Currently, there are eight described species of root weevils which are known to infest citrus in Florida. Of these species, five can cause damage of economic importance to both nurserymen and commercial growers. These species are: the southern blue-green citrus root weevil, *Pachnoda litus*; the blue-green citrus weevil, *Pachnoda opalus*; Fuller rose beetle, *Asynonychus godmani*; the little leaf notcher, *Artipus floridanus*; and the sugarcane rootstalk borer weevil, *Diaprepes abbreviatus*. Other less important species include *Tanymecus lacaena*, *Epicarerus fermdolosus* and *Parapantomorus fluctuosus*. These and other species can be found in other parts of the world and are a major production problem in the Caribbean region and South America.

Growers might first notice the damage done by the adult weevil feeding on the leaves of citrus plants and become alarmed from the visual damage to the foliage. However, the unseen damage done by the larvae in the soil, which feed on the plant root system can have a greater destructive effect on the vitality and future productivity of the overall tree.

**ADULT FEEDING BEHAVIOR**

Adult weevils can feed on a wide range of host plants including citrus. They feed at night, early morning or late afternoon and generally hide within the tree canopy during the heat of the day. The most apparent visual plant damage is a marginal notching of the leaf on young, tender shoots. Adult feeding always begins at the leaf margin; the amount of leaf consumption differing between species and food requirements of the adult. More than one weevil may feed on a leaf. According to laboratory studies by Syvertsen and McCoy (9) severe leaf injury can decrease water use efficiency up to 20% and decrease photosynthesis. However, injury from notching of the leaf causes no subsequent economic effect on yields from mature trees. Once the leaf has matured, feeding is reduced or expanded to include alternate host plants.

**EGG-LAYING BEHAVIOR**

Except for the Fuller rose beetle, female root weevils generally lay their eggs between two leaves. The female produces an adhesive substance that is secreted at the time of egg laying that holds the leaves together (10,14). Eggs are generally laid on new leaf flush. About 83% of the time Fuller rose beetles prefer to lay their eggs beneath the calyx of the fruit and the remainder of the time in cracks formed by the leaves or on the bark of the tree (4). The eggs of each species are laid in masses and will differ in number, size, shape and color as shown in Table 1.
Table 1. Estimated Number of Eggs and Total Eggs Per Lifetime of the 5 Major Root Weevil Species.

<table>
<thead>
<tr>
<th>Type of Weevil</th>
<th>Number of Eggs per Mass</th>
<th>Approximate Number of Eggs per Lifetime</th>
<th>Egg Size in mm</th>
<th>Egg Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pachnaeus spp.</td>
<td>50 - 75</td>
<td>4000</td>
<td>Flatten</td>
<td>Pale translucent yellow</td>
</tr>
<tr>
<td>Southern blue-green weevil</td>
<td></td>
<td></td>
<td>0.035 long 0.01 wide</td>
<td></td>
</tr>
<tr>
<td>Blue-green weevil</td>
<td></td>
<td></td>
<td>0.03 long 0.01 wide</td>
<td></td>
</tr>
<tr>
<td>Asynonychus godmani</td>
<td>70 - 100</td>
<td>3000</td>
<td>Flatten</td>
<td>Pale translucent yellow</td>
</tr>
<tr>
<td>Fuller Rose beetle</td>
<td></td>
<td></td>
<td>0.035 long 0.01 wide</td>
<td></td>
</tr>
<tr>
<td>Artipus floridanus</td>
<td>12 - 130</td>
<td>800 - 1000</td>
<td>0.03 long 0.01 wide</td>
<td>White to yellow</td>
</tr>
<tr>
<td>Little Leaf Notcher</td>
<td></td>
<td></td>
<td>0.035 long 0.01 wide</td>
<td></td>
</tr>
<tr>
<td>Diaprepes abbreviatius</td>
<td>30 - 264</td>
<td>5000</td>
<td>0.05 long 0.016 diam.</td>
<td>White when laid, brownish before hatching</td>
</tr>
</tbody>
</table>

LARVAL BEHAVIOR

After 10-20 days at 80-86°F, egg masses hatch into neonate larvae. They fall to the soil surface and immediately begin moving their way into the soil where they begin feeding on the fibrous feeder roots of the plant. Feeding damage by older larvae may be seen on major lateral (Plate 4, Plate 5) or pioneer roots when a tree is removed from the soil. Preferred feeding sites by weevil larvae are listed in Table 2. Larvae cause damage by channeling on the outer bark tissue into the cambium layer to the woody portion of the root, or by girdling a root thereby causing root death. In addition to the damage done to the root itself, channeling on the outer portion of the root could conceivably allow for pathogen invasion. Considerable tree kill has been observed in groves infested with both Diaprepes and Phytophthora (foot rot). The length of time for larval feeding on the root system varies depending on the species and soil conditions. See Table 3 for the estimated time of larval development. This long protracted period of time in the soil includes an inactive pupal stage of two to four weeks. Following pupation in the soil, the adult can emerge or remain in the soil for three to four weeks. Adult emergence from the soil frequently occurs after a period of extensive rainfall.

In typical flatwood soils where groves have a shallow root system, larval damage appears to be more pronounced. Since a greater percentage of the root system is close to the soil surface, larval movement through the soil to the roots is much easier.

Table 2. Characteristic Citrus Root Feeding Behaviors by Root Weevils.

<table>
<thead>
<tr>
<th>Root Part</th>
<th>Diaprepes</th>
<th>Asynonychus</th>
<th>Pachnaeus</th>
<th>Artipus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crown</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Major Lateral</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Tap (vertical)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Pioneer</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fibrous</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+ Indicates feeding on root part by weevil genera
- Indicates no known feeding on root part by weevil genera

Archival copy: for current recommendations see http://edis.ifas.ufl.edu or your local extension office.
Table 3. Approximate Larval Development Time in the Field.

<table>
<thead>
<tr>
<th>Weevil Genera</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diaprepes</td>
<td>6 - 24 months</td>
</tr>
<tr>
<td>Asynonchus</td>
<td>9 - 12 months</td>
</tr>
<tr>
<td>Pachnaeus</td>
<td>9 - 12 months</td>
</tr>
<tr>
<td>Artipus</td>
<td>35 - 40 days</td>
</tr>
</tbody>
</table>

BLUE-GREEN CITRUS ROOT WEEVIL

Southern blue-green citrus root weevil (*Pachnaeus litus*) and the northern citrus root weevil (*Pachnaeus opalus*) are the most widespread weevil pests in Florida (14). The southern blue-green citrus root weevil is commonly found in flatwoods plantings in south central and south Florida, the east coast as far north as Brevard County and on the west coast to Sarasota County. The northern blue-green citrus root weevil is commonly found in north and north central Florida. The two species can be found in the same grove in some central Florida counties such as Polk, Orange and Lake. Citrus root weevil is bright blue-green to aqua in color. The northern citrus root weevil is a pale grey-green in color but occasionally is bright aqua (5). For the grower who would like to differentiate between the 2 species of citrus root weevil one must look at the pronotal notch on the leading edge of the wing covers illustrated in Figure 1. The adult weevil with the notch is the southern citrus root weevil; the one with a smooth anterior portion of the wing cover is the blue-green citrus root weevil. Both species are fairly large, 0.33 to 0.55 inches in size. The larvae are white and legless with well-developed brownish-black chewing mouth parts.

While adults will emerge from the soil every month, peak emergence is generally from mid-May to mid-July. The average life span of the adult is 100 to 120 days. Mated females can deposit up to 4,000 eggs (Southern blue-green citrus root weevil eggs, Northern citrus root weevil eggs) in a lifetime (5). Adults can be found on as many as 70 species of plants which include all varieties of commercial citrus. Adults can be frequently found in Australian pine on the east coast of Florida.

FULLER ROSE BEETLE
(*Asynonchus godmani*)

The Fuller rose beetle was first reported in Florida in 1916 and can be found on a wide range of plants in both coastal and central Florida and as far north as Gainesville and south to Homestead. Adults are brownish to grey in color and are about 0.33 inches long. Since there are no males in this species females reproduce by the process called parthenogenesis which means the eggs develop without fertilization. Both adult Fuller rose beetle and little leaf notcher are flightless, limiting their movement from grove to grove. Adults will lay about 70 to 100 yellowish eggs per mass over a 4 month period. Eggs hatch in about 17 days. The larvae are white except for a yellowish head capsule (5). This species presents a problem for fresh fruit packers because egg infested fruit is rejected in quarantine by Japan where the beetle is not found (4).

Adult Fuller rose beetle can emerge anytime throughout the year but peak emergence is from May through July, as shown in Figure 2. Since the adults are flightless, they use the tree trunk, low hanging branches and/or grasses to migrate into the tree to feed on the leaves (13).

LITTLE LEAF NOTCHER
(*Artipus floridanus*)

Little leaf notcher was reported in Florida as early as 1876 and is found mainly along Florida’s east coast from Volusia County to the Keys. This species can be found on a wide range of host species which include 150 species (15) including salt tolerant plants as well as other species such as teaweed, ragweed, carpet grass and Australian pine. They have been frequently observed in citrus groves. This species is the smallest of the common weevils, measuring only about 0.20 to 0.25 inches in length. They are grayish-white in color, flightless and all female. Unlike other species, little leaf notcher has a 90 to 100 day life cycle with 3 to 4 generations/year. Adults can be found throughout the year with peak emergence in April-May, August-September and November-December. The adults will lay an average of 8 egg masses per day for up to 165 days. Eggs hatch in 7 to 9 days.
SUGARCANE ROOTSTALK BORER WEEVIL  
(*Diaprepes abbreviatus*)

The sugarcane rootstalk borer weevil or "Apopka weevil" (5) was first reported in Florida in 1964 in a nursery near Apopka. It is one of several species of *Diaprepes* that are a major pest of citrus, sugarcane and other crops grown throughout the Caribbean area. It has been observed on more than 75 species of plants in Puerto Rico and it is believed this pest entered Florida on imported ornamentals from that area.

No rootstock appears to be resistant to larval feeding and rootstock tests showed no feeding preference for rough lemon, sour orange, 'Carrizo', 'Milam' or 'Cleopatra' (8). It has been noted that as few as two weevil larvae per containerized seedling will remove the entire bark from the root system in 4-5 weeks.

This is the largest of the weevils found on citrus with a length of 0.37 to 0.75 inches. The adults have a black background with colored scales on the wing covers which range from white to orange. Adults can be found throughout the year with two peak emergence periods in June and September. The females will lay up to 5000 eggs during her lifetime with eggs hatching almost uniformly in seven days (12). The adult males are active for two months while adult females are active for up to four months. The pest is distributed mainly in Lake and Orange counties with smaller infestations in St. Lucie, Palm Beach and Polk counties.

HOW WEEVILS MOVE FROM GROVE TO GROVE

Weevils have three ways of moving from grove to grove. Initial introduction is probably via nursery stock either as larvae in containers or as egg masses on foliage. Additional movement can occur from grove to grove by equipment. The third way is by natural spread. Weevils can also be introduced to a new area on nursery plants other than citrus. Since the Fuller rose beetle and the little leaf notcher are flightless, their natural spread is very slow. The sugarcane rootstalk borer and the blue-green citrus root weevil are poor flyers but can fly from tree to tree.

DETECTION IN GROVES

The best way to determine the presence of weevils in a citrus grove is to look for the typical notching along the margin of the leaves. If notching is present, examine foliage for adult weevils and/or egg masses. Weevils are nocturnal and will be found on the outer portion of the tree in the early morning or late evening hours. When the adults are disturbed they will usually fall to the ground faking death. Growers can use "beating aprons" that can be fabricated or purchased from various vendors in the U. S. for easy detection of adults in the tree.

To determine the emergence period during the year, the use of emergence cages placed on the ground beneath the canopy to capture the adults as they ascend from the soil has proven successful. Growers should use a minimum of 50 cages per infested grove location to determine emergence time. Two cages should be placed near the trunk under each tree to be sampled. The cages should be checked on a weekly basis. In most cases, growers will find low numbers in each cage rarely finding more than five. When the first weevil is captured in April or May, this signals the beginning of a major emergence period that can continue throughout the summer for most species. These cages can be used year round. Once the emergence cages are placed in the grove, care should be used when working with machinery so as not to disturb or destroy them.

WHEN AND HOW TO CONTROL WEEVILS IN YOUR GROVE

Currently, no information exists on an economic threshold level for weevils. However, a number of factors should be considered when making control decisions. You must know the species of weevil that exists in your grove and its biology, soil profile, age of the grove and fruit harvesting objectives. A young tree has a smaller root system and can therefore not tolerate the same level of adult and larval feeding damage as a mature tree. If Fuller rose beetle is present and the fruit is to be marketed for export, then adult control strategies are of greater importance. The decision to control weevils is based on one of the following three strategies which are available to the grower: 1) foliar insecticide sprays to control adults, 2) soil insecticide to control larvae in the soil or, 3) cultural practices which minimize the impact of larval feeding injury in the grove.
If a foliar spray is applied it must be applied two to three weeks after adult emergence begins from the soil. The residue activity of a foliar chemical is variable but rarely exceeds four weeks, therefore, a second application may be necessary from time to time. If soil treatment is chosen, the optimum time for the first application is one to two weeks after emergence begins.

Applications of foliar chemical spray have been successful in suppressing adult populations in Florida (10). Adult suppression disrupts the life cycle via reduced egg laying thereby reducing the number of larvae entering the soil.

In addition to controlling the weevils in the grove, the grower should make sure that both adequate fertilization and irrigation are being applied to the grove to reduce tree stress. With species such as little leaf notcher, removal of host plants such as teaweed, ragweed and Australian pine may reduce overall weevil populations. If the grower has Fuller rose beetle or the little leaf notcher, which is flightless, then tree skirts should be raised and weeds removed which would reach the lower tree branches to inhibit the movement of the weevil upward into the tree.

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**Figure 1.** Citrus Root Weevils.

**WING COVER NOTCH**

**NO WING COVER NOTCH**

**Southern Citrus Root Weevil**

(P. litus)

**Northern Citrus Root Weevil**

(P. opalus)
CONTROL OPTIONS

Natural Enemies of Root Weevils

Natural controls include parasites, pathogens and predators. It has been reported that predators such as ants (10), earwigs and other insects (2,10) can attack the neonatal weevil larvae at the soil surface and reduce pest populations. In addition to the predators, parasitic wasp (2) larvae have been found attacking weevil eggs (1).

While these predators and parasites reduce the weevil population, natural control is not successful in all cases. It is speculated that pesticides currently used or those used to control ant and other soil insect control could be reducing the populations of these predators or parasites which would allow for larger population of weevils. Therefore growers should review their pest control program to look not only at target pests but at the possible harmful effect of pesticide applications on non-target beneficial organisms.

Beauveria bassiana, Metarrhizium anisopliae (9) and other fungi occur in the soil and are pathogenic to weevil larvae and adults of all weevil species under natural conditions. The fungi are most prevalent in the soil from June through August. This time period would correspond to peak weevil larvae abundance in the soil and when seasonal rainfall is the highest (6). The potential exists to supplement naturally occurring levels of existing fungi with commercially-produced strains during favorable seasonal conditions for control of the weevils.

It has been reported that entomogenous nematodes have reduced populations of several species of root weevils (1). In some countries with less expensive labor, hand removal of the adults and eggs has been used to reduce weevils with limited success. For control of Fuller rose beetle in California or Florida, removal of the low hanging limbs in
conjunction with wraps placed around the tree trunk have helped inhibit the movement of flightless adults upward in the tree.

**Biological Control**

Presently biological control of weevil larvae in the soil is limited mainly to the use of entomogenous nematodes in the genus *Steinernema*. Currently, *Steinernema carpocapsae* is being commercially mass produced via fermentation and are being marketed by Biosys under the trade name of BioVector®. These insect-feeding nematodes enter the root weevil larvae and release a bacterium which is lethal to the host. These nematodes are recommended as a soil treatment to control the larvae of citrus root weevil, bluegreen weevil and the Apopka weevil. They must be incorporated into the soil with adequate water via the low volume irrigation system or applied by herbicide boom when soil moisture is high. These nematodes do not infect the neonatal larvae. It should be recognized, however, that the use of soil nematicides can interfere with the entomogenous nematodes’ ability to locate larvae in the soil. All currently registered citrus nematicides can act as nematostats which means they do not kill the nematode directly but affect behavior and their ability to find a food source. Therefore, nematicide applications should be avoided or delayed if entomogenous nematodes are applied for weevil control. Generally, nematodes should not be applied within four weeks before or after nematicide use.

**Cultural Control**

Prevention or exclusion is the first line of cultural control that should be used to make sure that the replants used in a infested grove site are free of any weevil eggs, larvae or adults. Where weevils are already present, growers should do everything possible to minimize water stress to the tree. Proper and timely irrigation should be scheduled to allow adequate water uptake by the undamaged portion of the root system. As the root system is fed upon, the wounded area may be predisposed to foot or root rot damage, thereby increasing the need for preventive or corrective measures.

Maintaining an adequate tree nutrition is also important since a tree in poor nutritional status will decline quicker and more extensively than a healthy tree. Cultural control can be assisted by removal of alternate host plants in and around the grove site. It has previously been discussed that several species will feed on other host plants such as teaweed, ragweed, etc.

**Chemical Control**

Growers should be cautious about repeated application of broad spectrum pesticides as these chemicals can disrupt beneficial insects. Presently, only the nematicide Nemacur® is labeled for the suppression of root weevil larvae in citrus. Research is currently underway to determine the effectiveness of a slow release formulation of chlorpyrifos.

If materials are applied to the soil surface to suppress or control the larvae, these chemicals should be applied to the area under the tree canopy. This under tree canopy area is the area where the neonate larvae will first enter the soil as they fall from the leaves. If foliar sprays are used for adult control, a maximum of two sprays is required during the emergence period. The pesticides and cultural controls listed in the *Florida Citrus Pest Management Guide: Root Weevils* will give good knockdown of adult weevils for commercial citrus groves. Residual control varies according to the pesticide, but by using oil at 0.25% as a sticker spreader, residual control can be increased by 6 days.

**REFERENCES**


