BIOLOGICAL CONTROL:

- Peppers and tomatoes are not native to Florida – they were introduced. They are attacked by pests that are native to Florida and whose food is related native plants (usually of the same plant family) and pests that arrived from elsewhere.
- Beneficial insects to agricultural crop production include those that act as pollinators as well those that serve as predators or parasites of pest insects.
- It is well known that pollinators are a necessary part of most fruit and vegetable production schemes.
- The presence of a natural population of biological control organisms can be maintained by any number of production practices, including use of low risk pesticides and the introduction of additional flowering plants as a nectar and pollen source.

HABITAT MANAGEMENT:

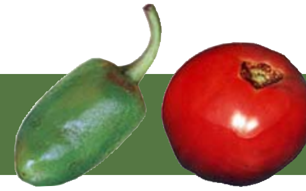
- Habitat management to enhance biological control refers to the establishment of environmental conditions amenable to natural enemies that increase and sustain their populations and improve their effectiveness in controlling pests.
- Population processes such as colonization, dispersal and foraging movements of predators can be influenced by habitat modifications.
- On farms, such dynamics of natural enemy populations can be altered through management of within-field strips, cover crops, field margins, hedgerows, fencerows, windbreaks, irrigation or drainage ditches and roadside margins **(Figures 1-3)**.

Figure 1. Bigeyed bugs are commonly found on wild plant species. Photograph by: Lyle Buss.

Figure 2. Ryegrass can act as a habitat for biological control organisms as well as a windbreak between crop rows. Photograph by: Phyllis Gilreath.

Figure 3. Some weeds in border areas can provide a habitat for natural enemies to harbor between growing seasons. Photograph by: Eric Simonne.

Prepared by: Drs. Jennifer Gillett and Howard Frank



BIOLOGICAL CONTROL: Introduction

Three forms of biological control are generally recognized:

- Manipulative or Conservation Biological Control
- Classical or Inoculative Biological Control
- Augmentative Biological Control

Here is how they apply in pepper and tomato production in Florida.

CONSERVATION BIOLOGICAL CONTROL:

- Native pests have native natural enemies such as predatory mites, predatory stinkbugs, minute pirate bugs, numerous species of parasitoid flies and small parasitoid wasps.
- For much of the time these native natural enemies keep the pests in check. However, these native natural enemies are at a disadvantage in some situations.

Figure 4. *Larra bicolor*, a parasitoid wasp, acts to pollinate while feeding on nectar. Photograph by: Lyle Buss.

Problem: The adult beneficial flies and wasps typically need plant nectar for energy – if their favorite nectar plants are absent in a large field containing nothing but the crop plant they may function well around the edges but not in the middle of the field.

Solution: Plant their favorite nectar-source plants in windbreaks (in a typical production field) or as patches in an organic production field **(Figure 4)**.

- Research needs to be done before the most appropriate plants and their optimal spacing is determined.
- Such plantings have been researched for other crops in European countries and they have proven highly effective.

Problem: Broad-spectrum chemical insecticides are usually deadly to natural enemies.
Solution: try not to kill the beneficial organisms.

- Use of the newer narrow-spectrum chemicals, minimization of use of chemicals, and appropriate timing of their use will help conserve natural enemies **(See Table 1 on pg. 197)**.

CLASSICAL OR INOCULATIVE BIOLOGICAL CONTROL:

- Pests that have arrived from elsewhere are the normal targets of classical biological control.
- These pests arrive without the specialist natural enemies that hold them in check in their countries of origin.
- Once natural enemies have been established, they need attention just like native natural enemies.
- Plants that can provide beneficial insects with nectar may help increase their numbers where their action is required.
- There is no guarantee that classical biological control attempts will be successful.
- Example: parasitoid wasp introduced and released against pepper weevil has not yielded much control and may not do so.
- Classical biological control research is a worthwhile endeavor because when it works the results are free.

Example: Pest mole crickets arrived a century ago in ship ballast from southern South America.

In the 1980s University of Florida researchers brought specialist natural enemies of mole crickets from South America, released them in Florida and established populations.

The intent was that these established populations should spread and eventually provide Florida-wide control of pest mole crickets.

The natural enemies were a fly, a wasp and a nematode. All are now present in many counties but none is yet known to be present in all counties, although given enough time they should get there.

Prepared by: Drs. Jennifer Gillett and Howard Frank

AUGMENTATIVE BIOLOGICAL CONTROL:

- Some natural enemies have been produced in large numbers by researchers and released experimentally in the field to augment the numbers already present.
- Sometimes this has resulted in a satisfactory level of control of pests.
- A few natural enemies are mass-produced and sold. Some of them are highly effective when used in greenhouse culture but are not economical for use in field production.
- In a greenhouse, the natural enemies (biocontrol agents) have no option but to do their job (attack the pests) or die. In a field crop they have a new option — to leave the field to find resources such as nectar.

- Examples of purchased natural enemies that can be effective in the field are *Bacillus thuringiensis* var. *aizawai* against cabbage looper and soybean looper, and *Steinernema scapterisci* against pest mole crickets.
- Nematodes were introduced to Florida as a classical biological control agent. It is being produced and sold commercially as a biopesticide. It can augment and establish the beneficial nematode population already in the field **(Figure 5)**.

Figure 5. *Steinernema scapterisci*, a nematode, is commercially used as a biopesticide against mole crickets. Photograph by: Khuong Nguyen.

ATTRACTING BENEFICIAL INSECTS INTO CROPPED FIELDS:

- Farm management to enhance the presence of beneficial insects refers to the establishment of food resources and habitat required by these species that increase and sustain their populations.
- Pollinators and parasitoids can be influenced to be present in cropped fields by including nectar producing flowering plants. For example the planting of sweet alyssum (*Lobularia maritime*) around cabbage fields is thought to increase longevity of parasitic wasps that are beneficial in reducing pest populations in the field.
- Insect predators and parasitoids of crop pests can be influenced to take up residence within cropping systems by providing habitat for them.
- These natural enemies can be attracted to cropped areas and their numbers increased by including within-field habitat strips, select cover crops, proper management of field margins, hedgerows, fencerows, windbreaks, irrigation and drainage ditches and roadside margins.

MICRO-SIZED GOOD GUYS:

- Just like people and plants, insects get diseases.
- Entomopathogens or insect killing diseases are an important aspect of IPM, because they are usually species or group specific killers that do not harm non target insects.
- Although many micro-sized good guys are found in nature, augmentation or spray applications of these biological controls can benefit other natural enemies in your cropping system.

- *Bacillus thuringiensis* or *Bt* as it is commonly referred to is a bacteria that infects and kills many larval pest insects, it usually safe to use around beneficial insect species.

- *Nuclear polyhedrosis virus* can be thought of as the HIV of the insect world, this viral killer can control many moth larvae.

References:

Jones, G.A. and J.L. Gillett. 2005. Intercropping with sunflowers to attract beneficial insects in organic agriculture. Fla Entomologist. 88(1): 91-96.

Frank, J.H., T.R. Fasulo and D.E. Short 2002. MCricket: Alternative Methods of Mole Cricket Control. http://molecrickets.ifas.ufl.edu/ (28 June 2006).

Frank, J.H. and J.P. Parkman 1999. Integrated pest management of pest mole crickets with emphasis on the southeastern USA. Integrated Pest Management Reviews 4: 39-52.

Frank, J.H., J.P. Parkman and F.D. Bennett. 1995. Larra bicolor (Hymenoptera: Sphecidae), a biological control agent of Scapteriscus mole crickets (Orthoptera: Gryllotalpidae), established in northern Florida. Fla Entomologist 78: 619-623.

CONTACT INFORMATION:

Dr. Jennifer L. Gillett
UF/IFAS Entomology and Nematology Dept.
Gainesville, FL 32611-0620
gillett@ifas.ufl.edu
352-392-1901 ext. 122

Dr. Howard J. Frank
UF/IFAS Entomology and Nematology Dept.
Gainesville, FL 32611-0620
frank@ifas.ufl.edu
352-392-1901 ext. 128

The following sheets explain the biology and importance of several biological control organisms.

Mole Cricket Nematode
Steinernema scapterisci

Description:

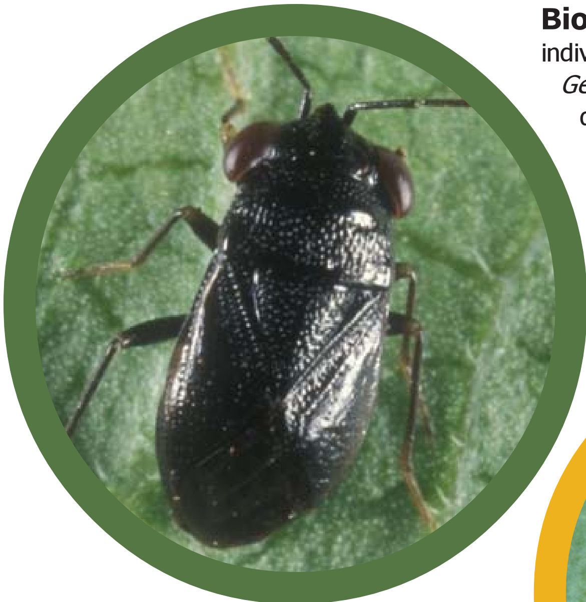
The most important insect pests of turf and pastures in Florida are mole crickets. Their feeding and tunneling also destroy seedlings of tomato and pepper. *S. scapterisci* is specific to mole crickets. The nematode was successfully introduced by inoculative applications in golf courses and pastures in Florida. The insecticidal nematode *S. scapterisci* is produced and marketed as a biopesticide under the name Nematac S®. When it is applied according to directions as a biopesticide, it will kill a high percentage of pest mole crickets within a few days. It will not harm other insects, plants, animals or humans.

This nematode has a special advantage: it reproduces inside pest mole crickets and its progeny are released into the soil. The progeny can persist, generation after generation, for years so long as a few pest mole crickets remain. The progeny will spread, carried by infected mole crickets. This means that the nematode can provide years of suppression of pest mole cricket populations. It is compatible with the use of most chemical insecticides (for killing other kinds of pest insects). It is not compatible with the use of chemical nematicides.

Adapted by J.L. Gillett from EENY-92 Featured Creature by: K.B. Nguyen.

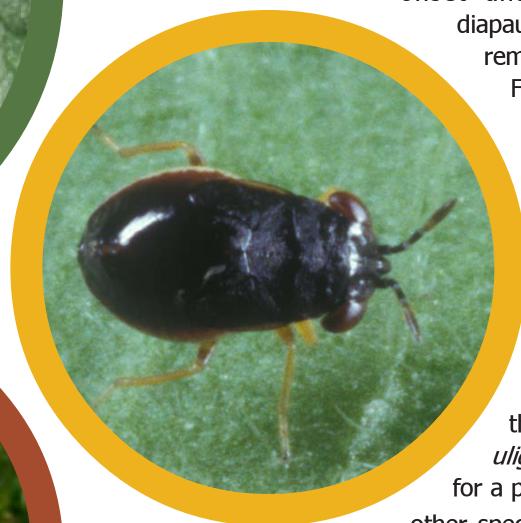
Photograph by: Lyle Buss.

Bigeyed Bug, *Geocoris punctipes, uliginosis* & *bullatus*



Biology and Lifecycle: Eggs are laid on plants. The biologies of the individual species of bigeyed bugs in Florida are somewhat similar. Females of *Geocoris punctipes* lay 75 to 150 eggs, depending on the quantity and quality insect prey. Eggs hatch in 6 to 10 days. Development of the nymphal instars requires almost 20 days, depending on temperature. The adults live over three weeks.

Environmental Factors: Bigeyed bugs overwinter in northern Florida from November to March as mated females in reproductive diapause. A combination of day-length and temperature influences the onset and duration of reproductive diapause. A portion of the population remains active during the winter in Florida, even in the northern part of the state.



Adult: Small oblong, elliptical bugs about 1/16 inch in length. Several features separate bigeyed bugs from similar bugs. The head is broader than long and the prominent eyes curve backward and overlap the front of the pronotum. The color of *G. uliginosis* is nearly all black except for a pale border along each side. The other species are pale above.

Immatures: The nymphal instars are oblong, elliptical. Late instars have wingpads. The color of the head and thorax of *G. uliginosis* late instar nymphs is dark brown. The color of the head and thorax of the nymphs of other species is pale.

Host Species: Abundant on crop and wild plant species.

Habitat/Nutritional Requirements: These predatory bugs feed on plant juices without causing damage to the plants. These predators are generalists feeding on many small insects and insect eggs.

Effectiveness: Integrated pest management programs are designed to conserve populations of predatory bugs and other natural enemies through the use of cultural tactics, pest resistant crop cultivars and reduced-risk insecticides. This predator feeds on aphids, mites, whiteflies, thrips and the eggs of numerous species of pests.

Figure 1. Adult *Geocoris uliginosis*. Photograph by: Lyle Buss.

Figure 2. Nymphal *Geocoris uliginosis*. Photograph by: Lyle Buss.

Figure 3. Adult bigeyed bug, *Geocoris* sp. feeding on a whitefly nymph. Photograph by: Jack Dykinga, USDA.

References:

Mead, F.W. 2004. Big-eyed bugs *Geocoris* spp. (Insecta: Hemiptera: Lygaeidae). UF/IFAS Pub. EENY-252.

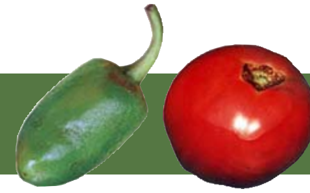
Reitz, S.R., E.L. Yearby, J.E. Funderburk, J. Stavisky, M.T. Momol and S.M. Olson. 2003. Integrated management tactics for *Frankliniella* thrips (Thysanoptera: Thripidae) in field-grown pepper. Journal of Economic Entomology 96:1201-1214.

Coll, M. and J.R. Ruberson (editors). 1998. Predatory Heteroptera: Their Ecology and Use in Biological Control. Entomological Society of America, Lanham, Maryland.

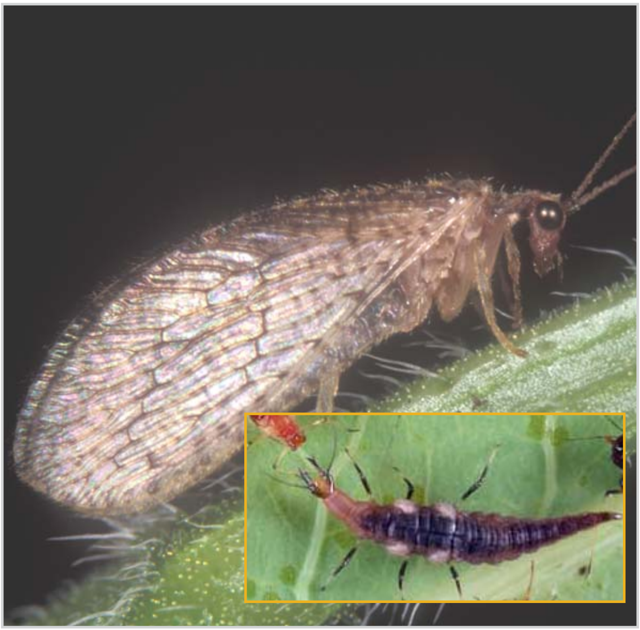
CONTACT INFORMATION:

Dr. Joe Funderburk
UF/IFAS NFREC
155 Research Rd
Quincy, FL 32351-5684
jef@ufl.edu
850-875-7146

IPM Integrated Pest Management Florida
UF UNIVERSITY of FLORIDA IFAS Extension



Brown Lacewing
Neuroptera: Hemerobiidae



Description:

Brown lacewings are small to medium-sized insects (forewing length 3 to 9 mm in Florida) which are predaceous both as adults and larvae. They prefer soft-bodied insects such as aphids, mealybugs, and also insect eggs. Because of the longevity of the adults (at least months in some species), voracious appetites (for example, *Micromus posticus* larva consumed an average of 41 aphids during its life, and high reproductive capacity (one female *Hemerobius humulinus* can lay 460 eggs, they are useful biological control agents. Some species have been utilized for this purpose. Females lay non-stalked eggs, usually singly or in small groups. Most groups appear to prefer aphids.

Adapted by J. L. Gillett from EENY-225 Featured Creature by: E.G. MacLeod and L.A. Stange. Photographs by: Lyle Buss.

Green lacewing
Chrysoperla

Description:

Green lacewings commonly occur in Florida and the lacy-looking adults are quite recognizable. Like lady beetles, lacewings are often found associated with aphid colonies. Unlike lady beetles, the adults do not always feed on insects and the larva is the beneficial stage. The large sickle-shaped mouthparts apparent in the larval stage are very effective for clamping onto prey and draining their body contents. The eggs of lacewings are placed in clusters on long thin stalks. Lacewings feed on insect eggs, scales, mealybugs, and mites as well as aphids. High quality *Chrysoperla* species are commercially available for augmentative biological control.

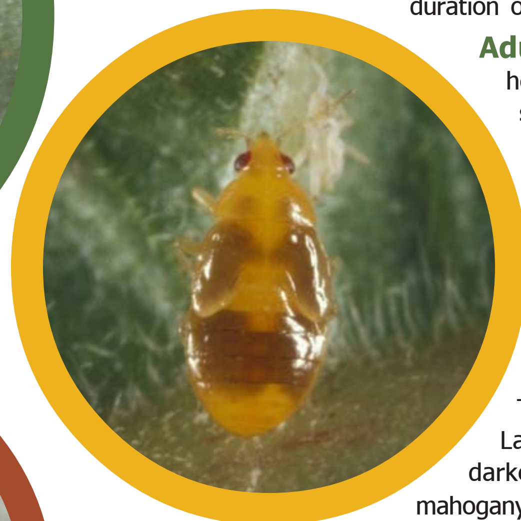
Adapted by J.L. Gillett from http://woodypest.ifas.ufl.edu/beneficl.htm.

Photographs by: James Castner and Lyle Buss.

BIOLOGICAL CONTOL: Minute Pirate Bug, *Orius insidiosus*

Biology and Lifecycle: Individual eggs are laid in plant tissues. Females lay over 75 eggs when consuming adequate numbers of insect prey. Eggs hatch in 6 to 10 days. Development of the nymphal instars requires at least 10 days, depending on temperature. The adults live three to four weeks.

Environmental Factors: The species overwinters as mated females in reproductive diapause. They are active from March to November in northern Florida, and year-round in southern Florida. A combination of day-length and temperature influences the onset and duration of reproductive diapause.



Adult: Elliptical with a triangular head. The head and thorax are shiny and black. The forewing has a small dark area at the base of the first pair of legs, then a whitish yellow area, then a triangular dark area. The rest of the forewing is membranous and pale.

Immatures: The five nymphal instars are ovoid. The first instar is slightly yellow. Later instars get progressively darker in color. The last instar is mahogany in color.

Host Species: Abundant on many crop and wild plant species. Very abundant on species of peppers (*Capsicum* spp.), but not on tomato (*Lycopersicon esculentum*).

Habitat/Nutritional Requirements: Minute pirate bugs have co-evolved with plants including pepper, okra, and cotton that have special structures called domatia that produce food and shelter for predators. The domatia allow predator populations to survive and successfully reproduce in the absence of prey. Minute pirate bugs persist in peppers after suppressing prey to low population levels, by feeding on pollen and plant juices without doing damage. Adults and nymphs are highly aggregated in the flowers of pepper.

Effectiveness: Integrated pest management programs are designed to conserve minute pirate bug populations through the use of cultural tactics and reduced-risk insecticides. Minute pirate bugs provide control of thrips when there is at least one predator per 180 prey. The predator also feeds on aphids, mites, whiteflies, and the eggs of numerous species of pests.

Figure 1. Adult minute pirate bug. Photograph by: James Castner.

Figure 2. Nymphal minute pirate bug. Photograph by: Lyle Buss.

Figure 3. Adult *Orius insidiosus* preying on an adult thrips. Photograph by: Stuart Reitz.

References:

Funderburk, J., S. Olson, J. Stavisky and Y. Avila. 2004. Managing thrips and tomato spotted wilt in pepper. UF/IFAS Pub. EENY-658.

Funderburk, J. and J. Stavisky. 2004. Biology and economic importance of flower thrips. UF/IFAS Pub. ENY682.

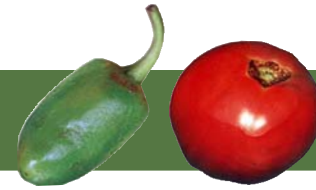
Reitz, S. R., E.L. Yearby, J.E. Funderburk, J. Stavisky, M.T. Momol and S. M. Olson. 2003. Integrated management tactics for *Frankliniella* thrips (Thysanoptera: Thripidae) in field-grown pepper. Journal of Economic Entomology 96: 1201-1214.

CONTACT INFORMATION:

Dr. Joe Funderburk
UF/IFAS NFREC
155 Research Rd
Quincy, FL 32351-5684
jef@ufl.edu
850-875-7146

IPM Integrated Pest Management Florida | UF UNIVERSITY of FLORIDA IFAS Extension

Prepared by: Dr. Joe Funderburk



Florida predatory stink bug
Euthyrhynchus floridanus

Description:

The predatory stink bug is considered a beneficial insect because most of its prey consists of plant-damaging bugs, beetles, and caterpillars. It seldom plays more than a minor role in the natural control of insects in Florida, but its prey includes such economic species as southern green stink bug. The females lay egg masses with individual eggs that are somewhat barrel shaped. Identification of the nymphs is difficult, particularly the earlier instars. The young stink bugs lack wings and have tubelike piercing-sucking mouthparts. The adult male length is approximately 12 mm and can be distinguished from all other stink bugs in the southeastern U.S. by a reddish spot at each corner of the scutellum outlined against a blue-black to purplish brown ground color. Variations occur that might cause confusion with somewhat similar stink bugs. *E. floridanus* has been collected during all months of the year in Florida. There is a peak in the spring and again in the fall.

Adapted by J.L. Gillett from EENY-157 Featured Creature by: F. Mead.
Photographs by: Lyle Buss.

Ladybird beetles
Coleoptera: Coccinellidae

Description:

There are many species of ladybirds. Ladybird adults are oval, range in length from about 1 mm to over 10 mm depending upon species and have wings. Females on average are larger than males. Adults of some species are brightly colored. Larvae are mobile and in some species are protected by waxy secretions. Pupae are unprotected by a cocoon but larvae may wander some distance from feeding sites before pupating. Typically, ladybirds have several generations each year and reproduction is slowed or halted by cooler winter weather, when adults may hibernate. Predatory species feed on mites, whiteflies, cottonycushion scale, mealybugs, armored scale insects, scale insects and aphids. Most species of ladybirds are considered beneficial because they are predators of Homoptera or Acarina, many of which are considered to be pests. These predatory ladybirds contribute to the regulation of populations of their prey, and in some situations contribute a high level of regulation.

Adapted by J.L. Gillett from EENY-170J Featured Creature by: H. Frank and R.F. Mizell, III.
Photographs by: Russ Mizell and Lyle Buss.

BIOLOGICAL CONTROL: Larra Wasp, *Larra bicolor*

Biology & Lifecycle: The adult female wasp searches for tunnels made by mole crickets. When a tunnel is located, the wasp then enters the mole crickets burrow and stings the host on the soft tissue on its underside, causing paralysis. The wasp places a single egg on the underside of the mole cricket. Incubation time may be from 5-7 days, depending on temperature. Development time for the larvae is approximately two weeks. In this time the wasp larva will consume the cricket's tissue and hemolymph. Once the cricket is consumed, the larva will build a cocoon out of cemented soil particles and emerge in about a week.

Environmental Factors: *Larra bicolor* originated in South America along with its host. It is distributed in tropical regions worldwide. They are not able to survive in temperate regions.

Adult: The *L. bicolor* female is approximately 22 mm with the males smaller in length. The adult wasp is completely black except for its abdomen which is red. The head has silvery-white markings. The wings are smoky brown to indigo blue.

Immature: The larvae will develop as an ectoparasitoid, undergoing five instars.

Host Species: The hosts are *Scapteriscus* mole crickets. The host, like the wasp, originated in South America. There are three species of *Scapteriscus* - *S. abbreviatus*, *S. borellii* and *S. vicinus* which occur in Florida, and all are attacked by *L. bicolor*.

Figure 1. Larra wasp stinging and ovipositing on mole cricket. Photograph by: Lyle Buss.

Figure 2. Larra grub on mole cricket. Photograph by: Lyle Buss.

Figure 3. *Larra bicolor* feeding on flower. Photograph by: Lyle Buss.

Habitat/Nutritional Requirements: *Larra bicolor* is distributed worldwide in tropical regions. They obtain nectar by feeding on wildflowers. *Hyptis atrorubens* and *Spermacoce verticillata* are know nectar sources of *L. bicolor. Spermacoce verticillata* was introduced as a nectar source in Florida in areas where *L. bicolor* has been released.

Effectiveness: *L. bicolor* is a very effective biocontrol agent of the *Scapteriscus* mole crickets. UF/IFAS is distributing these wasps to all Florida counties as a biological control agent.

CONTACT INFORMATION:

Charles J. Stuhl
USDA-ARS-CMAVE
Gainesville, FL
cstuhl@gainesville.usda.ufl.edu
352-374-5704

IPM Integrated Pest Management Florida | UF UNIVERSITY of FLORIDA IFAS Extension

References:

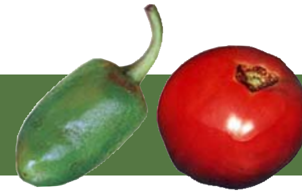
Arévalo H.A. and J.H. Frank. 2005. Nectar sources for *Larra bicolor* (Hymenoptera: Sphecidae), a parasitoid of *Scapteriscus* mole crickets (Orthoptera: Gryllotalpidae), in northern Florida. Florida Entomologist 88: 146-151.

http://ipm.ifas.ufl.edu/reports/mole_cricket_frank1.htm

http://molecrickets.ifas.ufl.edu/mcri0007.htm

http://creatures.ifas.ufl.edu/beneficial/Larra_wasps.htm

Prepared by: Charles Stuhl



Wasp Parasitoid

Description:

Several species of parasitoid wasps occur naturally in the United States, some species are sold for release in augmentative biological control programs. They are considered biological control agents of noctuid pests of vegetable crops, such as armyworm, hornworm, cabbage looper, etc. Insects infected with larvae of wasp parasitoids may look like other larvae or they may have a sluggish nature. When wasp larvae emerge from the host, they immediately begin spinning a tight silky cocoon. The cocoon is usually white. The cocoon can remain attached to the host larvae or it will be attached to plant material near the host. In Florida, many parasitoids naturally are abundant throughout the summer, but populations tend to decline from October to April.

Adapted by J.L. Gillett from EENY-123 Featured Creature by: A. Sourakov and E. Mitchell.

Photographs by: Debbie Waters and Andrei Sourakov.

Predatory mite
Neoseiulus californicus

Description:

The predatory mite *N. californicus* prefers spider mites (Tetranychidae) as food, but will also consume other mite species, small insects, such as thrips, and even pollen when the primary prey is unavailable. *N. californicus* is often used to control the twospotted spider mite, *Tetranychus urticae*, and other phytophagous mites on various crops in temperate and subtropical regions around the world. Natural populations of *N. californicus* are found in Florida.They prefer warm 10 - 33°C (50 - 91°F) temperatures, but they can tolerate much colder temperatures for short periods of time. For example, they can survive the winters in north Florida where temperatures can fall below freezing at night. They can tolerate a wide range of humidity (40 - 80% relative humidity), but prefer humidity at the upper end of this range. High quality *N. californicus* are commercially available for augmentative biological control.

Adapted by J.L. Gillett from EENY-359 Featured Creature by: E.M. Rhodes and O.E. Liburd.

Photograph by: Lyle Buss.

Table 1. Toxicity of chemical pest management tools to beneficial invertibrates in FL tomato and pepper.

Pest Management Tools (MoA Class) / Beneficial Insects/Mites	Beneficial mites	Big-eyed bugs	Damsel bugs	Ground beetles	Honeybees	Lacewings	Ladybird beetles	Minute pirate bugs	Parasitic wasps	Predatory midges	Predatory thrips	Spiders	Syrphid fly larvae
Registered materials													
Abamectin (6)	H	O	H	O	M	H	S	O	H	H	H	O	X
Acephate (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Acetamiprid (4)	S	O	O	O	M	M	M	O	M	H	H	O	O
Azadirachtin (18)	S	O	O	O	S	S	S	O	M	O	O	O	O
Azinphos-methyl (1)	M	H	H	H	H	H	H	H	H	H	H	H	H
Bifenazate (25)	S	O	O	O	O	S	S	O	S	O	O	O	O
Bifenthrin (3)	H	H	H	H	H	H	H	H	H	H	H	H	H
Buprofezin (16)	O	O	O	O	S	S	O	O	S	M	O	O	O
Carbaryl (1)	S	H	H	H	H	H	H	H	H	H	H	H	H
Chlorpyrifos (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Cryolite (9)	O	O	O	O	O	O	O	O	O	O	O	O	O
Cyfluthrin (3)	H	H	H	H	H	H	H	H	H	H	H	H	H
Cyhalothrin-gamma/lambda(3)	H	H	H	H	H	H	H	H	H	H	H	H	H
Cyromazine (17)	O	M	M	O	S	O	O	M	O	O	O	O	O
Diazinon (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Dicofol (unknown)	H	S	S	S	S	S	S	S	M	H	S	S	H
Dimethoate (1)	H	H	H	H	H	H	H	H	H	M	H	H	H
Dinotefuran (4)	M	M	M	M	H	M	H	H	H	H	H	M	H
Emamectin (6)	H	O	H	O	M	H	S	O	H	H	H	O	O
Endosulfan (2)	H	H	H	H	H	H	H	H	M	H	H	H	H
Esfenvalerate (3)	H	H	H	H	H	H	H	H	H	H	H	H	H
Fenpropathrin (3)	H	H	H	H	H	H	H	H	H	H	H	H	H
Imidacloprid (4)	M	M	M	M	H	M	H	H	H	H	H	M	H
Indoxacarb (22)	S	S	S	S	M	S	S	S	H	S	S	O	H
Malathion (1)	M	H	H	H	H	H	H	H	H	H	H	H	H
Methamidophos (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Methomyl (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Methoxyfenozide (18)	O	O	S	O	O	O	O	S	O	O	O	O	O
Naled (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Oils (none)	M	O	O	O	O	S	S	O	S	S	S	O	S
Oxamyl (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Oxydemeton-methyl (1)	H	H	H	H	H	H	H	H	H	H	H	H	H
Permethrin (3)	H	H	H	H	H	H	H	H	H	H	H	H	H
Pymetrozine (9)	O	O	O	O	O	O	O	O	O	O	O	O	O
Pyrethrins + Rotenone (3)	M	M	M	M	M	M	M	M	M	M	M	M	M
Pyrethrins + PBO (3)	M	M	M	M	M	M	M	M	M	M	M	M	M
Pyriproxyfen (7)	S	S	S	S	S	S	H	S	S	S	S	S	M
Soaps (none)	H	M	M	S	O	H	M	S	M	M	M	O	M
Spinosad (5)	M	S	S	S	M	M	M	S	M	S	S	O	S
Spiromesifen (23)	M	O	O	O	O	S	S	S	S	S	S	O	S
Sulfur (8)	M	S	S	S	S	S	S	S	S	S	S	O	S
Tebufenozide (18)	O	O	S	O	O	O	O	S	O	O	O	O	O
Thiamethoxam (4)	S	M	H	M	H	S	H	H	H	H	H	M	H
zeta-Cypermethrin (3)	H	H	H	H	H	H	H	H	H	H	H	H	H

Toxicity scale: O = nontoxic M = moderately toxic S = slightly toxic H = highly toxic

Prepared by: Dr. Mark Mossler

Notes: