's Florida Biological Control Laboratory in Gainesville, FL. This work was done in quarantine at temperatures of 25° ± 3°C with a 16-hour photoperiod (16:8 L/D) and a relative humidity of 50-55%. The *E. floridanus* and *P. maculiventris* males, females and 3rd-5th instars were kept individually in a Petri dish with a bean pod and moistened paper for 24 h. They were then exposed to a single D. *abbreviatus* male or female in Petri-dishes for 24 h. Twenty replications were made. At the end of the experiment percent predation was determined. *Euthyrhynchus floridanus* was more efficient than *P. maculiventris* at feeding on *D. abbreviatus* adults in the lab with no choice tests. This particular stinkbug can be easily mass reared and therefore has potential as augmentative biological control agent for the citrus root weevil. However, more testing is necessary to determine the overall impact of this predator in the field.

**Key Words:** Generalist predator, Pentatomidae, citrus root weevil

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