Efforts Toward Establishment of Biological Control Agents of Diaprepes Root Weevil

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The Diaprepes root weevil, an unwelcome introduction into Florida, has made itself at home in the state for over 30 years. The weevil attacks citrus, ornamental plants, root crops, tropical fruit crops and grasses. In 1997 a cooperative effort of the University of Florida, U.S. Sugar Corporation, Florida Department of Agriculture, The Kerr Center for Sustainable Agriculture and the United States Department of Agriculture, partially funded by the Florida Citrus Production Research Advisory Council, Florida Nursery Grower Association and USDA, was established to introduce biological control agents against this insect. The effort has focused until today on the introduction of small wasps that destroy eggs of the weevil and have the potential to help with the management of the weevil in Florida. Since biological control of Diaprepes root weevil eggs by parasitoids already exists in Puerto Rico, Guadeloupe and other countries in the Caribbean, the first goal of the team was to introduce biocontrol agents from the islands to see if any would eventually become established in Florida. The introduction and establishment of exotic species for the long term suppression of pests is referred to as “classical biological control.”

Classical biological control is intuitively appealing as a pest management tactic because it involves natural selected components of the ecosystem, is nontoxic and is often self-sustaining. In theory and practice, the goal of classical biological control is to reunite natural enemies with pest species that have invaded new geographical areas with the expectation that effective pest suppression will result. In the case of Diaprepes root weevil, the objective of this approach is to explore, select and import natural enemies as biological control agents in the original or adapted ecosystems of Diaprepes abbreviatus or related species.

While these efforts seem like a good idea, there are many aspects of the life cycle of the weevil, such as characteristics of healthy and parasitized eggs that need to be better understood by affected growers to improve their chances for success. The objective of this article is to answer several questions raised by concerned growers.

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One question addressed is: *How can we find Diaprepes weevil eggs? What do they look like?* Mated female weevils lay eggs in concealed sites, most often in the space between two adjacent leaves (Fig. 1). While sampling for eggs, leaves that have been glued together by spiders, or by the effect of rainfall, may be confused with leaves where the weevil has deposited her eggs. However, weevil egg masses are deposited in a gelatinous cement which seals the leaves together and thus provides protection to the eggs (Fig. 2). *Diaprepes* eggs (Fig. 3) also are laid on broad leaved plants (Fig. 4), grasses (Fig. 5) and palm fronds (Fig. 6).

**Figure 1.** Citrus leaves glued by *Diaprepes* weevil during oviposition.

**Figure 2.** Eggs of *Diaprepes* weevil on citrus leaves.

**What Egg Parasitoids Have Been Introduced and Released in Florida?**

Two egg parasitoids, *Quadrastichus haitiensis* and *Ceratogramma etiennei* were introduced from the Caribbean Region, placed under quarantine conditions and eventually released in Florida. The egg parasitoid, *Quadrastichus haitiensis* (Fig. 7) is a small wasp, but it is larger than *Ceratogramma* (Fig. 8). In nature, the female deposits her eggs through leaf tissue into weevil...
eggs. In the rearing laboratory at DPI, citrus leaves are replaced by a wax paper strip (Fig. 9).

![Figure 7. Adult of Quadrastichus haitiensis wasp.](image)

The species, *Ceratogramma etiennei*, is a very small wasp (Fig. 8). The adult female parasitoid wasp may use chemical and visual cues to locate eggs. The chemical cues called kairomones, could be found on the scales on *Diaprepes* root weevil wing covers left near the egg by the female weevil during oviposition, on weevil feces or on the sticky substance that the weevil uses to cement eggs between leaves. Some egg parasitoids may also encounter eggs by following sexual pheromones of the weevil. Visual clues (physical configuration of hosts) are probably less used to locate *Diaprepes* eggs than chemical cues since *Diaprepes* eggs are laid in concealed sites. A study conducted by D. Amalin, a post-Doctoral fellow at UF-TREC, has observed that once the parasitoid finds the egg, the parasitoid may drill a hole through the leaf, and then drill a hole through the egg chorion (egg shell), inserting an egg into the *Diaprepes* weevil egg (Fig. 11).

![Figure 10. Diaprepes weevil eggs parasitized by Quadrastichus wasp.](image)

![Figure 9. Diaprepes weevil eggs on wax paper strips (Rearing facility, DPI).](image)

*Quadrastichus haitiensis* prefers to lay eggs in young *Diaprepes* eggs (1-3 days old). The percentage of weevil eggs that produce adult *Quadrastichus* is usually much higher when young weevil eggs are parasitized than when older eggs are parasitized. Three days after *Diaprepes* eggs are parasitized, the eggs turn light brown in color (Fig. 10). Since the majority of *Quadrastichus* do not cut a hole through the wax strips, parasitized eggs are peeled off 8 or 9 days after being exposed to adult parasitoids and held for about 13 days at 80°F and 80-85% RH until adult progeny emerge.

![Figure 11. Oviposition punctures of Ceratogramma on Diaprepes eggs.](image)
Diaprepes eggs in the early stages of development are more suitable for parasite development than older Diaprepes eggs; for example, those in which the head capsule of the larva is visible, are not usually parasitized and if they are, parasitoid survival is much lower. Since Diaprepes eggs will hatch between 6-10 days after deposition, the parasitoid egg will hatch quickly, and the parasitoid larva develops rapidly too. Parasitoid larvae then transform to an inactive pupal stage of Ceratogramma (Fig. 12). When attacked by the Ceratogramma wasp, the weevil egg chorion becomes golden-brown. After some days, the adult wasp emerges from the pupa and escape the Diaprepes egg by chewing an irregular hole in the egg shell (Fig. 13).

![Figure 12. Diaprepes eggs parasitized by Ceratogramma.](image1)

![Figure 13. Ceratogramma wasps emerging from Diaprepes eggs.](image2)

**Are These Wasps Established in Florida?**

Close to 363,000 wasps of the species C. etiennei have been released since 1998, and more than 160,000 Q. haitiensis were released between 1999 and 2000. Wasps have been released throughout Florida in citrus groves, ornamental plantings and also in undisturbed areas. Ceratogramma etiennei has been recovered from Diaprepes eggs in Dade county. Quadrastichus haitiensis has been recovered from weevil eggs in Dade, Glades, Hendry and Polk counties. These recoveries indicate that the parasitoids will become established in Florida. Even though the parasitoids are currently found in some groves, more efforts need to be directed toward further wasp releases, augmentation and quantitative surveys to rank the effectiveness of the imported parasitoids, determine their dispersion between infested groves and study the effect of pesticide application on parasitoid survival. We expect that the wasps will contribute to mortality of weevil eggs. However, we are fully aware that a multiple effort, consisting of monitoring, plant resistance, microbial control and other tactics will be needed to make a significant impact on the insect populations.

We will continue releases in Florida locations to establish these parasitoids and to document its enhancement of the natural enemy complex of the Diaprepes root weevil.

**References Consulted**


