Using Biocontrols for Insect Pests in High Tunnels

Margaret Skinner & Cheryl Sullivan

Univ. of VT, Entomology Research Laboratory

Elsa Sanchez & Kathleen Ayers

Penn State Univ.

&

Mark Hutton & Jason Lilley

Univ. of Maine Coop Extension

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Focus on Aphids
The #1 Pest in High Tunnels

Topics for Discussion

- The nature of the beast
- Management components
  - Prevention
  - Early detection
  - Natural enemies
  - Plant-mediated systems
  - Insecticides

What is going on here?

There is NO silver bullet!

Drama in Real Life!

- Overwintered leafy greens infested
- Preparation of the beds
- Planting tomato seedlings

What would you do?

Aphids
The Nature of the Beast

- Order = Hemiptera (True Bugs)
- Soft bodied, pear shape, 0.03-0.16 inches long
- Exhaust pipe structures on the rear end (cornicles)
- Over 30 different species on greenhouse crops
- Come in many colors that vary within species

Keep your friends close,
and your enemies closer.

Sun-tzu, 400 BC

Aphids Suck

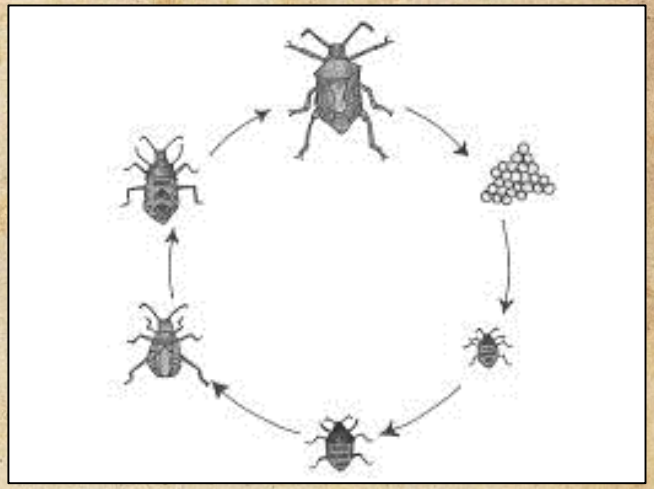
What do they do?

- Piercing-sucking mouthparts
- Insert stylets in plant tissue & remove sap from phloem
  - Distort leaves & stunt plant growth
  - Cause flower drop
  - Transmit viruses
- Excrete sugary substance on leaves (honeydew) that supports sooty mold growth

Life Cycle Basics

Immature insects are called either

NYMPHS or LARVAE



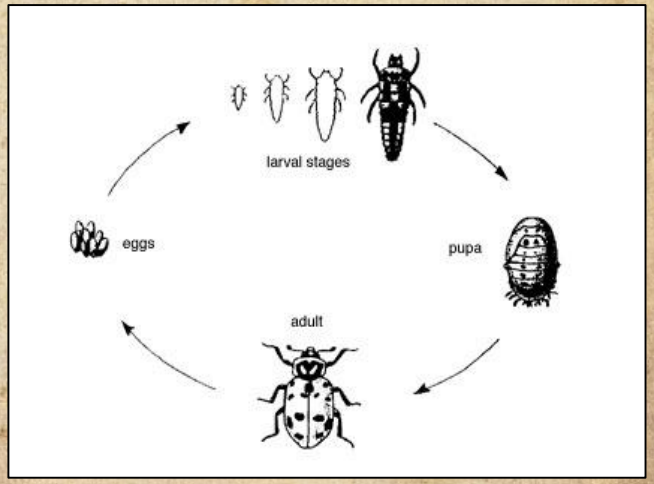
METAMORPHOSIS
(change by molting/shedding their skin)

- Aphids have Simple Metamorphosis

  Immatures - NYMPHS
  Adults and immatures have same basic body form
  Adults can be winged or wingless
  Other examples: stink bugs, grass hoppers

- Beetles have Complete Metamorphosis

  Immatures - LARVAE
  Adults look very different from immatures and have a non-feeding stage (pupa)
  Other examples: flies, bees and wasps



Aphid Life Cycle

Why do aphid populations increase so fast?

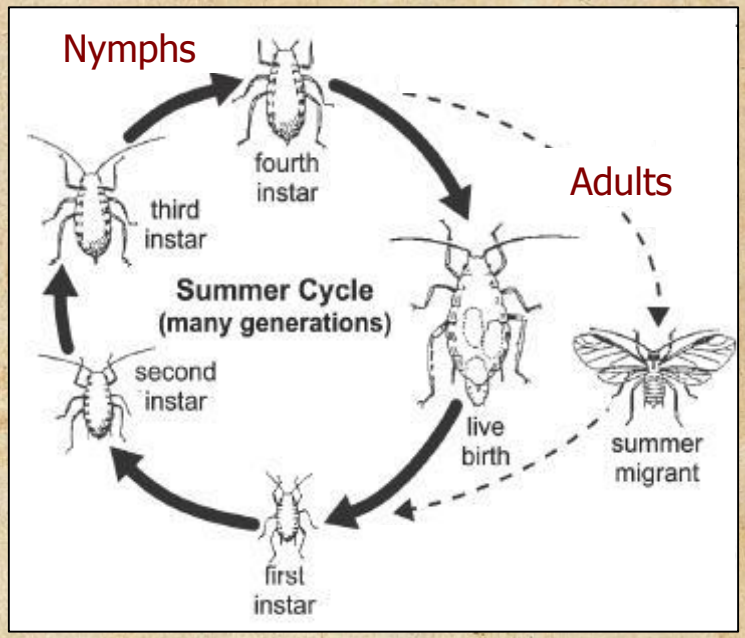
- Asexual reproduction (Parthenogenesis)
  - All are females and reproduce
  - Give birth to Live young (no eggs/pupae)
  - No mating needed

Too crowded? No problem!

- Grow wings, fly to new host & begin again

Too cold? No problem!

- Lay eggs, and wait till it warms up



Overwintering phase

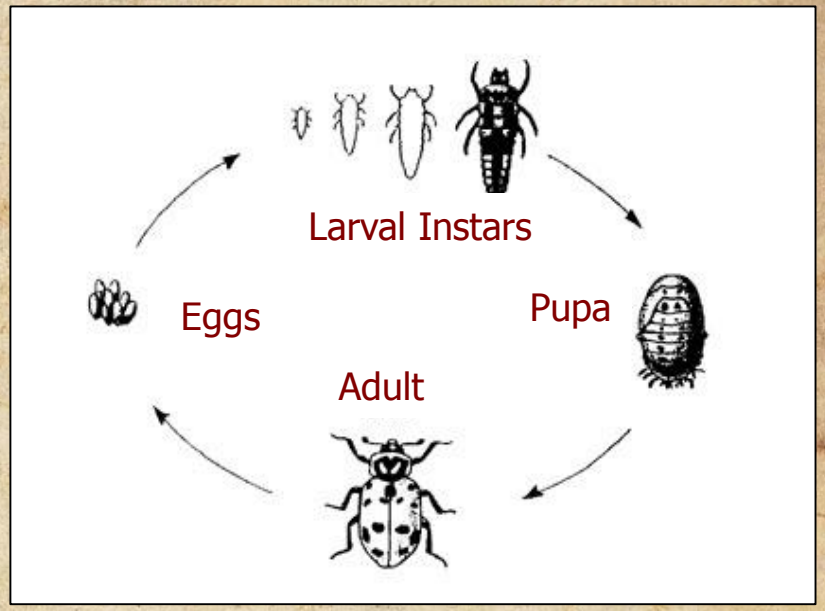
Natural Enemy Life Cycle

Why do natural enemy populations increase slower than aphids?

- Sexual reproduction
  - Only 50% are females and can reproduce
  - Have 2 non-feeding stages (egg/pupa)

Too cold or Too dark?

- Develop slower, eat less or hibernate



Aphid vs Lady Beetle Life Cycles

Life cycle specifics depend on species, temperature, humidity & food source.

Aphids

- 10-12 days to complete 1 generation
- Adults live approx. 20-40 days
- Each adult produces 40-100 nymphs (3-10 per day)
- Nymphs can mature in 6 days
- Over 20 generations/year

Lady Beetles

- 10 days–4 wk to complete 1 generation
- Adults live 1 – 3 years
- Adults lay 50-2,000 yellowish eggs in clusters of less than 20
- 1 larva eats 500 – 1,000 aphids, 1 adult eats up to 2,500 aphids
- Eggs hatch in 3-7 days, larvae develop for 2-4 wk, pupate on leaf for 5-10 days
- 1-6 generations/year
- Adults aggregate in plant debris to hibernate

	7 days	14 days	21 days	Total @ 21 days
2 aphids ♀ ♀	100 (2x50)	5,000 (100x50)	250,000 (5,000x50)	255,100
2 beetles ♂ ♀	100 (1x100)	100 Still immature	5,000 (50x100)	5,100
Aphid Predation	3,500 (35x100)	10,000 (100x100)	250,000 (50x5000)	263,500

Be PROACTIVE!

Aphids vs Lady Beetles

Jan. 1

Jan. 5

Jan. 8

Jan. 15

Jan. 25

Be PROACTIVE!

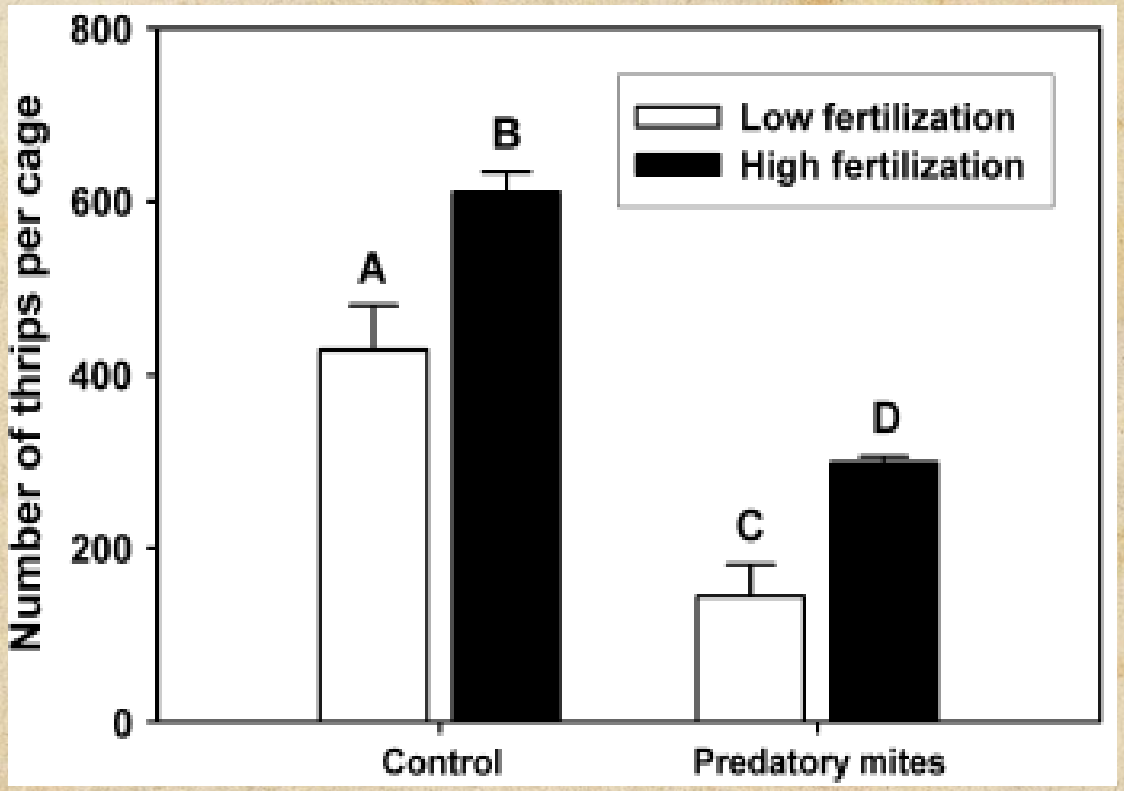
The 1st Step: Cultural Control

- Prevention
  - Sanitation and plant inspection
  - Remove infested leaves in hot spots
  - Wash infested leaves with strong water spray
  - Weed removal in and outside the high tunnel
  - Cultivar and crop selection
  - Fallow periods
  - Remove pet plants from outside
  - Low N fertilizer regimes

There is no silver bullet!

Fertility Effects

33% more thrips with high fertilizer regime



Aphids also respond positively to high fertility.

The 1st Step: Cultural Control

- Early detection
  - Plant scouting, yellow sticky cards, indicator/trap plants
- Careful record keeping

Marigolds for Thrips

Eggplant for Whiteflies

Beans for Spider Mites

There is no silver bullet!

Scout Frequently

- Yellow sticky cards (only works for winged forms)
- Inspect crop plants and weeds in and outside the tunnel (for wingless and winged forms) Focus on buds, stems & undersides of leaves
  - Damage
  - Cast skins
  - Shiny leaves
  - Tap plants over white paper
- Use indicator plants in strategic locations
- Take samples and get them identified by an expert

Mass Trapping

- Yellow & blue sticky cards
- Only works for winged forms, particularly suitable for thrips
- Catches beneficials as well as the pest

Aphid Id Matters for IPM!

5 species we commonly found in high tunnels, but there is great diversity

- Some species reproduce faster than others
- Many natural enemies are species-specific
- Aphid id is complicated, get an expert opinion

Melon
Aphis gossypii

Green Peach
Myzus persicae

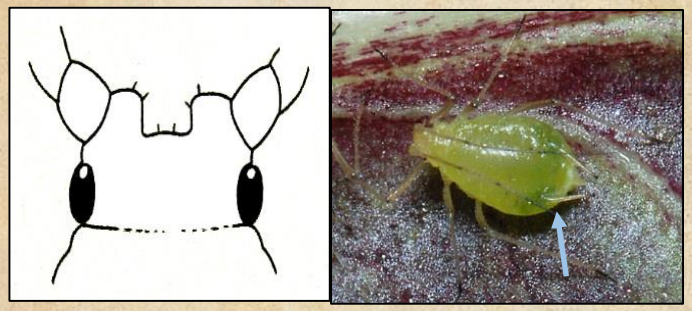
Foxglove
Aulacorthum solani

Potato
Macrosiphum euphorbiae

Carrot-Willow
Cavariella aegopodii

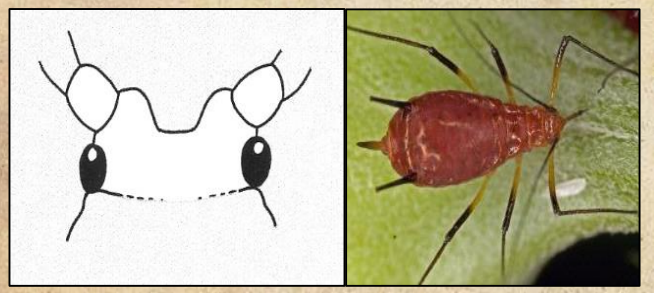
Aphid Species Id

Foxglove



- Pale green, yellow & shiny
- Parallel tubercles
- Dark spots at cornicle bases
- Tend to fall off plants when disturbed

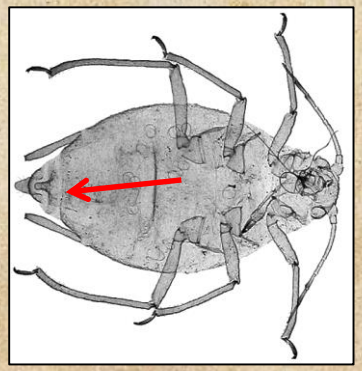
Potato



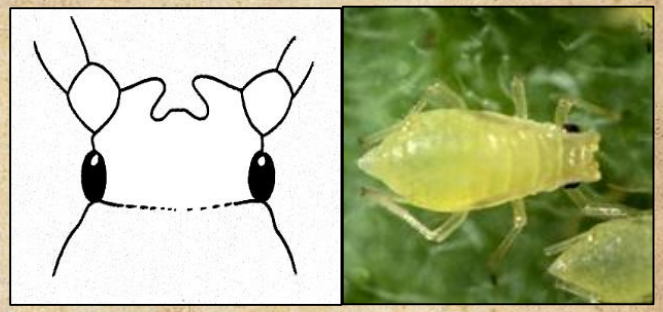
- Pink or green
- Slightly diverging tubercles
- Slender, pear shaped body
- Very long cornicles

Carrot-Willow

- Green or reddish
- Supracaudal process
- Tips of antennae & legs brownish
- Siphunculi swollen

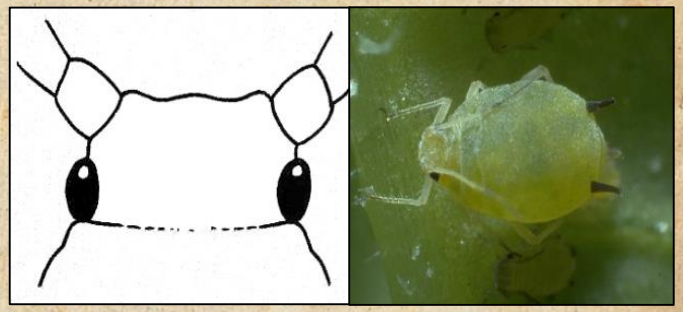


Green Peach



- Green, pink, or orange
- Tubercles converging inward (W)
- Long cornicles with black tips

Melon



- Green or yellowish
- Flat tubercles
- Short, dark cornicles

Getting Help With Id

Consult a specialist (extension agent/supplier/consultant) first

Helpful Hints

- Send a sample! (in alcohol) in crushproof, non-leaking container, double bagged in a box, or send live specimens in a plastic bag in a crush-proof container
- Choose the biggest, fattest, most mature aphids
- Send lots of specimens (not 1 or 2 individuals)
- Indicate the host plant (some are specific to the type of plant and pose no risk to your crop)

Biological Control: The Next Line of Defense

The options:

- Parasites
- Predators
- Insect-killing fungi

The strategies:

- Regular releases or applications
- Banker plants
- Promoting native natural enemy establishment

Parasitoids

Aphidius spp.

(*colemani, matricariae, ervi*)

Adults

What do they do?

- Adults lay eggs inside aphids
- Larva-pupa develop inside, turning aphid into 'mummies', killing them
- Adults feed on honeydew
- Work best in cooler temperatures

Appearance

- Species tend to be difficult to tell apart
- Adults
  - Long antennae & legs & small waist
  - 2-3mm in length
  - Black with brown/red highlights
- Larvae-pupae
  - Within golden brown mummies

Aphid mummy

Parasitoids

Aphelinus abdominalis

What does it do?

- Adults lay eggs inside aphids
- Larvae-pupae develop inside, turning aphid into 'mummies', killing them
- Adults feed on aphids & honeydew
- Works better in higher temperatures

Adult

Appearance

- Adults
  - Short antennae & legs
  - 3mm in length
  - Black & yellow
- Larvae
  - Within blackened mummies

Aphid mummy

Parasitoids

Not All Wasps Are Created Equal

Parasitoid	Green Peach	Melon	Foxglove	Potato
Aphidius colemani	X	X		
Aphidius ervi			X	X
Aphidius matricariae	X			
Aphelinus abdominalis			X	X

Predators

Aphidoletes aphidimyza

Aphidol "EAT" es – Eats Aphids

What does it do?

- Adults are midges (flies)
- Larvae (predatory maggots) eat **most types** of aphids
  - Inject them with paralyzing toxin & slurps them up
- Adults feed on honeydew & nectars
- Subject to diapause (need supplemental light early/late)

Larvae/Maggots

Adult

Appearance

- Adults (mosquito looking)
  - Pink/brown color
  - Long legs & antennae
  - Active at night
- Larvae (maggots) - Orange/red color
- Pupae - Oval & brown in the soil

Predators

Syrphid spp. - Hover/Flower Flies

What do they do?

- Adults are flies
- Larvae (predatory maggots) eat **most types** of aphids
- Adults feed on honeydew & nectars

Appearance

- Adults (look like bees)
  - Black/brown color marked bands/dots, white/yellow
- Larvae (maggots)
  - Pink, yellow, green & brown marked with white/black color
  - Slightly tapered at front
- Pupae - Oval & brown on plant/soil surfaces

Adults

Pupa

Larvae/Maggots

Predators

Orius spp.

What do they do?

- Predatory bugs (adults & nymphs)
- Generalist predators (also eats thrips, mites, pollen/nectars)
- Pierces & sucks pest juices
- Some undergo diapause
- Needs food source to establish early in season

Appearance

- Adults, black, grey, white & brown
- Nymphs red/brown

Adult

Nymph

Predators
Lady Beetles

What do they do?

- Predatory beetles (adults & larvae eat aphids)
  - Requires lots food to stick around
- Generalist predators (also eats thrips, mites & pollen)
- Does well year-round

Appearance

- Red, orange, yellow with black markings
- Larvae alligator-like
- Pupa attached to leaf surfaces

Adult

Larvae

Pupa

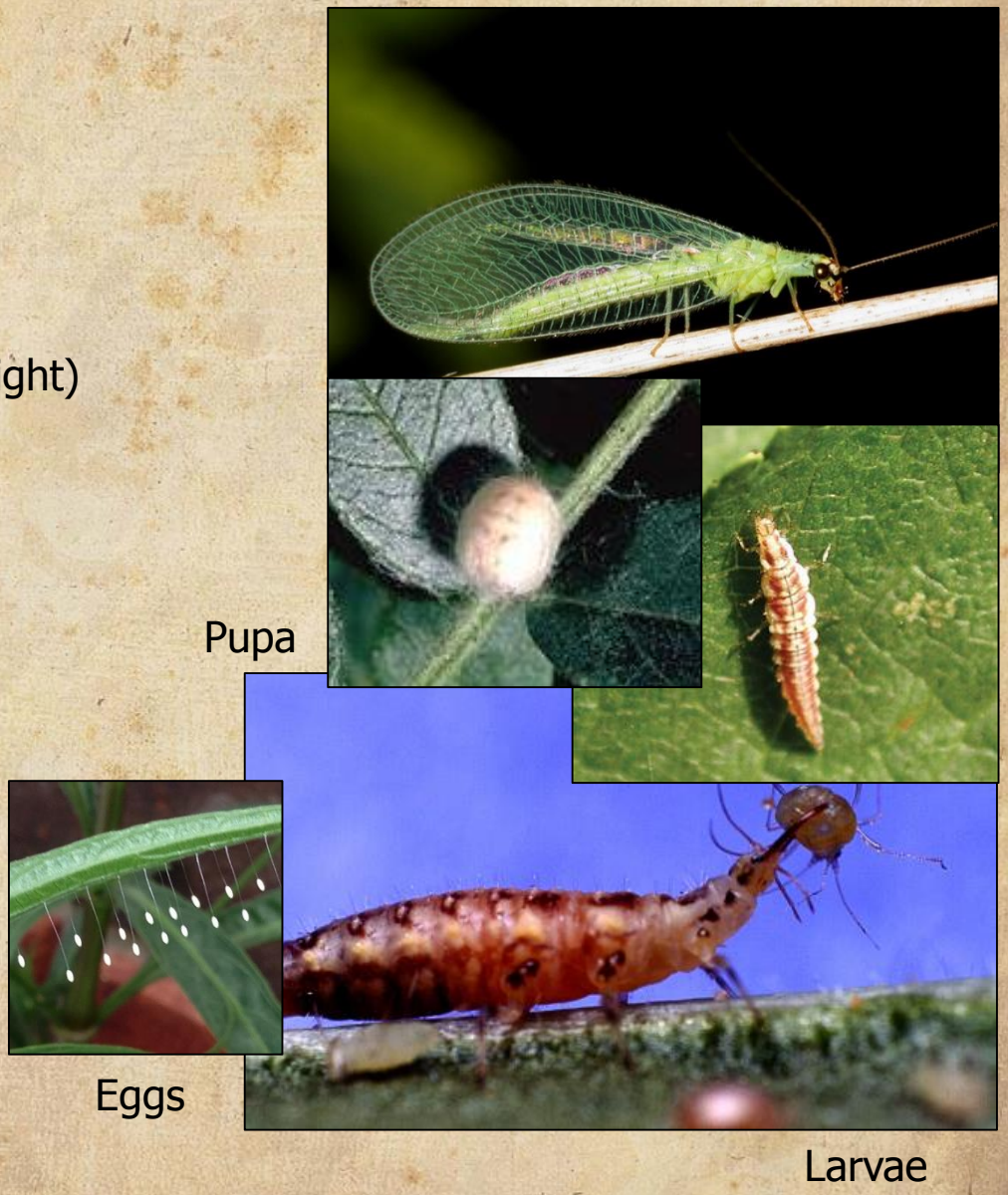
Predators
Lacewings

What do they do?

- Larvae are generalist predators
  - Can be cannibalistic
- Adults consume pollen & nectars (at night)
- Needs lots food to stick around

Appearance

- Adults green-brown
- Larvae alligator-like, brown
- Pupa cocoons on leaf surfaces
- Green lacewing eggs stalked on vegetative surfaces



Insect-Killing Fungi

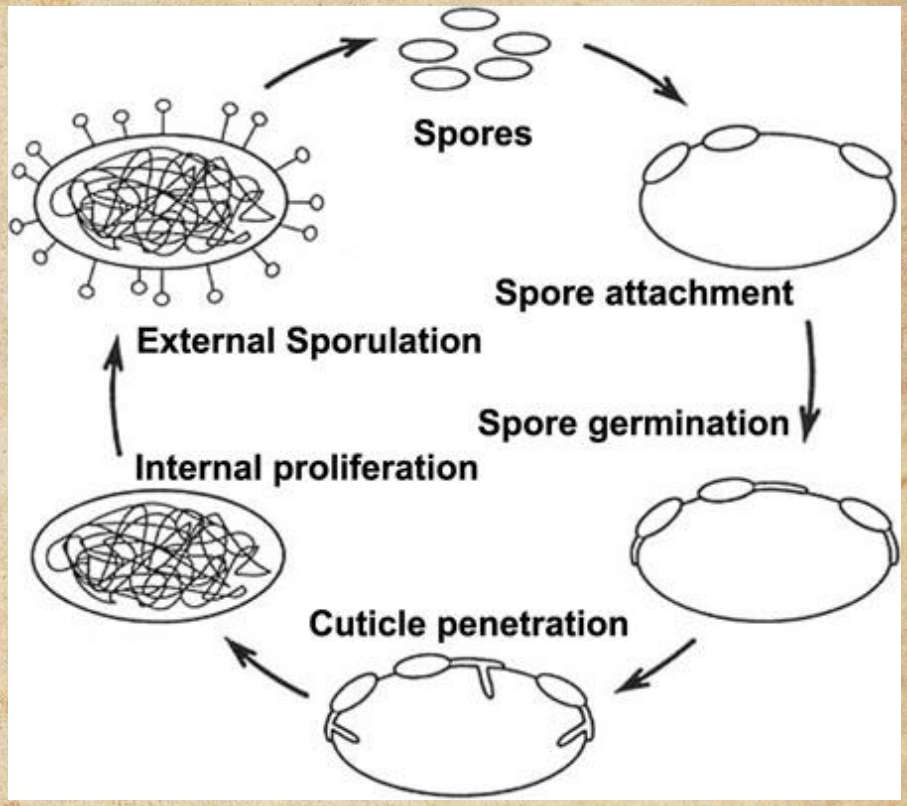
Fungi that infect and kill insects, NOT plants or humans

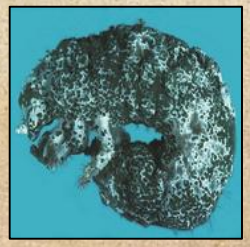
Advantages

- Easy to mass produce
- Long shelf life
- Grow in the absence of the pest
- Potential to persist
- Compatible with other bios
- Low impact on the environment & human health

Disadvantages

- Sensitive to environmental conditions
- Killed by UV light



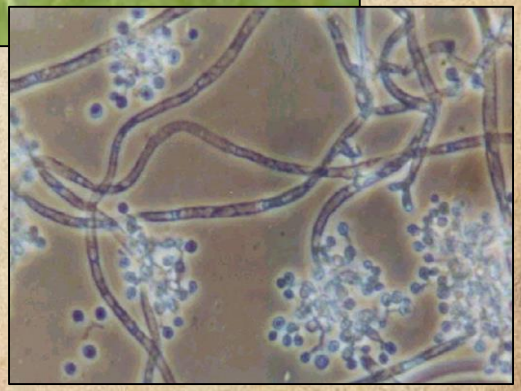


Insect Killing Fungi

- Broad host range (thrips, whiteflies, predatory beetles)
- Several commercial products available
  - *Beauveria bassiana*
  - *Isaria* (=*Paecilomyces*) *fumosoroseus*
  - *Metarhizium anisopliae*
- Contact is necessary
  - Multiple applications usually needed
  - Dense canopies challenging
  - In general need high humidity (>80%) and warm temps

Mycelium (spore masses) on infected aphids

Spores



There is NO silver bullet!

Drama in Real Life!

- Flowering greenhouse tomato crop in February
- Infestation of potato aphids
- Aphids on every inch of the tomatoes
- Multiple releases of natural enemies

What would you do?

Sustaining Natural Enemies

Natural enemies & shipping is expensive! Make Your Own!

Plant-Mediated IPM Systems - Plants (usually non-crop), used as a foundation, in combination with other IPM practices, to manage pests

- Site for nat. enemy releases
- Site to provide food & shelter to establish nat. enemies
- Attracts/maintains purchased & naturally occurring nat. enemies

Aphid Banker Plants
Plants that provide nutrition (non-pest host insect or pollen) for an ongoing supply of nat. enemies

3 States x 2 Sites x 3 Tunnels/Site

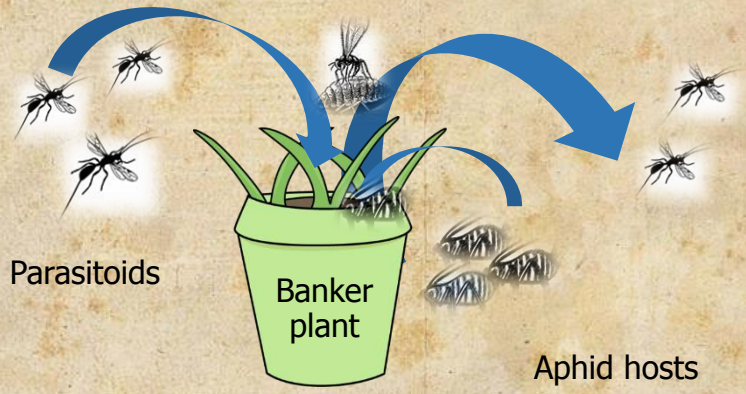
Habitat Plants
Plant combinations that provide food & shelter to attract/sustain natural enemies

Plant-Mediated IPM Systems

Advantages

- Happy Bios: A proactive approach
  - ✓ Reduce starvation when prey absent
- Cost: Eliminates multiple orders
  - ✓ Shipping is a killer
- Better Quality: Fresh is best
  - ✓ Improved searching, longevity & reproduction
- Biocontrol Efficacy: Already established
  - ✓ Ready to roll & acclimated

Aphid Banker Plant System (ABS)



Winter wheat/rye/barley is purchased infested with bird cherry oat aphids, *Rhopalosiphum padi*

A. colemani are released onto the system

Wasps reproduce within the system

Wasps disperse into crop to search for green peach or melon aphid

Promotes establishment of general predators

Aphid Banker Plant System

Success Tips

Plan Ahead!

Put them out when you put in your transplants

Get on banker rotation schedule

Allow 6 weeks to establish

- Once inoculated with *A. colemani*, it takes approx. 4 wks for wasps to multiply

Minimum rate of at least 1/acre (43,560 sq. ft.)

- Cycle 1-2 new ABS in weekly

One ABS can last 10 wks

- Hide unsightly ones to allow remaining wasps to disperse

ABS containment box

Bouffant

Grow ABS in a secluded location, preferably in a different greenhouse & protect them. Parasitoids VERY good at finding hosts

Please view production guidelines handout

Aphid Banker Plant System

Aphidius smooth & no lid

Some hyperparasitoids have lids

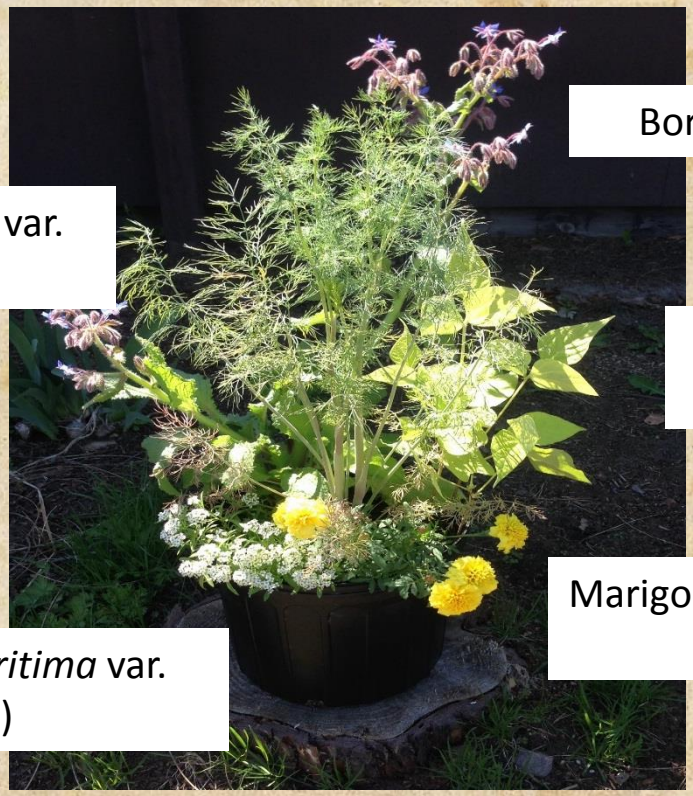
Challenges

- Labor intensive with learning curve
- Hyperparasitoids reduce *Aphidius* efficacy
  - Examine mummy lids after wasp emerges
  - Do not keep systems into late summer
- Ants guard aphids & prevent parasitism
- Not recommended if monocotyledons (lilies or ornamental grasses) are more than 10% of your crop

Dendrocerus carpenteri hyperparasitoid jagged & no lid

Habitat Plants

Summer



Borage (*Borago officinalis*)

Dill (*Anethum graveolens* var. Bouquet)

Bush Bean (*Phaseolus vulgaris* var. Provider)

Marigold (*Tagetes patula* var. Little Hero Yellow)

Alyssum (*Lobularia maritima* var. Snow Princess)

Hard Red Spring Wheat Aphid Banker

Habitat Plants

Winter

Dwarf Calendula (*Calendula officinalis* var. Yellow Gem)

Alyssum (*Lobularia maritima* var. Snow Princess)

Marigold (*Tagetes patula* var. Little Hero Yellow)

Viola (*Viola tricolor* var. Helen Mount)

Bush Bean (*Phaseolus vulgaris* var. Provider)

Cold tolerant
Max. Height under 18in

More for spring time

Hard Red Winter Wheat Aphid Banker

Plant-Mediated IPM Systems

Current Study Images

Plant-Mediated IPM Systems

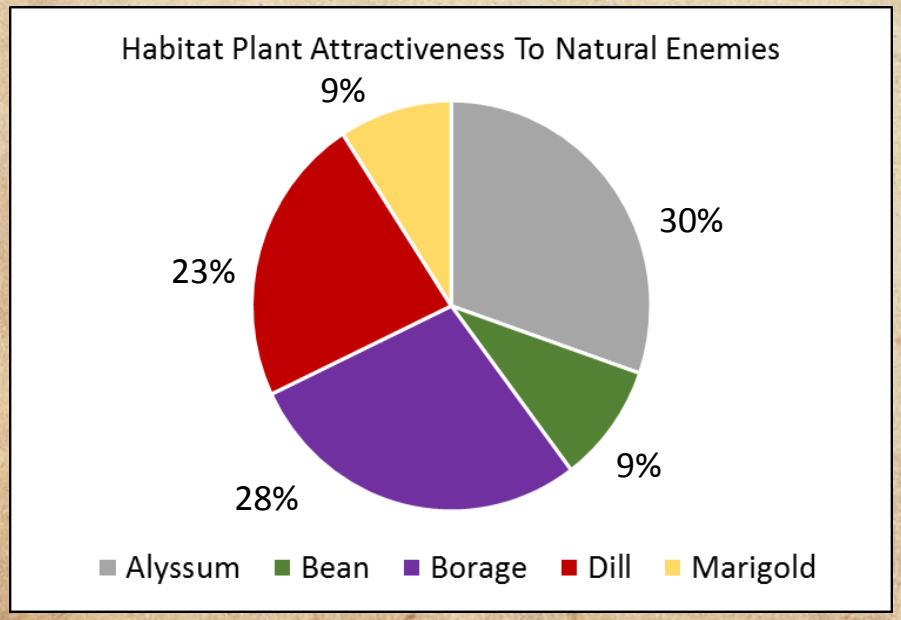
Preliminary Results: Year 1 Summer

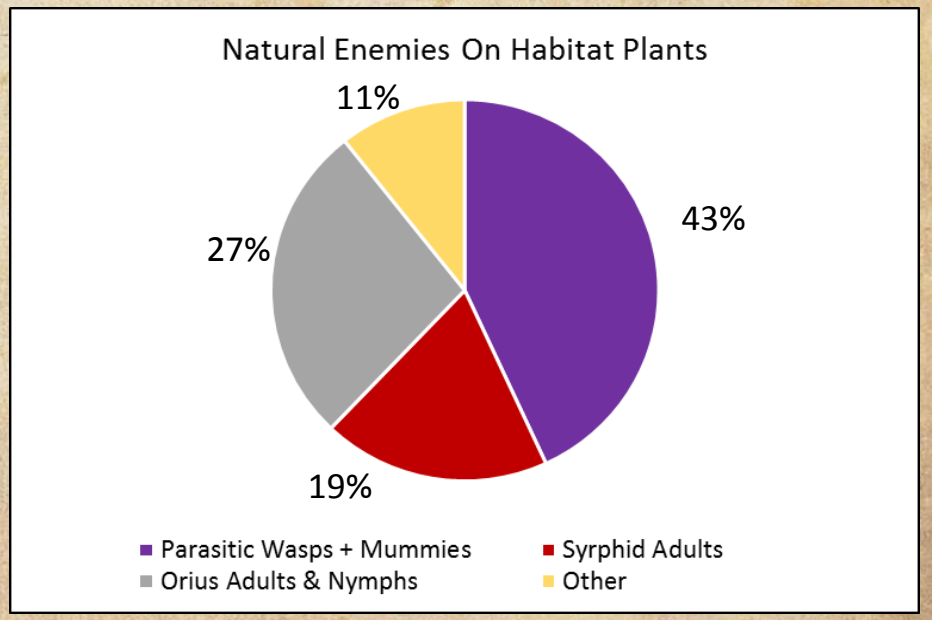
Over 700 individual natural enemies encountered

Borage, Dill & Alyssum attracted primarily parasitic wasps & mummies, *Orius* adults & nymphs & syrphid adults

Others include various lady beetle life stages, predatory maggots, assassin bugs, lacewing eggs and larvae, etc.

6 species of aphids attracted





What's the Recipe for Success?

- ✓ Scout regularly
- ✓ Make a plan and timeline before the season begins
- ✓ Get to know the pests and beneficials
- ✓ Keep records or take notes
- ✓ Identify susceptible crops or varieties
- ✓ Accept that they aren't going away
- ✓ Embrace biodiversity and encourage it
- ✓ Locate a biocontrol supplier you trust
- ✓ Become a happy zoo keeper
- ✓ **Figure out what works for you**

Bail Out Options

Chemical Considerations

- Choose least toxic insecticides
- Check side effects on natural enemies
  - Ask nat. enemy supplier

  Biobest: http://www.biobestgroup.com/en/side-effect-manual

  Koppert: http://side-effects.koppert.nl/?_ga=1.71195792.123436521.1445879572

  Syngenta: http://www.syngentaflowers.com/country/us/en/Bioline/Documents/Catalog/Bioline-Compatibility_Chart.pdf
- Coverage
  - Don't wait until the plants are 10 ft tall
  - Thin foliage to allow for penetration into the plant canopy
  - Test a few plants for phytotoxicity before you spray the whole crop

Remember, Timing Is Everything

Be Proactive, Not Reactive

Don’t be shy

Contact your support groups (Suppliers/Consultants/Univ. Extension Agents)

Questions?

Time to start planning for Spring!

Visit our Website!
http://www.uvm.edu/~entlab/

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