UF UNIVERSITY of FLORIDA
IFAS Extension

ENY-834

Insect/Mite Management in *Annona* spp.[1]

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Within the Annonaceae, sugar apple and atemoya fruit have the greatest potential for utilization in Florida. The major constraints to high productivity of these include key pests and the lack of pollinating agents.

Pollinators and Pollination

The majority of Annonaceae are pollinated by beetles, although some are pollinated by thrips. The activities of beetles in the flowers, including feeding, mating, and quiescence, result in prolonged visits from several hours to a few days while the flowers advance from the female to the male phase.

In Florida, flowering of atemoyas begins in April, and sugar apples in May, and continues until early August.

Atemoyas and sugar apples are most often pollinated by nitidulid beetles, which breed and feed in decaying fruits or sap flows. The beetles are attracted to the fruity, fermenting odor of *Annona* flowers, especially when they are hungry.

The number of beetles per flower affects the likelihood of fruit set, and also the quality of the fruit in some cases. All studies provide evidence for increased fruit set as numbers of visiting beetles increase.

In Florida, about nine species of native and exotic nitidulids (sap beetles) visit the flowers, but *Carpophilus mutilatus* is the most important pollinator in terms of efficacy and abundance in flowers, followed by *C. fumatus* and *Haptoncus luteolus.*

Pollinator Management

Trials to increase fruit set in atemoya orchards by augmenting sap beetle populations have yielded mixed results. Pollination by sap beetles can be improved by using chemical lures. The effect of nitidulid-pheromone bait stations on sugar apple and atemoya fruit set has been determined in south Florida. Maximum percent fruit set fluctuates between 10-38% during the first 4 weeks after treatment in plots with bait stations, and is significantly higher than in the control plots (5%).

Figure 1. Sap beetle entering an atemoya flower.

1. This document is ENY-834, one of a series of the Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date July 2006. Reviewed July 2013. Visit the EDIS website at http://edis.ifas.ufl.edu.

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Pests

Two hundred and ninety-six species of arthropods are associated with *Annona* spp. in the Neotropics. The families most frequently observed are Coccidae (Homoptera), Noctuidae, Oecophoridae (Lepidoptera), and Eurytomidae (Hymenoptera). The most common species in Florida are *Bephratelloides cubensis,* (Hymenoptera: Eurytomidae), *Cocytius antaeus* (Lepidoptera: Sphingidae), and the papaya scale *Philephedra tiuberculosa*. Larvae of the moths, *Gonodonta nutrix* and *G. unica* feed on leaves, but they are heavily parasitized by braconid wasps.

The Annona Sead Borer, *Bephratelloides* Species

Bephratelloides spp. develop strictly in *Annona* seeds. Economic damage occurs when the adults chew their way out of the fruit, creating a 2 mm diam tunnel that provides entry for other insects and decay organisms. *Bephratelloides cubensis* is thelytokous, reproducing without males. It has approximately 4-5 generations per year. The egg stage lasts 12 to 14 days, the larval stage 6-8 weeks, the pupal stage 12-18 days, and the adult rarely lives beyond 15 days.

Figure 2. Adult of the annona seed borer.

Bephratelloides cubensis prefers to oviposit in fruits ranging from 1.5-5.5 cm in diameter, which corresponds to fruit ages from 3-7 weeks after bloom. Although fruits larger than 5.5 cm are probed, when *B. cubensis* populations are high, most of these attacks do not result in infestation. Preferred fruit sizes presumably correspond with seeds that have not yet hardened and are easy to penetrate with the ovipositor, while the seeds of older fruits are probably too hard to penetrate. Larger fruits may be less preferred because the distance from the fruit surface to the seed may exceed the length of the ovipositor. The probes in young sugar apple and atemoya fruits look like dark pinpricks surrounded by a round whitish patch, and are visible for about two weeks; in older fruits the whitish patch does not appear, and the probe marks are permanent and often ooze sap.

Oviposition activity by *B. cubensis* begins at about 9:00 h and continues throughout the daylight hours with peaks in activity around 12:00-13:00 h. The wasps spend the night on the underside of leaves on their host trees, and move to the upper surface at sunrise. Flying individuals can be observed soon afterwards and throughout the day.

MONITORING AND SAMPLING

In Florida, *A. reticulata* sets fruit in September - November, and fruits remain on the trees as late as May. Atemoyas set fruit from April - August, and sugar apples from May- August. *Bephratelloides cubensis* populations in Florida overwinter mainly in *A. reticulata* and then move to atemoyas that begin to set fruit during April. After a developmental time of 9 weeks the adults emerge from the early atemoyas and infest younger atemoya and also sugar apple fruits. Second and third peaks of adult emergence and infestation occur in atemoya and sugar apples until young fruits are no longer available and the wasps switch to *A. reticulata* fruits in September. Wasp populations increase throughout the warm months because of the availability of large concentrations of atemoya trees, and are bottlenecked in winter because *A. reticulata* is grown only sporadically as a dooryard tree in Florida. Low infestations in sugar apples may be due to low movement from atemoya to sugar apple orchards when plentiful fruits are available. No evidence of diapause has been found in mumified stemoya and sugar apple fruits that overwinter on trees or on the ground.

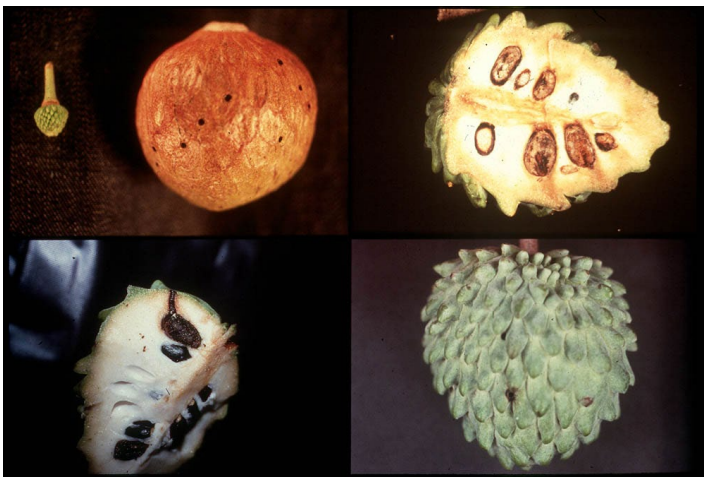

Figure 3. Annona fruits with symptoms of seed borer infestation.

Peaks of adult *B. cubensis* activity are observed between 1100 - 1700 h, and numbers are higher during the warmer part of the summer. Monitoring could concentrate on the

outer layer of the canopy at the middle third of tree height and should be conducted during hours of peak activity.

CONTROL TACTICS

Fenvalerate or permethrin provide significant adult mortality of the seed borer; however, sprays do not prevent fruit infestation. Fruit bagging is considered one of the best methods to prevent infestation by *B. cubensis* by several researchers. However, bagging encourages the growth of mealybugs on some fruits, probably because natural enemies are excluded. Although the method is effective, a cost comparison must be made between bagging and other potential control methods to determine its economic feasibility.

BIOLOGICAL CONTROL

No significant native parasitization or predation of *Bephratelloides* spp. has been reported. In Florida, the fungus *Beauveria bassiana* was applied to *B. cubensis* adults under laboratory conditions has provided 90% adult mortality for 8 days after treatment.

Minor Pests

Several other species of insects and mites may cause minor losses. In Florida, the foliage feeders most frequently reported on *Annona* are scales, mealybugs, leafhoppers and whiteflies (Homoptera), lace bugs (Hemiptera), some Lepidoptera and mites.

Foliage Pests

Soft Scales

In Florida, the scales, *Parasaissetia nigra*, *Saissetia coffeae, S. oleae* and *Philephedra tuberculosa* cause damage by feeding on sap. Sudden increases in populations of these insects coincide with plant stress and absence of effective natural enemies.

Figure 4. *Philephedra tuberculosa* infesting atemoya.

Armored Scales

Armored scales are uncommon and include *Aspidiotus destructor* Signoret, *Pseudaulacaspis pentagona* (Targioni-Tozetti), *Chrysomphalum aonidum* (L.), *Chrysomphalum dictyospermi* (Morgan), *Howardia biclavis* (Comstock).

Mealybugs

Some species of mealybugs can cause significant crop losses, although they seldom approach major pest status. Factors that may contribute to increases in mealybug populations include certain ants which reduce effectiveness of natural enemies, and transport mealybugs from one place to another. Most parasites of these mealybugs are hymenopterans of the family Encyrtidae and the most effective predators are coccinellid beetles. The judicious use of several insecticides can result in reduction of mealybugs. However, the use of some pesticides (e.g. organophosphates) is limited because they are not currently registered to be used on *Annona* crops.

The pink mealybug, hibiscus mealybug *Maconellicoccus hirsutus* (Green), cause severe damage to soursop. *Maconellicoccus hirsutus* is an extremely polyphagous species. It affects at least 74 plant families, about 144 genera. Some major hosts include mango, hibiscus, palms, coffee, grape, citrus and *Annona* spp.

Figure 5. Pink hibiscus mealybug infestation on soursop.

The development of this species occurs in 3-4 weeks and each female can produce approximately 500 eggs. In the summer, females may not seek shelter to lay eggs. Eggs hatch in 3-8 days and the nymphal stage lasts 10–22 days.

Several insecticides have been tested against this mealybug. However, most researchers agree that chemical and cultural control provides relief for a short period of time or they are ineffective control methods.

Aphids

The cotton aphid, *Aphis gossypii* Glover and the black citrus aphid, *Toxoptera aurantii* (Boyer de Fosncolombe), infest young leaf shoots.

Lepidopterous Leaf Feeders

In Florida, larvae of the fruit piercing moths, *Gonodonta nutrix* and *G. unica* feed on tender leaves. They do not cause significant damage because they are heavily parasitized by a braconid wasp.

Figure 6. Larva of *G. nutrix*.

Figure 7. *G. nutrix* parasitized by a braconid.

Mites

Brevipalpus phoenicis affects up to 85% of the epidermal surface of unripe soursop fruit. The fruit becomes bronze colored with darker epidermal cracking and lighter striations, resembling rust. The eriophyid *Aceria annonae* iinfests leaves of soursop and pond apple. There are no records of its economic damage or control.

Figure 8. Leaf of soursop infested with *Aceria annonae.*

References

Crane, J., and Mossler, M. 2006. Pesticides Registered for Tropical Fruit Crops in Florida. University of Florida, IFAS Extension, EDIS, FS HS177 (http://edis.ifas.ufl.edu/HS177).

Table 1. Insecticides registered for atemoya and sugar apple in Florida.

Chemical Name	Brand Name(s)	Pest(s) Controlled
Azadirachtin	Align, Azatin	general insecticide
Bacillus thuringiensis	Dipel, others	lepidoptera
Beauveria bassiana	Mycotrol	leaf hoppers, seed borer, thrips, others
Bifenazate	Floramite[1]	mites
Bifenthrin	Talstar[1]	various insects, mites
Fenoxycarb	Precision[1]	ants
Fenpropathrin	Tame[2]	various insects, mites
Hexythiazox	Savey[2]	various insects, mites
Hydramethylnon	Amdro[1]	ants
Kaolin (clay)	Surround	barrier and irritant to various insects
Methidathion	Supracide	scales
Potassium salts of fatty acids	Safer Soap	aphids, mites, plant bugs, scales, thrips
Pymetrozine	Endeavor[2]	aphids, whiteflies
Pyrethrin + rotenone	Pyrellin (atemoya only)	aphids, lepidoptera, thrips
Pyrethrins	Pyronyl (atemoya only)	aphids, thrips
Pyriproxyfen	Esteem ant bait	ants
Pyriproxyfen	Knack, Esteem	scales
S-methoprene	Extinguish	ants
Spinosad	Spintor	lepidoptera
Various refined horticultural oils	Sunspray, citrus spray oil, crop oil, FC 435-66, FC 455-88, others	aphids, mites, scales

[1]For use with non-bearing trees only.
[2]For nursery/non-bearing trees only.