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)**.

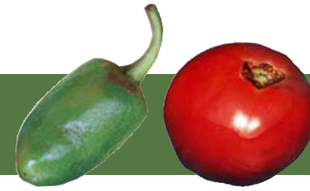
Figure 1. Bigeyed bugs are commonly found on wild plant species. Photograph by: Lyle Buss.

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. 8)**.

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.

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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.

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

Mole Cricket Nematode
Steinernema scapterisci

Description:

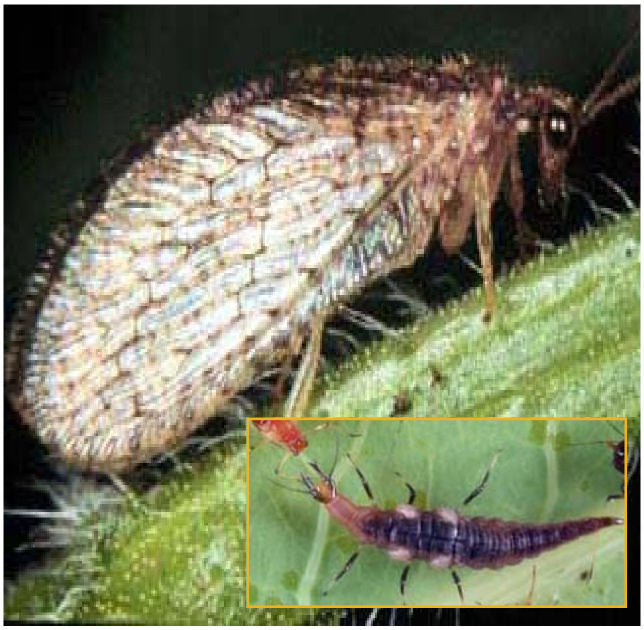
The most important insect pests of turf and pastures in Florida are mole crickets. Their feeding and tunneling also destroy seedlings of tomato and pepper. *S. scapterisci* is specific to mole crickets. The nematode was successfully introduced by inoculative applications in golf courses and pastures 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.

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.
Photograph by: James Castner and Lyle Buss.

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.
Photograph by: Lyle Buss and Russ Mizell.

BIOLOGICAL CONTROL: Wasp Parasitoid & Predatory Mite

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 *Tetranychid* mites 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.

BIOLOGICAL CONTROL: Beneficial Agents Interaction with Pesticides

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