Scouting Citrus for Pests

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Immokalee

Citrus rust mite

Citrus Psylla

Diaprepes

Citrus leafminer

Spider mites

Orchid Thrips

When citrus was brought as seed to Florida by the Spanish in the16th century it could only have been attacked by a few generalist herbivores native to Florida such as grasshoppers and “orange dog” larvae. Unfortunately, movement of citrus and other plant material into the state has brought with it more and more pests. Fortunately, most are under satisfactory biological control and only occasionally cause economic damage to the state’s largely (90%) process fruit industry. Exceptions occur, especially in the more exigent fresh fruit market where cosmetic damage to the peel can translate to economic loss. However, profitability of even process blocks can be threatened by pests that kill or debilitate trees such as *Diaprepes* or unexpected outbreaks of occasional pests of which there are many. Regular scouting is the grower’s best protection against unwelcome losses.

Pesticide Use in Florida Citrus

- **Most pests under biological control**
- **Most process fruit receives 1 or 2 oil sprays, primarily for greasy spot**
- **Copper 2nd most used pesticide**
- **Acaracides used primarily on fresh fruit**

Relatively low margins obtained from process citrus in recent years require that production costs be low to maintain profitability. Experience has shown that most pest and disease problems can be controlled with one or two sprays of horticultural mineral oil (HMO), possibly combined with a copper fungicide for susceptible varieties. The primary objective is to reduce defoliation by the disease “greasy spot” caused by the fungus *Mycosphaerella citri*. Additional benefits of HMO include rust mite control, control of sucking insects and removal of sooty mold from fruit and leaves. Further control of citrus rust mite may be required for fresh fruit, necessitating the addition of an acaracide. The need for this or any additional pesticide applications directed at insects or mites should be based solely on the verified presence or expectation of economically damaging populations.

Why Scout Citrus for Pests?

- **Sprays 30% production costs for fresh grapefruit.**
  - **Optimize inputs to maximize profits**
- **Reduce risk and avoid surprises**
- **Footprints: the most valuable input**

Spraying citrus destined for the fresh fruit market represents a major proportion of total production costs; an average of 30%. Thus, it is important to optimize control obtained with each spray. Proper timing and choice of pesticides can only be achieved with the help of accurate information on pest incidence. Therefore, regular scouting is necessary for successful management.

Even in process blocks, unexpected pest outbreaks can damage trees or threaten a crop, from whence the adage that the most valuable inputs to a grove are footprints.

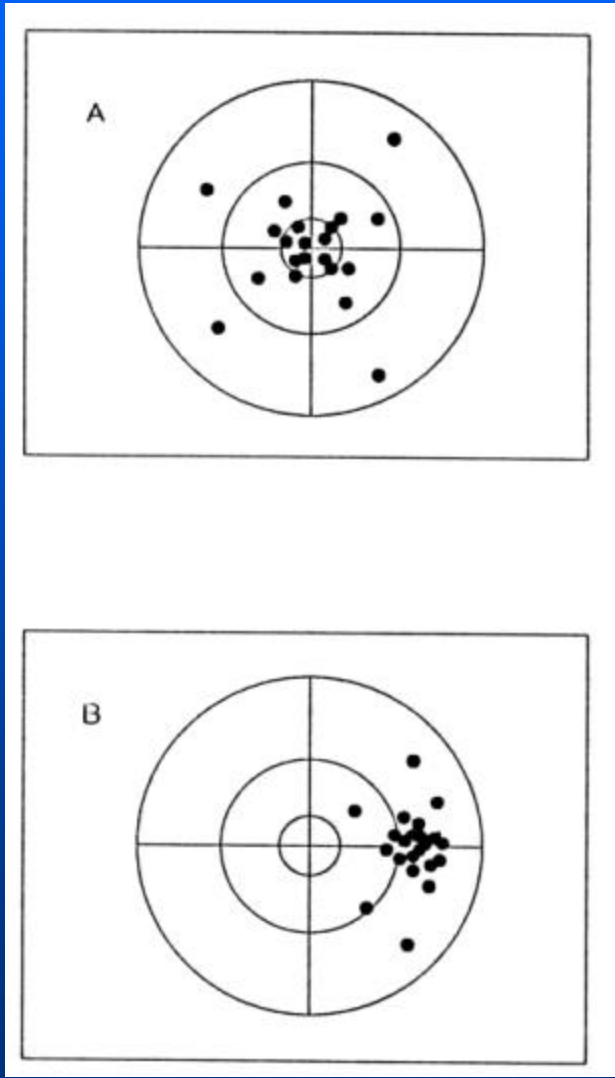
Types of Sampling Error

Variance

- Inconsistent, non-directional error
- Masks true pest level

Bias

- Consistent, directional error
- Over- or under-estimates pest level



Dealing with Sampling Error

- Reduce variance by increasing sample size
- Eliminate bias by randomizing samples:
  - Start in a different place each time
  - Cover the entire block
  - Avoid border rows
  - Scout both swales and middles

The objective of scouting is to obtain an *estimate* of true pest incidence based on a representative sample. Given that the number of fruit or leaves that we might inspect is only a tiny fraction of the total, there is ample room for error, of which basically, there are two types. Random error is due to natural variation, and should be distributed evenly around the mean or average which it masks. The more the population is aggregated or clumped, the greater will be the random error. The only way to reduce random error is to increase sample size. Error which is consistent and tends in a certain direction is called bias. It is caused by sampling in a particular way that favors one part of the population over another. Examples might be sampling certain rows, sides of the tree, size fruit, etc. Bias can be avoided with a sampling plan that employs randomization at some, if not all levels.

Bugs to Scout for in Fresh Fruit

Citrus Rust Mite
Phyllocoptuta oleivora

- **Still the principal arthropod pest of Florida citrus**
- **Most pesticide directed against**
- **Rarely reaches economic pest status in process fruit**

A measure of the economic impact of a pest is the sum of yield losses and control costs. By that criterion, the worst pest of Florida citrus is still the citrus rust mite (*Phyllocoptruta oleivora*) aided by the related pink rust mite (*Aculops pelekassi*). Even though very high populations can compromise yield and quality of process fruit, rust mites are largely fresh fruit pests. That is because lower populations are able to cause blemishes which can knock fruit out of grade. These blemishes are caused by feeding of the tiny mites on the epidermis (top layer) of the peel. Cells killed by this feeding are replaced with corky tissue that expands with growth of the fruit. Therefore, old damage is rough to the touch while new damage is smooth and even shiny. Rust mites reproduce rapidly and population densities may double in less than 2 weeks. Therefore, it is important to scout frequently, particularly in fresh fruit blocks.

Variables in Scouting for Rust Mites

- **Frequency**
- **Stops/acre**
- **Path through the grove**
- **Number of fruit/stop**
- **Number of lens fields per fruit**
- **The Lens Field**

  Count mites

  Percent over a threshold (0, 1, 2)

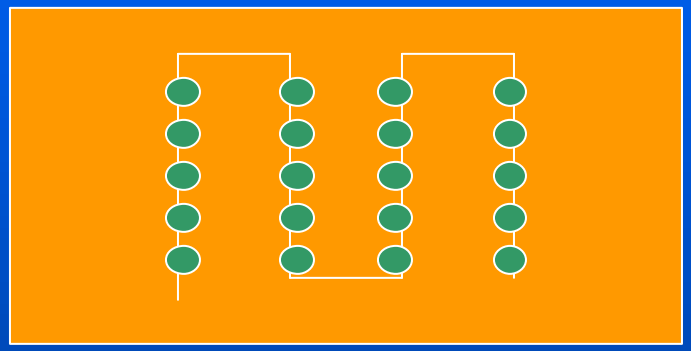
  HB system

Time constraints require that perhaps as few as 40 of the millions of fruit in a block actually get sampled for rust mite. Therefore, it is important to choose these samples in a way that will be most representative and yet do it efficiently. Frequency of sampling, number of sample locations per acre, path through the grove, number of sampled at each stop, location of fruit in the tree must all be determined. The lower the action threshold, the more samples must be taken for a given level of accuracy. Once a fruit is chosen, a hand lens is used to observe the mites. The number of lens fields per fruit and the way each is evaluated are additional factors. Mites may be either rated as exceeding a certain limit (one or more, three or more), rated to estimate the actual number using an HB or Horsfall-Barrett system based on the fact that it is easier to visually perceive differences at extreme ends of a scale. An HB system of grouping rust mite population densities into 6 categories has been proposed*. Whatever system is used, trends over time are often more informative than the counts themselves, so it is important to scout regularly.

*Rogers, J. S et al. 1994. Standardized visual comparison keys for rapid estimations of citrus rust mite (Acari: Eriophyidae) populations. J. Econ Entomo. 87 p. 1507-1512.

Florida Pest Management Guide*:

- Every 10-14 days (fresh fruit)
- Stops/ 10 acre block = 20
- Path through the grove
- Fruit/stop = 4
- Lens fields per fruit = 1
  - 80 lens fields total

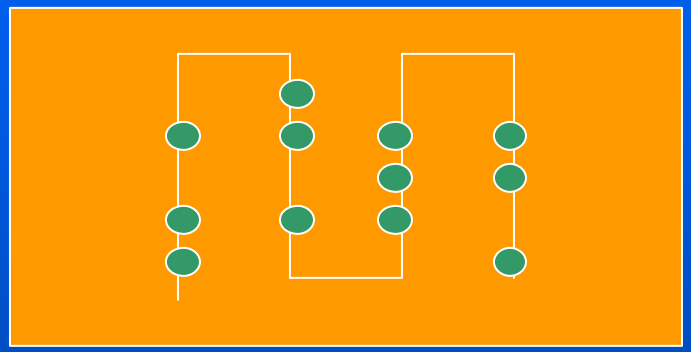


- Location of Fruit = midway in canopy
- Mites/lens field
- Provides < 25% variation if CRM > $10/cm^2$

*2001 Florida Citrus Pest Management Guide, J. P. Knapp, Ed. Publication SP-43, UF Gainesville http://edis.ifas.ufl.edu/MENU_CG

Stansly Variation:

- Stops/ block = 12
- Path through the grove



- Fruit/stop = 4

  Both sides of 2 trees on either side of middle
- Lens fields per fruit = 2

  96 lens fields total
- Location of Fruit = midway into canopy

When to Spray? (Threshold)

- **2 CRM/ 1 cm^2 lens field = 43% infested lens fields for fresh fruit (Florida Citrus Pest Management Guide)**
- **10 CRM / lens field for process fruit**
- **Trends may be more important than thresholds**
- **The longer the history, the easier the decision**

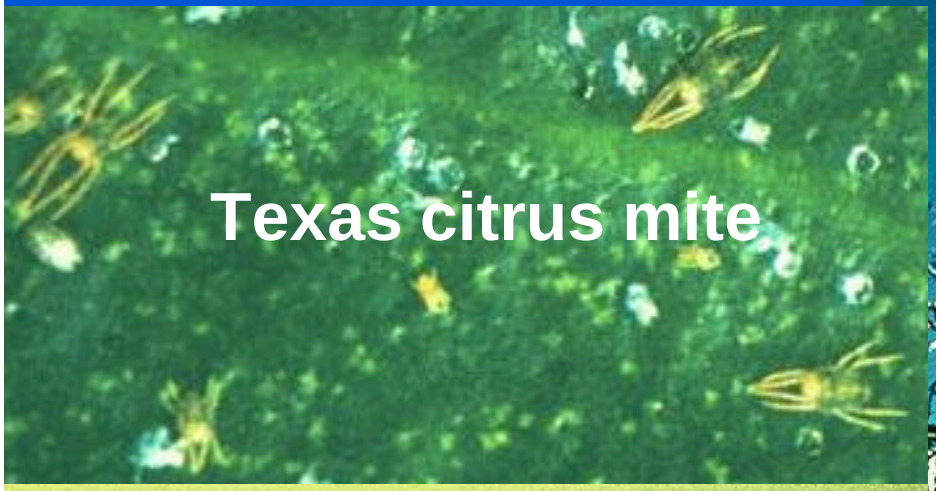
What Else to Scout for?

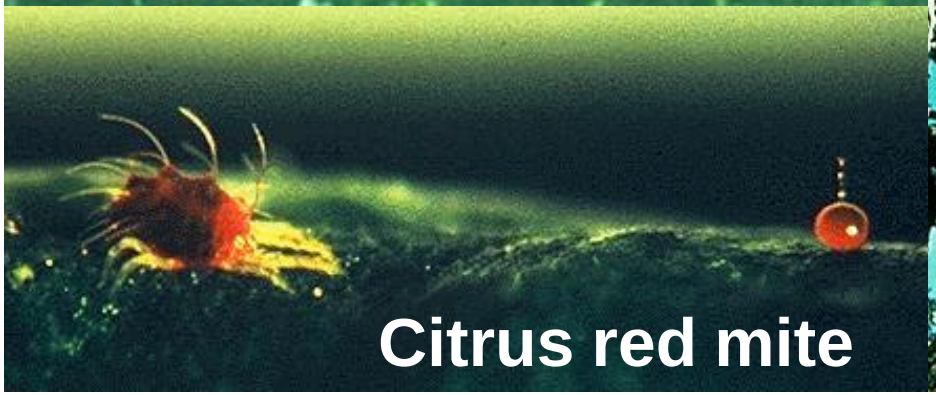
- **All trees:**
  - **Spider mites**
  - ***Diaprepes* and other root weevils**
  - **Selenisa (irrigation tube perforator)**
  - **BENEFICIALS**
- **Young trees:**
  - **Leafminers, orange dogs, fire ants grasshoppers, black scale, aphids, psyllids**
- **Fresh fruit:**
  - **Orchid thrips (grapefruit), armored scale**
- **Fresh and process fruit:**
  - **Grasshoppers, stinkbugs**

While any pest could be on any tree, some pests present potential problems for certain classes of trees. Pests of new flush such as leafminers, aphids and psyllids are most damaging to young trees that flush often. Young trees are also especially susceptible to damage from fire ants, orange dogs, grasshoppers and black scale. Spider mites and root weevils can cause problems on all size trees, although young trees are again more susceptible. In addition to rust mites, armored scales can blemish fresh fruit and orchid thrips can cause ring spots at touch points on grapefruit. Fresh or process fruit is subject to damage from grasshoppers and stinkbugs. And watch out for larvae of the moth *Selenisa sueroides* that can perforate micro-sprinkler tubing while. looking for pupation sites. In addition to pests, scouts should always be on the lookout for beneficial insects and mites that are so necessary to successful pest management and whose presence indicates health and resiliency of the grove.

Spider Mites:

- Dry weather
- Upper leaf surfaces
- Stippling





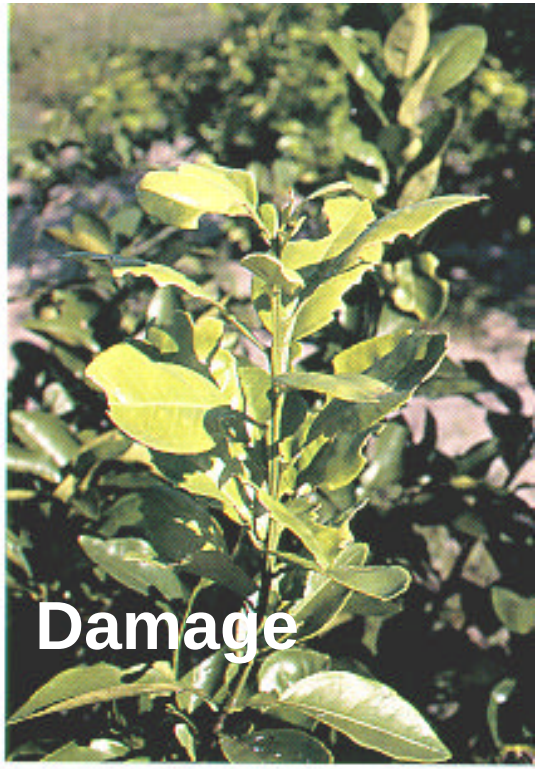
Spider mites are always present, although they are most likely to reach damaging population densities during dry weather. Spider mites prefer to feed on upper leaf surfaces of recently hardened leaves.They are considerably larger than rust mites and feed deeper in the leaf tissue. Groups of leaf cells thus emptied of contents leave white spots known as stippling. Heavy stippling my lead to leaf desiccation known as “firing”, especially when trees are stressed by drought, dry winds or other factors. The two most common spider mite pests in Florida are the citrus red mite, *Panonychus citri* and the Texas citrus mite, *Eutetranychus banksi*. All stages of the former are red including the eggs which are round and secured by silk guy wires to a silk mast. The Texas mite is greenish and the eggs are button-shaped. Both mites have 1 six-legged and 2 8-legged nymphal stages before becoming adults. Males are more elongate with longer legs than females, especially Texas citrus mite.

Scouting for Spider Mites

- **Follow CRM sample pattern**
  Increase for lower threshold
- **4 leaves per tree**
- **Threshold 5-10/leaf, depending on :**
- **Population trends**
  - **Predominantly males**
  - **Nymphs and females**
- **Weather**
- **Tree Condition**

When scouting for spider mites, a similar pattern can be followed as for CRM, although action threshold levels for both pests will determine how many samples need be taken for a given level of accuracy. At each stop, sample one leaf from each quadrant of the tree. The threshold of 5 to 10 mites per leaf may indicate the need to treat. Population trends can help decide what threshold to use. A predominance of younger stages and females indicates an expanding population, while a predominance of males indicates a declining population and should probably not be sprayed. Imminent rainy weather might foretell a population decline, while stressed trees would be more susceptible to firing.

Scouting and Monitoring *Diaprepes* and other Root Weevils



Adults root weevils feed on young flush and eggs are laid in adjacent older flush, sandwiched between two leaves. Within 2 weeks eggs hatch and the “neonate” larvae drop to the ground and dig in to search for feeder roots. Larvae feed on successively larger roots as they develop over a period of from 4 months to a year or more. They pupate in the soil emerge when conditions are favorable. Diaprepes is the largest and most damaging of the root weevils and can best be detected by inspecting young flush in late spring and early summer. Monitoring populations trends is important to optimize application timing and can best be done with the “Tedders” pyramidal trap. This consists of 2 interlocking triangular vanes topped with a screen cone “boll weevil” trap. Weevils emerging from the soil are looking for a dark silhouette indicating a tree trunk, and mistakenly climb up through a hole in the screen cone.

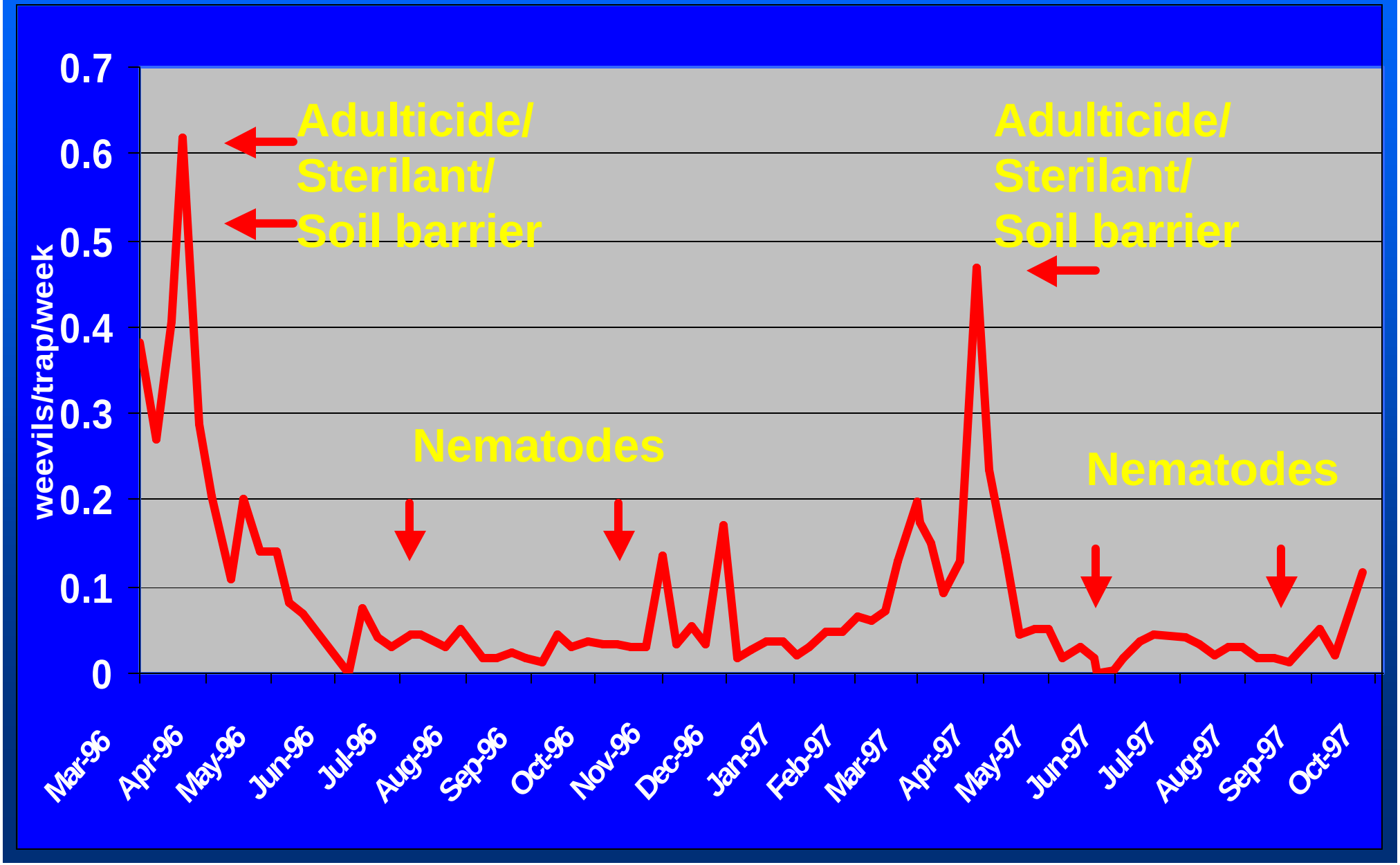
Monitoring Devices

“Tedders” trap.
Attracts emerging adult weevil by simulating a tree.

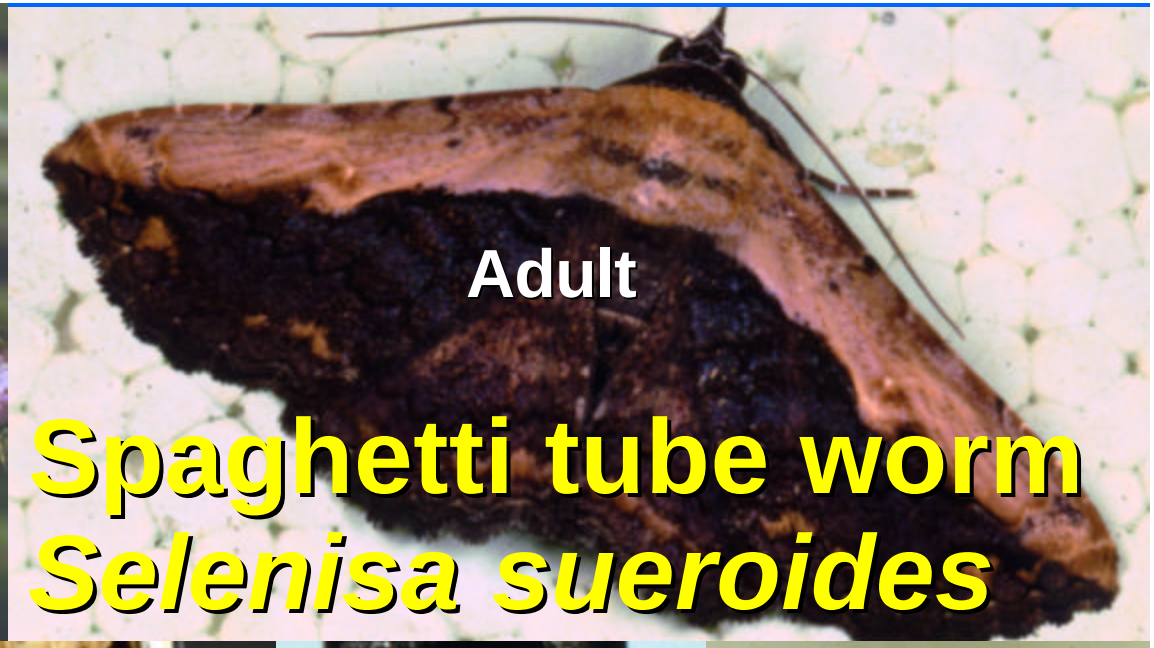
Cone or Emergence Trap

Captures all adult weevils emerging underneath.

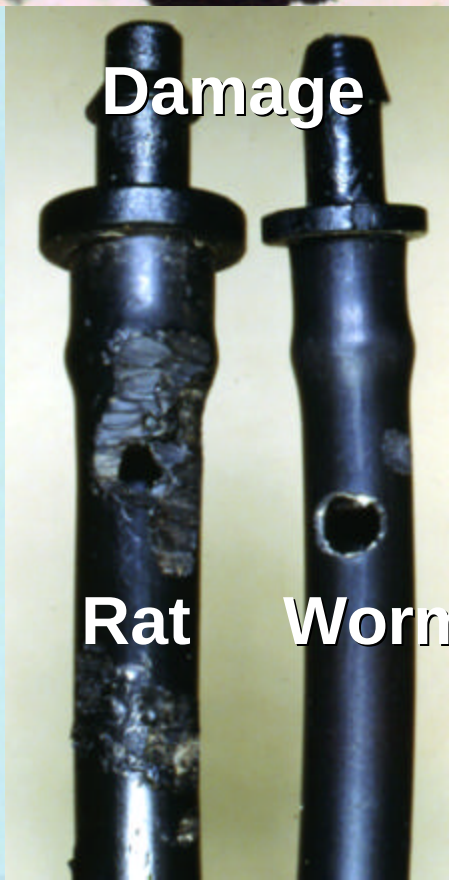
Diaprepes Emergence in Hendry County, Groves ONE and TWO Combined



Tedders trap data from established populations in irrigated groves often shows one large emergence peak of *Diaprepes* in springtime with a smaller, secondary peak in fall. This pattern indicates one primary generation per year and lends itself to planning applications for control. Treatments directed against adults, eggs or neonate larvae should be applied soon after the spring peak to achieve maximum effect. At that time largest number of adults are present and laying eggs. Nematodes directed against larvae should be applied during the summer rainy season. At this time most of the weevil population is in the larval state, and that soil moisture is optimal. See accompanying presentation of management of *Diaprepes* for further information.

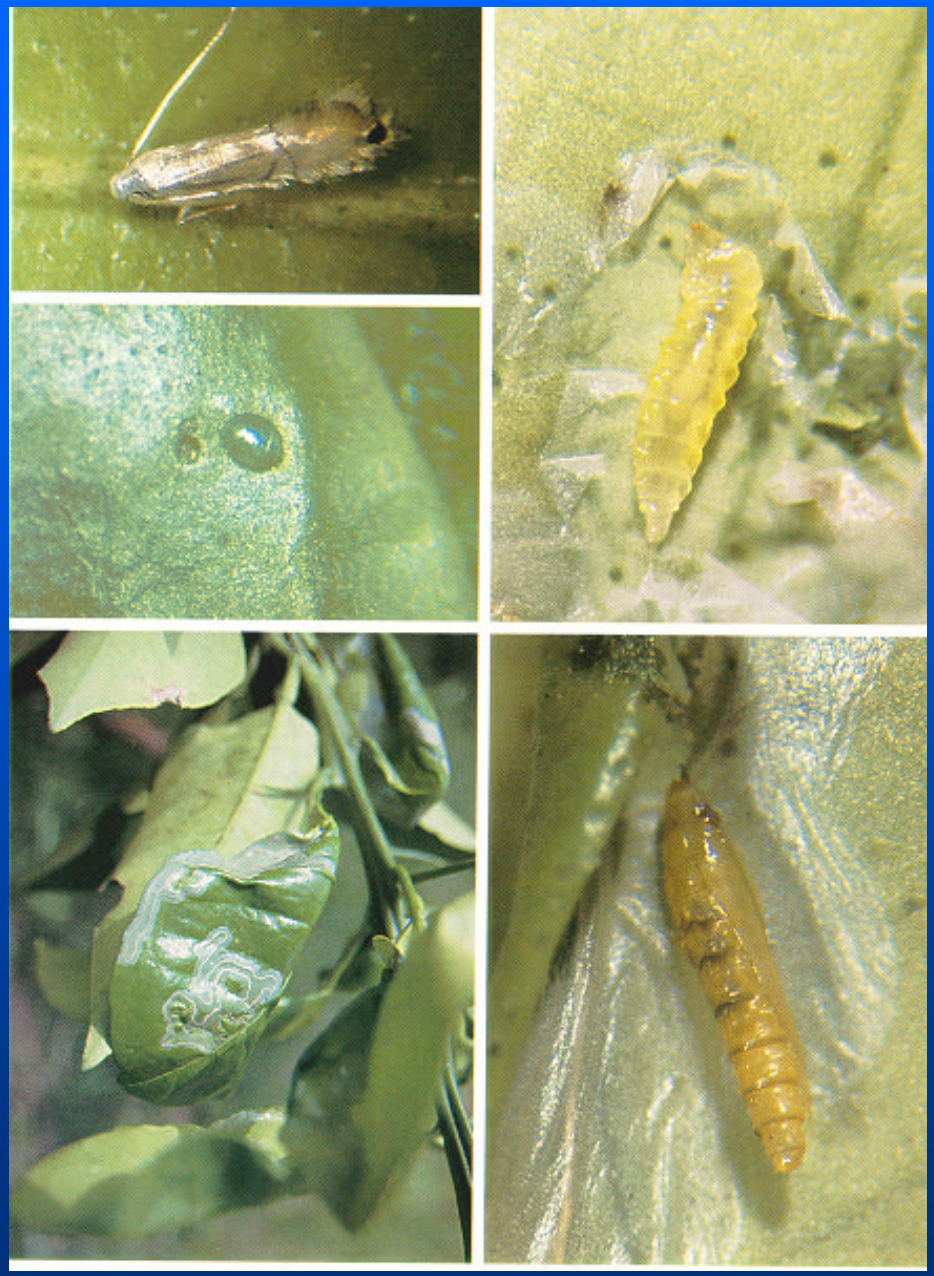


Spaghetti tube worm
Selenisa sueroides



Selenisa sueroides is a native moth whose larvae feed on legumenous weeds, particularly *Aeschynomene* but also *Sesbania* and phasey bean. In late summer or early fall, mature caterpillars move off host plants seeking hollow stems in which to pupate. The vertical “spaghetti” tubing of microsprinklers is an acceptable substitute, and the caterpillars are capable of boring through the tough, polyethylene wall. The resulting hole is about 3/8 inch in diameter and almost perfectly round, in contrast to irregularly shaped rodent damage. The larva pupates inside the tube but is jammed up against the emitter when the water is turned on. The best control is to keep legumenous weeds mowed to avoid population buildup.

Citrus Leafminer *Phylllocnistis citrella*



Citrus leafminer (CLM), is the larva of a tiny moth (*Phyllocnistis citrella*) first detected in the western hemisphere in 1993 infesting Persian limes in south Dade County. CLM probably arrived as a hitchhiker on smuggled citrus, and set a record for rapid spread by sweeping through the state in less than 6 months, south to Mexico and thence Texas within a year and throughout Central America, northern South America and the Caribbean in 2 years. Once present only in the Asian home of citrus, it now occurs in most all citrus growing regions of the world. The tiny moth becomes active at dusk, seeking young flush to lay her eggs. She most often lays a single egg on the underside of unexpanded leaves near the main vein upon which she has alighted. The tiny larva hatches directly into the leaf, usually tunneling initially adjacent and parallel to the main vein before embarking on a zig-zag path of parallel mines just under the cuticle that make efficient use of the leaf surface. A yellowish trail of excrement that dries to white follwos the worm. The mine ends at the leaf margin which the mature larva folds together with silk to make the pupal cell.

Parasitoids

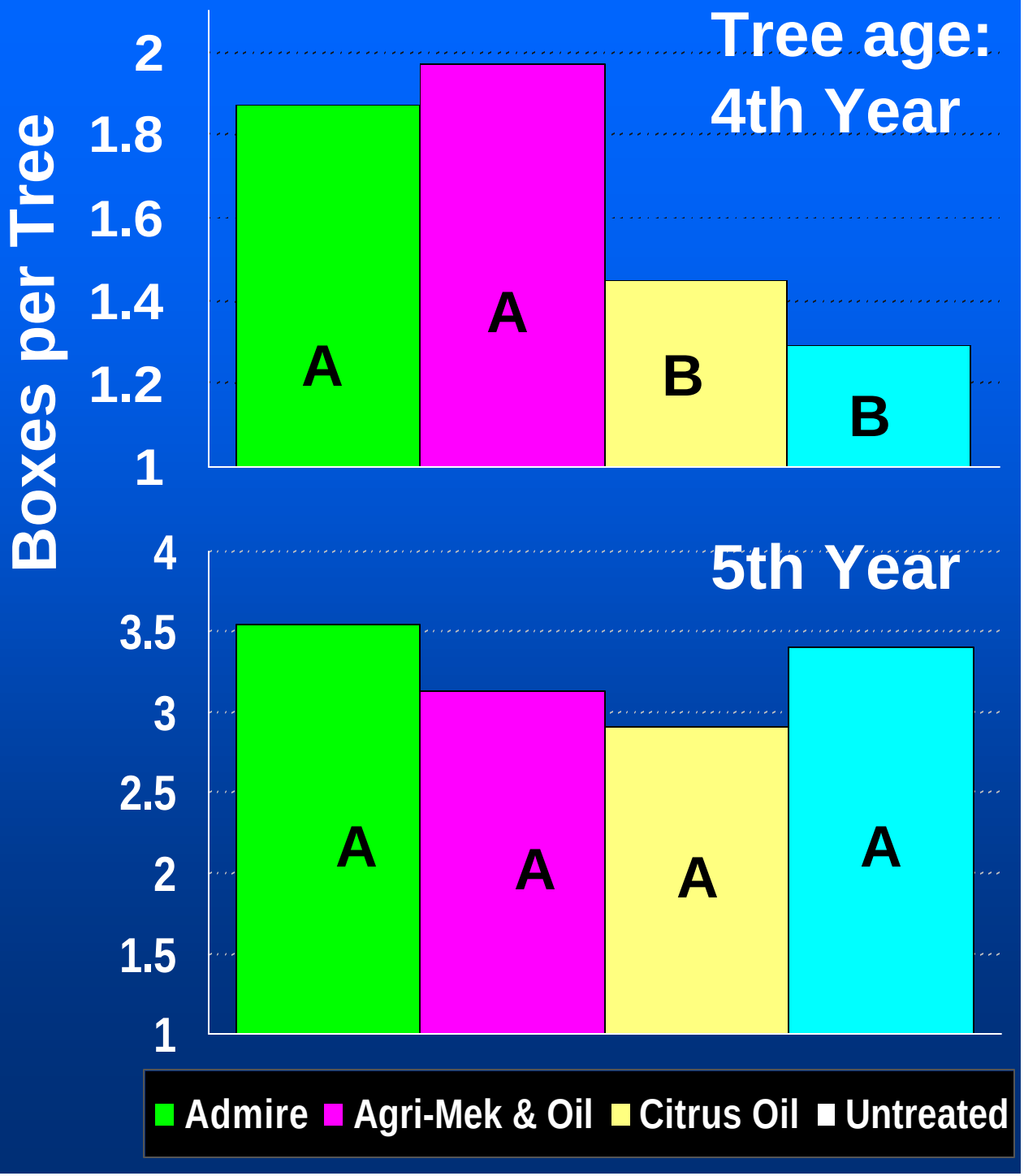
- *Ageniaspis*
  - Host specific
  - Parasitize CLM eggs
  - Internal development
  - Koinobiont
- Indigenous
  - Generalists
  - Parasitize CLM larvae and pupae
  - Most external development
  - Idiobionts

Predators: Lacewing larvae
Ants
Spiders

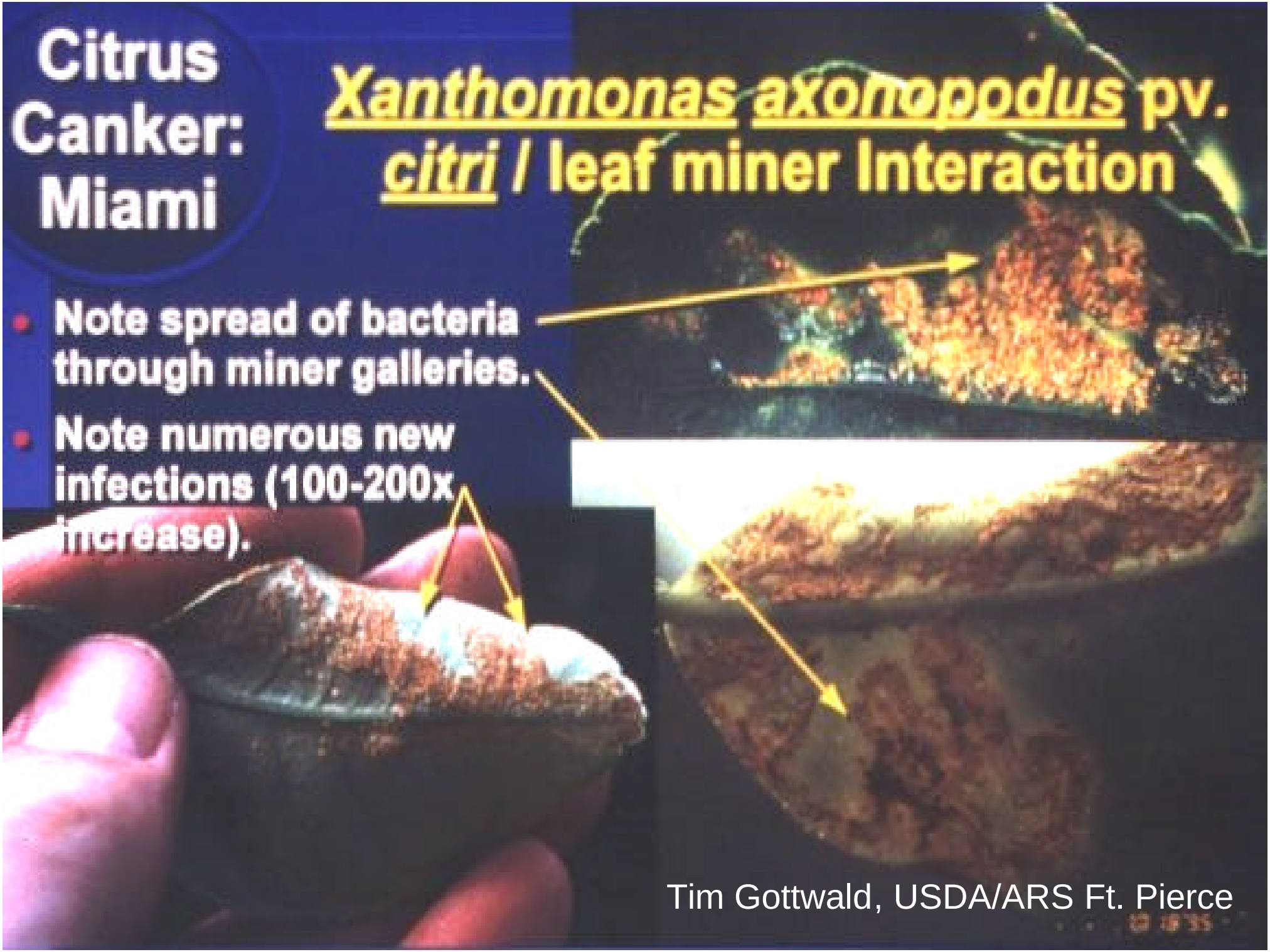
Fortunately, the initial pest explosion in Florida has gradually died down as biological equilibrium re-establishes, a frequent scenario with new invaders. An important equilibrium factor is undoubtedly hungry insect predators and parasites discovering a new food source. Their efforts have been supplemented by a foreigner, *Ageniaspis citricola*, a tiny parasitic wasp which evolved with citrus leafminer in its Asian home. The female actively seeks out the tiny leafminer egg, punctures it with her "ovipositor" (egg tube) and lays an even tinier egg inside. Instead of developing immediately, the leafminer is allowed to feed, grow and even spin a pupal cell before one or more tiny wasps consume the hapless host from within. One to 12 grubs then pupate inside the leafminer skin to later emerge as wasps in search of more leafminers.

Effect of CLM Control on Grapefruit Yield by Tree Age

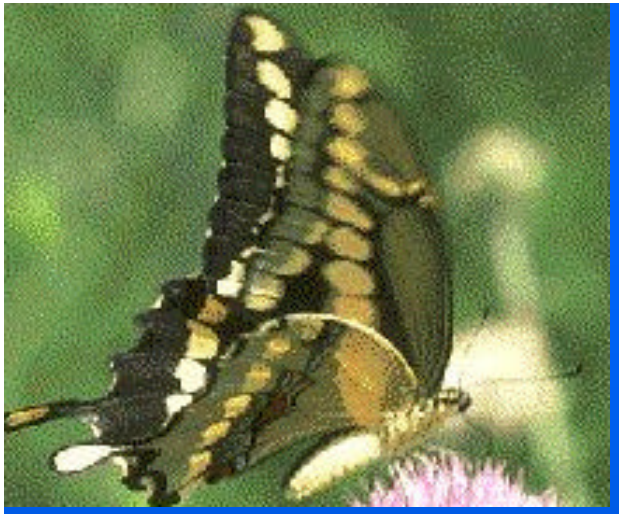
- Treatments: Oil alone, Oil + AgriMek, Admire, Control
- Applications as needed
- CLM, damage yield evaluated



Growers were at first shocked at the sight of decimated young foliage and concerned with the prospect of expensive controls. Fortunately, initial fears for the spring flush were replaced with relief when it was realized that too few leafminers survived winter to serious damage the flood of new leaves. However, attacks on successive flushes can be significant, so young trees are more susceptible to damage. Our research in 1995-96 showed that trees could be profitably protected up through the 4th year, but that subsequently, there was no measurable yield response to leafminer control.


Citrus Canker: Miami
Xanthomonas axonopodus pv. citri / leaf miner Interaction
Note spread of bacteria through miner galleries.
Note numerous new infections (100-200x increase).
Tim Gottwald, USDA/ARS Ft. Pierce

Unfortunately, the recent specter of citrus canker in the state has renewed concerns about citrus leafminer because of interaction with this disease. Although leafminers don't vector the casual bacteria, they increase the amount of inoculum by spreading it throughout the mine, forming multiple lesions. Furthermore, rupture of the cuticle caused by leafminer feeding and movement renders the leaf more susceptible to bacterial attack and therefore more likely to become infected. Hopefully, efforts to eradicate citrus canker will be successful and we continue to think of citrus leafminer only as a pest of nursery stock and young trees.



Orange Dog
Papilipo cresphontes

- Eggs laid on young flush
- Ragged, irregular damage
- Largest populations in fall
- Concern on young trees only

The “orangedog” (*Papilio cresphontes*) is a black and white larva resembling a bird dropping. The brown adult with 2 lines of large yellow spots across wing is called the giant swallowtail. Larvae may defoliate young trees, especially in late summer. They are attacked by parasitic insects such as tachinid flies. Bacillus thuringiensis ("BT") is usually recommended when an application is required since it is quite effective at low rates and will not harm beneficial insects

Imported Red Fire Ant
Solenopsis invicta

- Damage young trees
- Nest under raps, attracted to honey dew
- May plug irrigation lines Other ants as well
- Nuisance to picking crews

In most groves IRFA is the dominant ant, particularly among those foraging on the ground. While valuable as a predator of *Diaprepes* larvae and possibly other pests, it can be a pest in its own right for many reasons. Removal of bark from the base of young trees to feed on sap can induce the onset of foot rot caused by the fungus *Phytophthora spp.* The ants may also eat leaf and flower buds. Emitters may be plugged up by ants searching for water, although other ant species do this as well. Finally, they can be a serious nuisance for personnel, particularly harvesting crews. The best control for fire ants are baits containing slow-acting toxicants. Examples include (Logic® and Extinguish®) utilizing the juvenile hormone mimics fenoxycarb and methoprene respectively, and Clinch® containing abamectin. Extinguish and Clinch are labeled for use on all citrus and Logic on non-bearing citrus. Temporary control of fire ants in bearing citrus can be effected with soil-directed sprays or injections of Lorsban®. An oil spray may be sufficient to gain a few days relief for pickers.

Homoptera: Sucking Insects

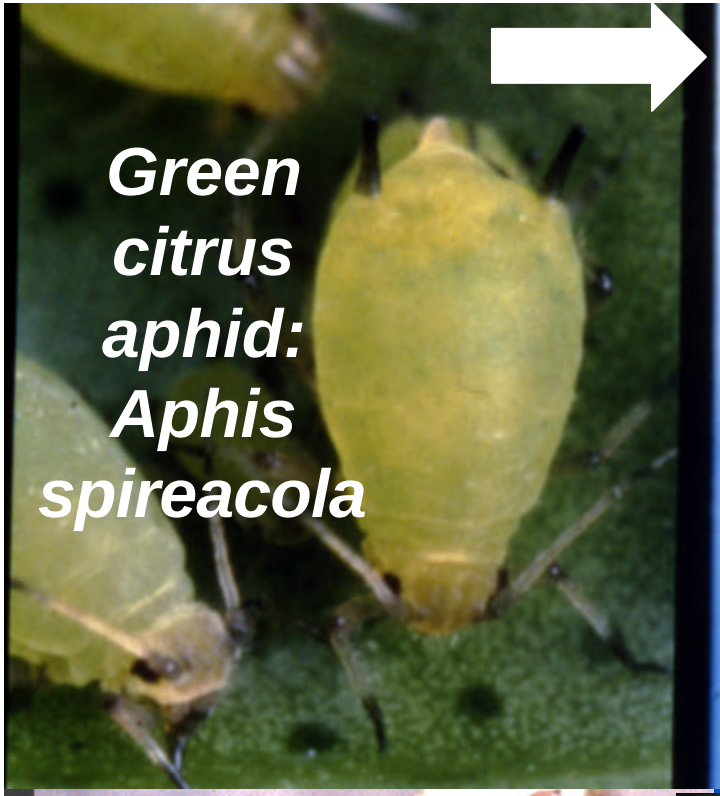
	Nymphs	Adults	Honey Dew?
Aphids	Like adults	Usually no males	Yes
Whiteflies	Immobile after crawler-scalelike	Males and females winged	Yes
Armored Scales	Only crawler mobil	Cover separates, Males winged	No
Soft Scales	Can move when disturbed and at molts	Cover attached, Males winged	Yes
Mealy bugs	Retains mobility	Waxy filaments. Males winged	Yes

Homoptera are prodigious sap feeders and all but the armored scales secret honeydew as a means of eliminating excess water and sugars thereby concentrating the more dilute amino acids and other nutrients required for growth and development. Honeydew causes the formation of black sooty mold on leaves and fruit. Sooty mold diminishes the ability of leaves to photosynthesize and also may lower fruit grade if not removed. Sooty mold can be loosed by oil sprays and usually removed in the packing house. The mouthparts specialized for sucking sap and are equipped with piercing stylets. Most feeding stages (nymphs) are immobile or move very little except for the first nymphal stage or crawler, which after leaving the egg and mother wonders on the plant surface in search of a good place to feed. Adult females may be winged and motile (aphids, whiteflies) or immobile (scales). Males are winged. Transition stages between nymph and adult whitefly and mealybug are often (incorrectly) referred to as pupae.

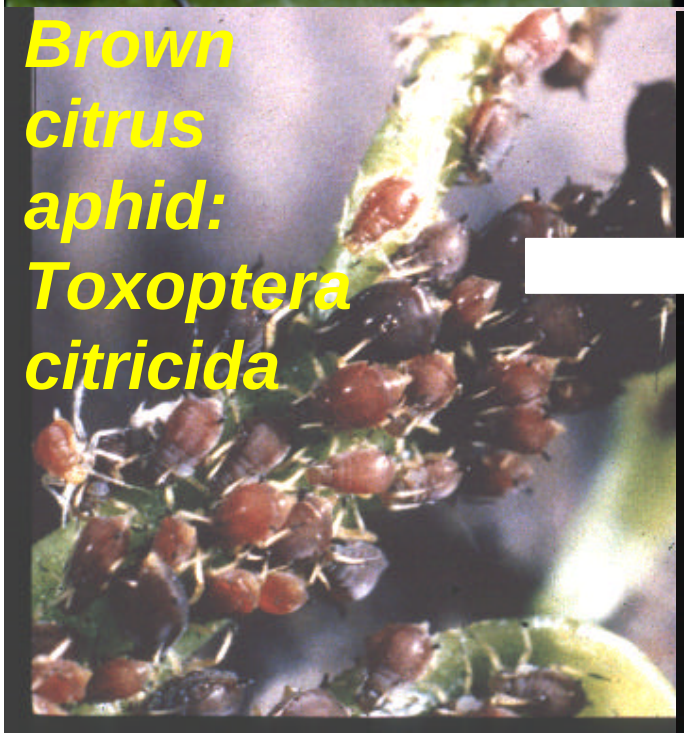
Black Scale *Saissetia spp*

- H pattern
- Nymphs on leaves, twigs
- Adults on larger limbs
- Copious honeydew
- Can’t control adults
- Spray window in spring when most crawlers emerged, parasites still protected.

The most damaging soft scale in Florida is probably black scale, *Sassiata* spp. Large adult females are found on interior branches and twigs but at higher infestation levels infest the outer canopy where sooty mold from honeydew they secret may cover fruit. High infestations most common in young groves may cause twig dieback. The first generation in spring hatches from thousands of eggs deposited underneath each female from which crawlers migrate to leaves and petioles. As scales mature they gradually move back to twigs and branches. Only early instars are susceptible to insecticides. The primary biological control agent is the wasp *Scutelista cyanea* which lays its egg under the female scale from which a grub hatches to feed on scale eggs. Insecticide applications made too late in spring may kill adult wasps and provoke high infestations later in the year.



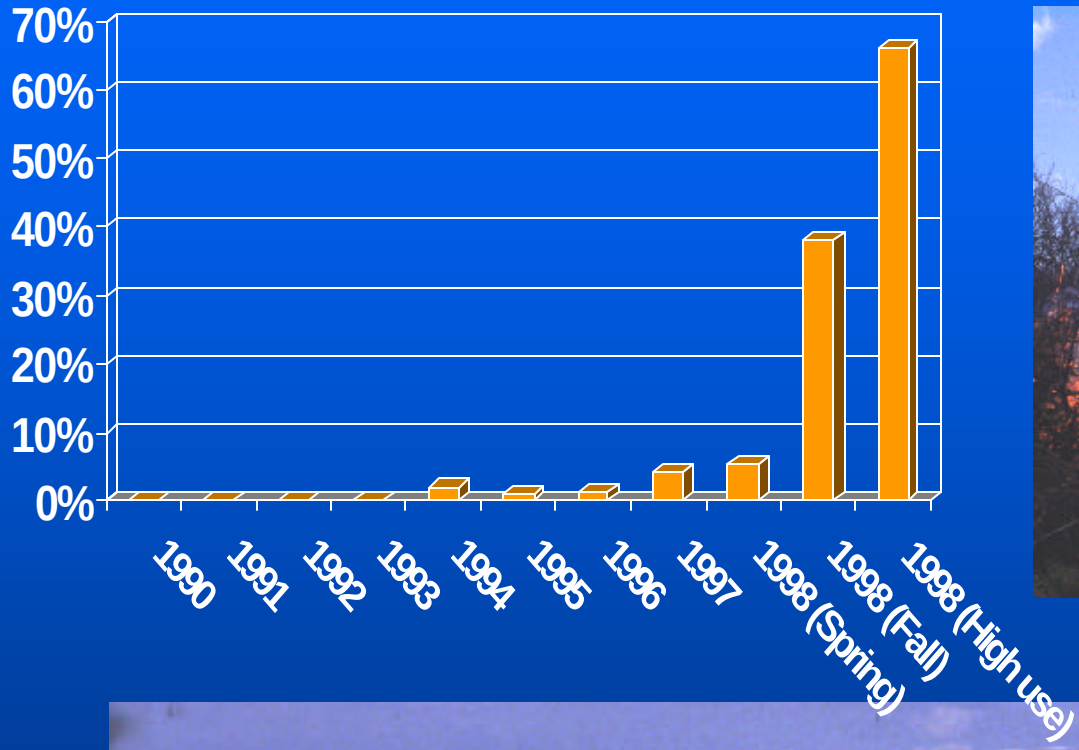
Citrus Aphids



Aphids are unarmored, having legs, antennae, and cornicles (tailpipes) which produce defensive excretions. Most reproduction in Florida is parthenogenic (asexual), males being rare or non-existent. Also young are born live so populations can build up quickly. Winged forms are produced for dispersal under crowded conditions. Nymphs and adults secrete copious honeydew and are usually attended by ants. Spirea aphid (green citrus aphid) *Aphis citricola* is small, dark green, with black legs and cornicles. Affected leaves curl tightly and remains so. Spirea aphid is rarely attacked successfully by parasitic wasps and is not a vector of citrus tristeza virus (CTV). The Brown citrus aphid *Toxoptera citricida* (BCA) is native to the orient and present in south America since the 1930's. Introduced into the Central America and the Caribbean, including Cuba in the early 1990's and first detected in Florida in 1996 its host range is limited to citrus and near relatives. It is very prolific under favorable conditions and is the most efficient vector of CTV. All citrus budded to sour orange is inevitably killed out within a few years after BCA is introduced. Also transmits "stem pitting" strains of CTV not yet seen in Florida which cause stunting and reduction of fruit size and yield. Attacked by the wasp *L. testicipes* which seldom, however, successfully emerges.

Severe CTV: Immokalee Budwood Grove

Problem



Solution

One of the first casualties of the brown citrus aphid was the citrus budwood grove at our Center in Immokalee. Every tree had been indexed yearly for severe CTV and all infected trees were pulled and burned. However, in 1998 we saw a rapid increase in incidence following a heavy infestation of the aphid a year earlier. Since all budwood in Florida must be certified free of severe strains of CTV, our only recourse was to grow budwood in a screen house.

Better Biological Control of BCA = Fewer CTV Transmission = Slower Spread of Stem Pitting

Habitat Manipulation

Native *L. testicipes* attacks BCA but develops poorly. Alternate hosts are needed and better adapted species can be brought in.

Predators need alternate prey to maintain numbers in the grove

Given high levels of severe CTV inoculum in most of Florida, it is likely that the 20% of our citrus budded to sour orange rootstock is doomed. However, CTV still presents a danger for citrus on tolerant rootstocks due to so-called stem pitting strains that cause injury regardless of rootstock. These strains are presently rare in Florida but may increase in response to selection pressure from the aphid. Since this selection pressure is a function of the aphid population, biological control could forestall movement of stempitting strains into our groves by decreasing aphid populations. Two ways of increasing biological control are introduction of new species parasitic wasps, and manipulation of habitat to provide refugia and alternate prey for beneficials when aphids get scarce.

Citrus Psylla and Greening

Psyllids or jumping plant lice belong to a family (psyllidae) of aphid-like insects. However, they are different from aphids by the presence of jumping legs, the absence of cornicles, presence of eggs and winged males in all generations. Like aphids they inhabit young flush, secreting honeydew and causing leaf distortion. However, psyllid adults are stronger fliers than aphids and can survive longer without fresh flush. Asian citrus psylla was first reported in Florida in June, 1998. It can transmit “greening disease” caused by a phloem-limited bacteria. Greening is the most serious disease of citrus in Asia but has not yet been reported in the U.S.

Biological Control:

Tamarixia radiata
External Parasite
Released June, Hendry and Collier Co

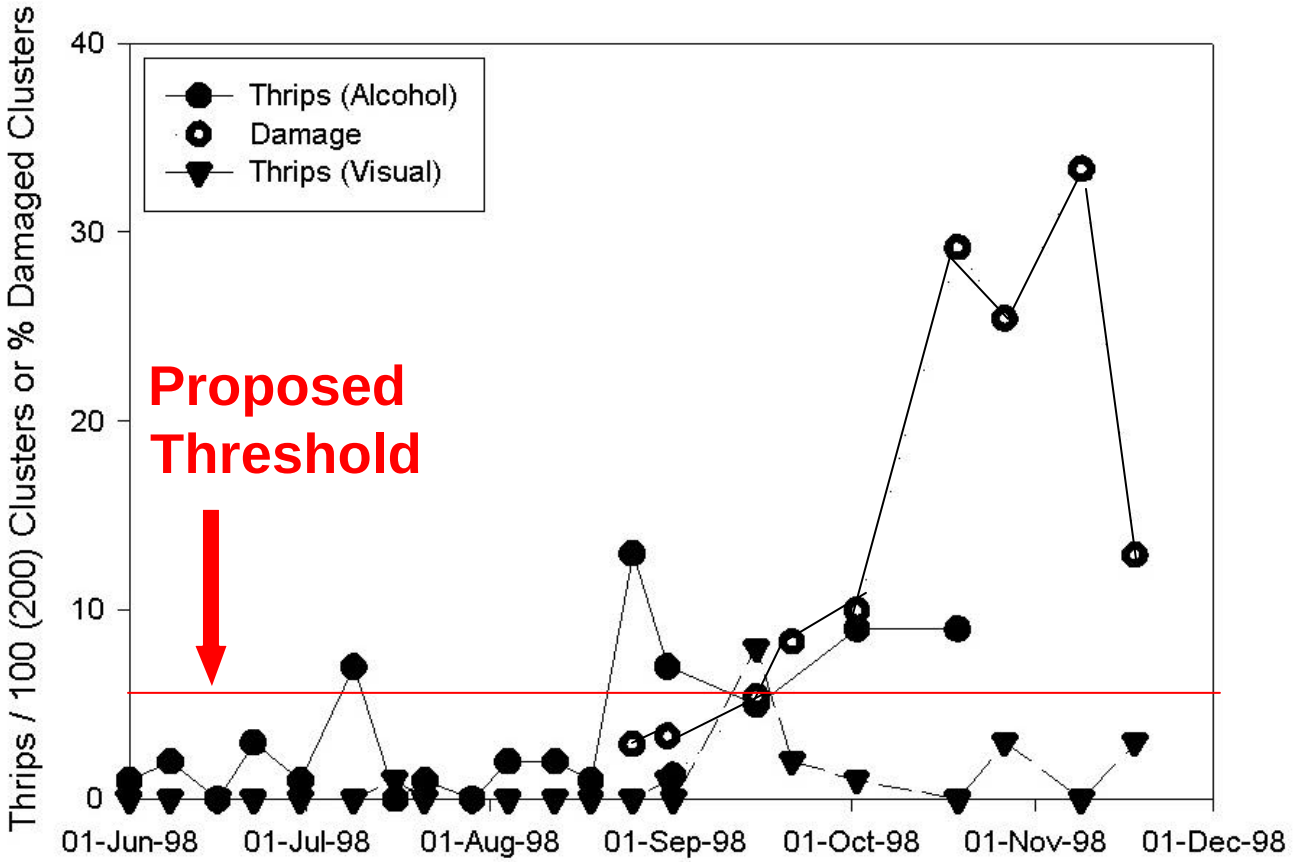
Diaphorencyrtus aligarhensis
Internal Parasite
Not yet released

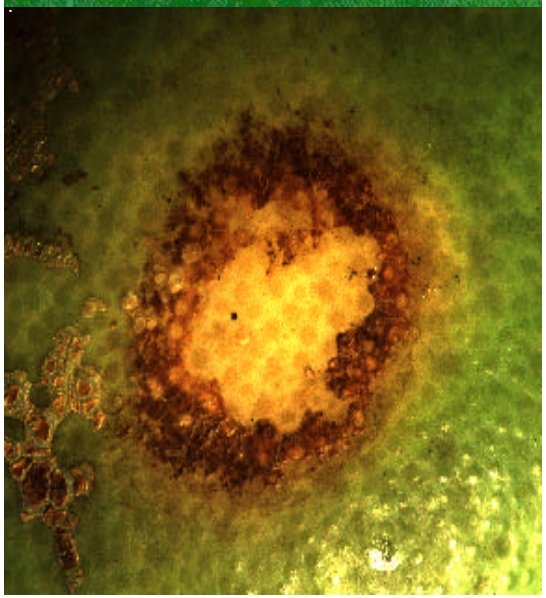
Parasitoids supplied by
Dr. Marjorie Hoy, UF Gainesville

Two species of parasitic wasp from Asia are being released in Florida. Preliminary results indicate that the external parasite, *Tamarixia radiata* is becoming established.

Threshold for Ringspot Damage on Red Grapefruit

Carl Childers & Phil Stansly

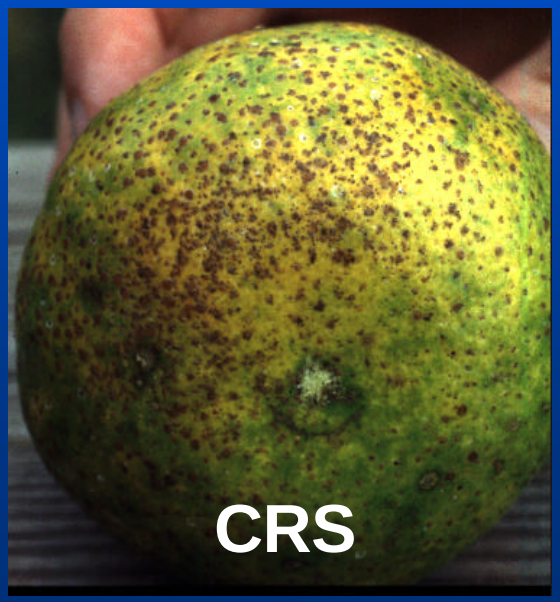




Plant-feeding thrips are tiny insects most commonly found in flowers. Immature stages have no wing buds and are called larvae. When feeding stops they enter into 2 "prepupal" stage which drop to the ground and pupate. Adults resemble larvae and feed the same way, sucking out plant contents as do mites. High populations of the common flower thrips *Frankliniella bispinosa* in spring time has been associated with decreased fruit set in Florida. Feeding of the orchid thrips and other related species has been associated with ring-spot injury of grapefruit.

Scouting for the thrips on grapefruit is virtually impossible because of their rapid movement and the fact that so few can cause significant injury. However, it is possible to see nascent damage before serious injury develops. In this study done with Carl Childers (UF/CREC) we saw that 3% early damage corresponded to 10% fruit infested and, if treated at that time, would avoided serious injury.

California Red Scale and Florida Red Scale



- Armored scales now only occasional pests of Florida citrus
- CRS still principal pest of citrus in dry climates
- Insecticides can aggravate scale problems

Stink Bugs and Leaffootted Bugs

- Thin skinned varieties most susceptible (Hamlin)
- Perforate fruit, introduce pathogens
- Build up on weeds

Hemiptera are sucking insects with the first pair of wings thickened at the base. Many give off a distinct odor when handled are called stinkbugs. Damage by piercing fruit causing blemishes and allowing pathogens (disease organisms) to enter fruit. They are generally considered minor pests. The citron bug and leaffooted bug (family Coreidae) are brown, narrow, moderate size and common on certain weeds. Southern green stink bug (*Nezara viridula* is broad, with smooth "shoulders" and green. It is a pest of many crops and also common on many weeds and leguminous cover crops. Scout margins and weedy areas. Keep weeds and cover crops mowed. Spot treat if necessary.

Grasshoppers, Katydids, Crickets

- Build up on weeds.
- Large nymphs most damaging
- Foliar damage irregular (like orange dog)
- Occurrence usually localized in grove

Most grasshoppers that feed on citrus have relatively short antennae and lay their eggs in the ground. There are four nymphal stages, the last of which is more damaging than the adult, sometimes causing defoliation of young trees, damaging bark and fruit. Nymphs of the Eastern lubber grasshopper (*Romalea microptera*) are black with yellow markings. Adults also have red markings; are large and heavy with small wings and cannot fly. The American grasshopper (*Schistocerca americana)* is light brown with black markings, smaller than the lubber with adults that fly. Katydids have long, hair-like antennae and wings resembling leaves. With the long blade-like ovipositor the flattened eggs are inserted into leaf margins by the female. Bush crickets live above the ground in vegetation and may damage fruit.

Scout margins and weedy areas especially. Disk or mow in weeds before grasshopper have time to develop. However, mowing weeds which already have grasshoppers in them could force them onto trees. Spot treatments with insecticides may be necessary to control localized populations.

Types of Biological Control Agents:

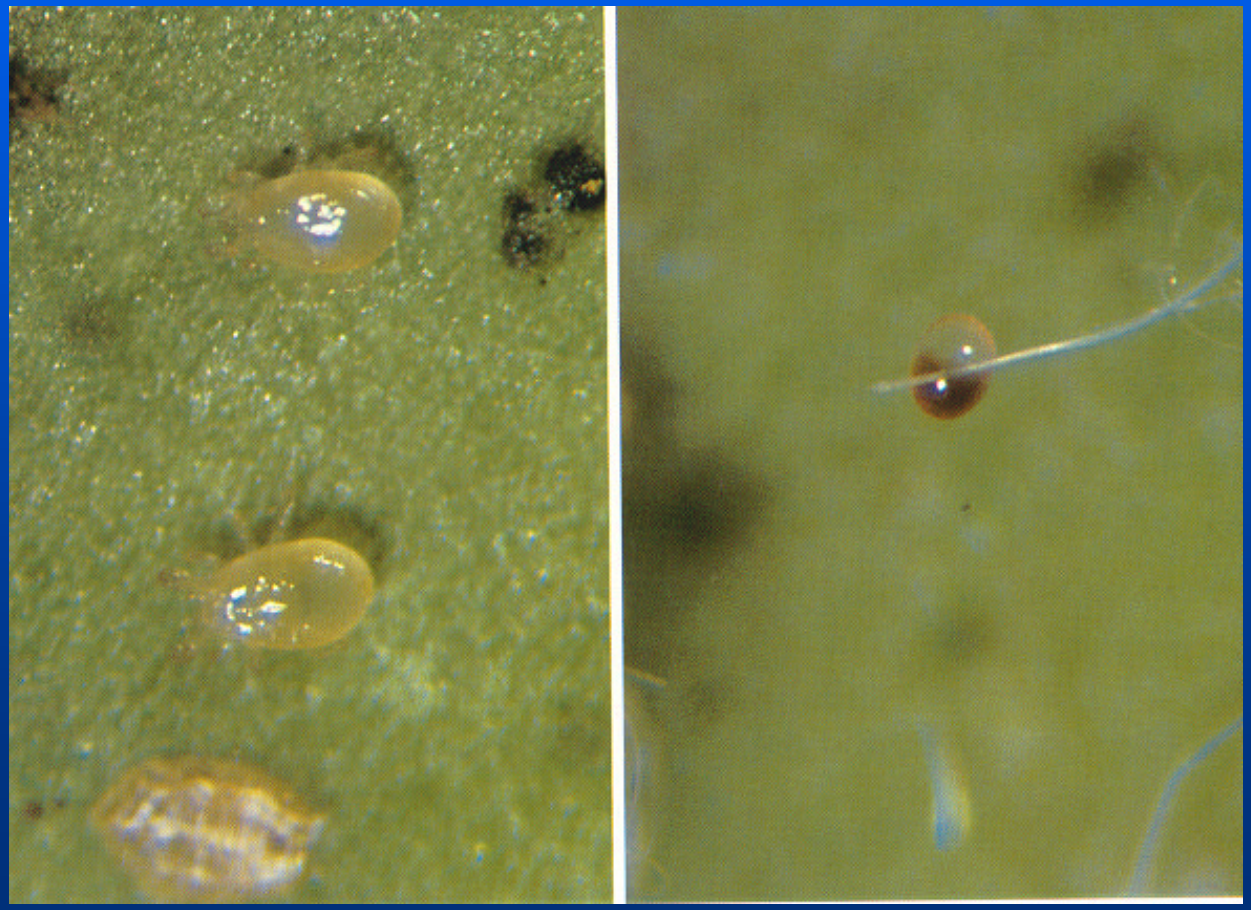
- Predadores
- Parasitoides
- Pathogenes

Biological control is the most important control strategy in Florida citrus. Since most citrus pests are from Asia, their most effective natural enemies have been brought from there (“classical” biological control). Natural enemies can be conserved through reduced pesticide use, use of selective pesticides, and by providing them alternate habitat and food sources. They can be classified in 3 broad categories: Predators that must consume numerous prey to complete development and include ladybeetles (large orange type) adults and larvae, lacewing larvae including trash bugs, syrphids (hoverfly) larvae, ants, spiders and others. Parasitoids that are usually small wasps or sometimes flies and lay eggs on or in the host where larvae develop. Pathogens that are microorganisms including nematodes, fungi, bacteria and viruses that attack pests. These natural enemies represent the next trophic level utilizing plant-eating pests for food and thus helping to maintain a healthy equilibrium in the grove. Scouts should become aware of natural enemies and learn to evaluate there populations or incidence as an important indicator of grove health and resiliency.

Predators: Ladybeetles

Predators: Lacewings

Predaceous mites



Parasitoids: Parasitic wasps

Encarsia spp

Pathogens: Fungi

Pathogens: Nematodes

- Specific to insects
- Exist naturally in soil
- Seek out host
- Contain symbiotic bacteria that attack host from within
- Commercial preparations applied with herbicide rig or through microjets