Introduction to Applied Entomology, Lectures 15 & 16
Natural and Biological Control

Know ...

- the difference between natural biotic control and biological control.
- the "players" (by category) in biological control, what are they used for, and how are they used.
- the categories of pathogens that attack insects.
- the various forms of *Bacillus thuringiensis* and the groups of insects that each affects.
- the habitat in which *Steinerrnema* and *Heterorhabditis* are most likely to be successful (and who they are).
- why the Vedalia beetle is famous.
- the identity and primary prey or hosts of: lady beetles in general, *Cryptolaemus*, lacewings, *Orius*, and *Encarsia*.

Natural control:

- Biotic

- Abiotic

Biological control:

What it is not ...

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What it is ... ("3 sets of 3")

I. Who?

1. P

2. P

3. P

II. To do what ? To reduce, delay, or prevent pest infestations

1. Reduction ...

2. Delay

3. Prevention ...

III. How? By conservation, augmentation, or importation of natural enemies.

1. Conservation ...

2. Augmentation ...

3. Importation ("classical biological control") ...

Pathogens:

Bacteria, viruses, fungi, protozoa (microsporidia), nematodes

Many are important in causing population crashes in nature (natural biotic control, not biocontrol), especially...

- viruses in *Heliothis* / *Helicoverpa* (tobacco budworm and corn earworm), alfalfa looper, tent caterpillars and forest sawflies;
- fungi in alfalfa weevil, potato leafhopper, and green cloverworm;
- microsporidia in grasshoppers, corn borer, many others (not complete population crashes, just markedly "poor performance")

See handout for more details. Though some have been mass-produced and packaged, for the most part, these have not been readily formulated as effective "microbial insecticides".

Viruses

Check the web site on baculoviruses at:

http://www.nysaes.cornell.edu/ent/biocontrol/pathogens/baculoviruses.html

Viruses commonly cause disease outbreaks and population crashes in caterpillars. A few virus-based biopesticides are available commercially, but they are not used widely in the U.S.
Products include viruses that infect codling moth, gypsy moth, corn earworm, tussock moth, and others.)

Bacteria

- *Bacillus thuringiensis*: rarely responsible for obvious natural control, but effective as a microbial insecticide ...
    - *B.t. kurstaki* and *B.t. aizawai* -- kill caterpillars (Dipel, Agree, XenTari)
    - *B.t. israelensis* -- kills larvae of several mosquitoes, black flies, fungus gnats (Altosid, Vectobac, Gnatrol)
    - *B.t. tenebrionis* -- kills larvae of Colorado potato beetle, elm leaf beetle, a few others (M-One, M-Trak, Foil)

- *B. sphaericus* --

- *B. popilliae* & *B. lentimorbus* --

Insect-pathogenic fungi

Insect-pathogenic fungi often cause disease outbreaks in insect populations, but few have been commercialized as biopesticides, largely because of (1) difficulty in producing virulent strains that maintain viability "on the shelf", and (2) the importance of weather conditions and microhabitat on the effectiveness of products applied in the field. Fungi that kill insects include:

- *Metarhizium anisopliae*: infects a broad range of hosts, including corn rootworms, white grubs, and root weevils. A commercial cockroach bait station uses *M. anisopliae*to kill cockroaches.
- *Beauveria bassiana*: (white muscardine fungus)

- *Entomophthora muscae* (and *E. grylli* and others):

Microsporidia

An important Midwestern example is *Nosema pyrausta*, a pathogen of the European corn borer. Although microsporidia can kill their hosts outright, infections often do not cause death rapidly. Infected individuals develop more slowly, are smaller, and females lay fewer eggs, many of which will become infected and die. *N. pyrausta* causes periodic collapses in European corn borer populations in Illinois and neighboring states. Microsporidia have not been commercialized as biopesticides except for *Nosema locustae*, a species that attacks grasshoppers.

Insect-parasitic nematodes

The nematodes that have been cultured for sale as "biopesticides" include species in the genera *Steinernema* and *Heterorhabditis*. They enter an insect's body through the mouth, anus, or spiracles, move into the body cavity, and release symbiotic bacteria (*Xenorhabdus* or *Photorhabdus* species) that multiply within the host insect. Infection by these bacteria is what kills the insect host. The nematodes feed on the bacteria, complete their development, and reproduce, yielding thousands of progeny that then seek another host. Nematodes can be effective against soil insects, particularly in settings where irrigation can be used to maintain soil moisture. (Targets have included root weevil larvae, seed and root maggots, fungus gnat larvae, and several other pests. Nematodes have NOT proven to be effective against wireworms, corn rootworms, grape phylloxera, or several other key pests.)

Using pathogens as microbial insecticides is a form of augmentation. Conservation and importation are also possible approaches.

Read through the summary provided on the "pathogen" portion of the Cornell University biological control web site.

http://www.nysaes.cornell.edu/ent/biocontrol/pathogens/nematodes.html

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Be sure to check the handout to understand why microbial insecticides are considered good from an environmental and human health perspective and to learn their general limitations.

Reference:

Weinzierl, R., and T. Henn. 1991. Alternatives in Insect Management: Biological and Biorational Approaches. North Central Regional Extension Publication No. 401. Cooperative Extension Service, University of Illinois at Urbana-Champaign. (Handouts taken from this)

Predators and Parasites

Importation

The classic example of successful importation ... Vedalia beetle for control of cottony cushion scale in citrus

- 1868 & 1870s:

- 1887: C.V. Riley convinced the California Fruit Growers' Convention to pressure the U.S Congress to provide $2,000 for the covert collection of natural enemies in Australia. Albert Koebele sailed for Australia in August, 1888 (presumably to represent the California citrus growers at the world agricultural exposition). Koebele brought back several thousand parasites (*Cryptochaetum iceryae*) and a few hundred *Rodolia cardinalis* -- the Vedalia beetle. The Vedalia beetles were held on trees under mesh tents to increase their numbers, then transferred from orchard to orchard on branches by growers.
- Result:

Other successful introductions:

- *Cryptolaemus*

- Larval parasites (Hymenopteran) of cereal leaf beetle

- Parasites of the alfalfa weevil

- Carabids for gypsy moth suppression

(Many more)

Difficulties with introductions:

- Finding a "guild" of natural enemies that together provide adequate control (of not only one but most of the pests in a system.
- Natural enemy survival in pesticide-treated crops or habitats
- Quarantines, production of high numbers for release, fitness, climate, more

Conservation

There are many natural enemies "in place" in any region. Read your handout to become familiar with several groups and species, including ...

- Carabids
- Coccinellids

- Staphylinids
- Syrphid flies
- Lacewings

- Hemipteran predators (*Orius* [a minute pirate bug], *Nabis* [a damsel bug],*Geocoris* [big-eyed bug], *Podisus* [spined soldier bug])
- Mantids (usually not very beneficial because of prey choice and cannibalism)
- Many predaceous mites

(Not all predaceous or parasitic insects are beneficial ... some kill the natural enemies of pests instead of pests.)

What steps are involved in conservation? (See handout for details)

1.

2.

3.

4.

5.

Be aware ... Cultural practices influence pests and beneficials simultaneously. For example, ground cover plants that provide nectar and pollen for beneficial insects may also attract and serve as a food source for cutworm moths and their larvae.

Augmentation:

Natural enemies that are available for purchase and release include:

- Convergent lady beetle (fly away, fly away ...)
- Mealybug destroyer (good in greenhouses)
- Green lacewings (best of general purpose and aphid predators; larvae that hatch on the ground often die)
- Spined soldier bug (fun to watch, feeding rate & pop dynamics don't allow a purchase of relatively few of these bugs to keep up with pests)
- Praying mantids (ditto but worse; often eat nonpest insects)
- Predaceous mites for spider mite control (some good results in greenhouses, dependent on conditions; possible benefit to re-inoculating orchards)

- Mites that prey on thrips (good stories from greenhouses, dependent on conditions)

- *Encarsia* for whitefly control (many successes in greenhouses, often complicated by other pests)

- Parasites of fly pupae (successes in poultry have been difficult to match in other livestock facilities)

Some useful web sites:

- Biological Control: Approaches and Applications. D.A. Landis, at: http://ipmworld.umn.edu/chapters/landis.htm

- Biological Control: A Guide to Natural Enemies in North America, from Cornell University at: http://www.nysaes.cornell.edu/ent/biocontrol/

- Weinzierl, R., and T. Henn. 1991. Alternatives in Insect Management: Biological and Biorational Approaches. North Central Regional Extension Publication No. 401. Cooperative Extension Service, University of Illinois at Urbana-Champaign. (Handouts taken from this) http://www.ag.uiuc.edu/%7Evista/abstracts/aaltinsec.html