Beneficial Insects and Biocontrol

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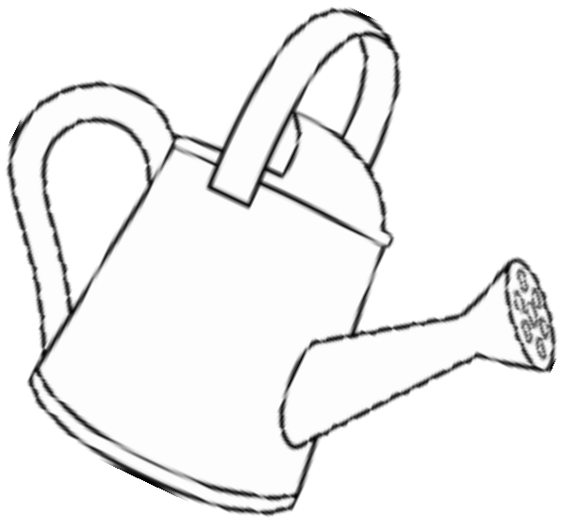
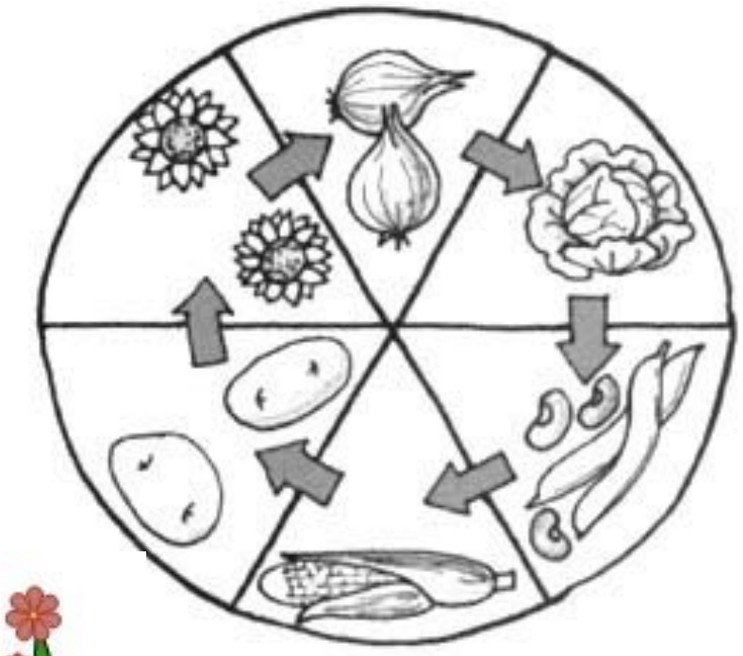
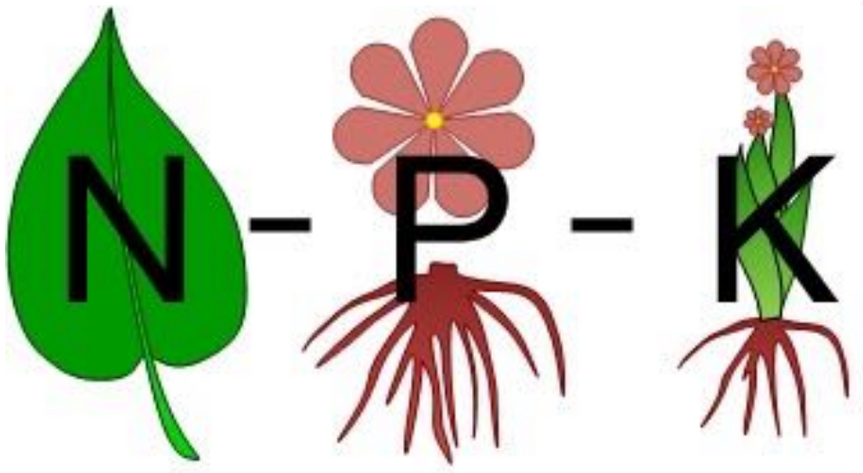
Agricultural History







Nitrogen Phosphorous Potassium

TEXAS A&M AGRILIFE EXTENSION

Agricultural History

The Green Revolution

- Between 1940's - 1960's
- "saved over a billion people from starvation"
- high-yielding varieties of cereal grains
- Expansion of irrigation infrastructure

- Modernization of management techniques
- Distribution of hybridized seeds, synthetic fertilizers,and pesticides to farmers

Norman Borlaug

Agricultural History

Show Colours Filters

26 May 2012 20:00
CO_2 151,618 t
Containers 14,196,884
Dry 548,572 kt
Liquids 397,004 kt
Gas 60,750,672 m^3
Vehicles 10,297,624 kt

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Agricultural History | Invasive species

502 Records

$ billions in economic impact

Spotted Wing Drosophila
Estimated revenue loss in 2008
$511.3 million

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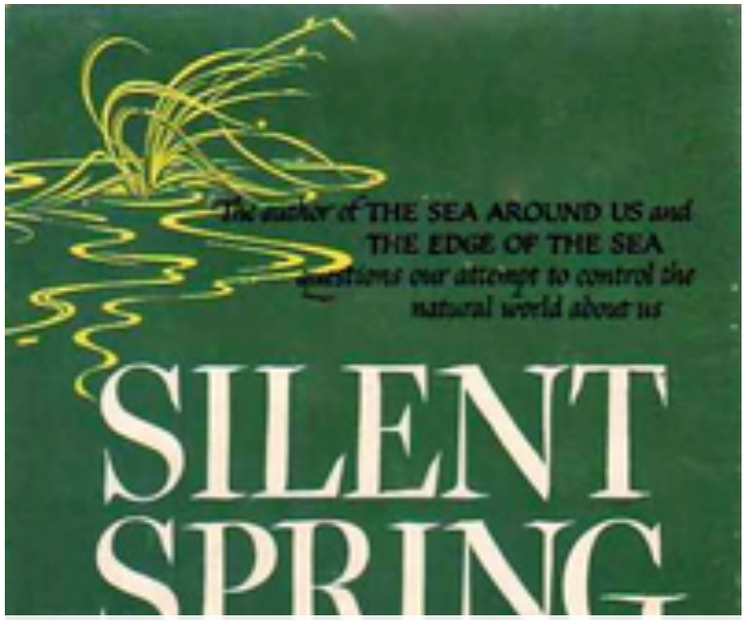
Agricultural History

Integrated Pest Management



"Why should we tolerate a diet of weak poisons, a home in insipid surroundings, a circle of acquaintances who are not quite our enemies, the noise of motors with just enough relief to prevent insanity? Who would want to live in a world which is just not quite fatal?"

1970's

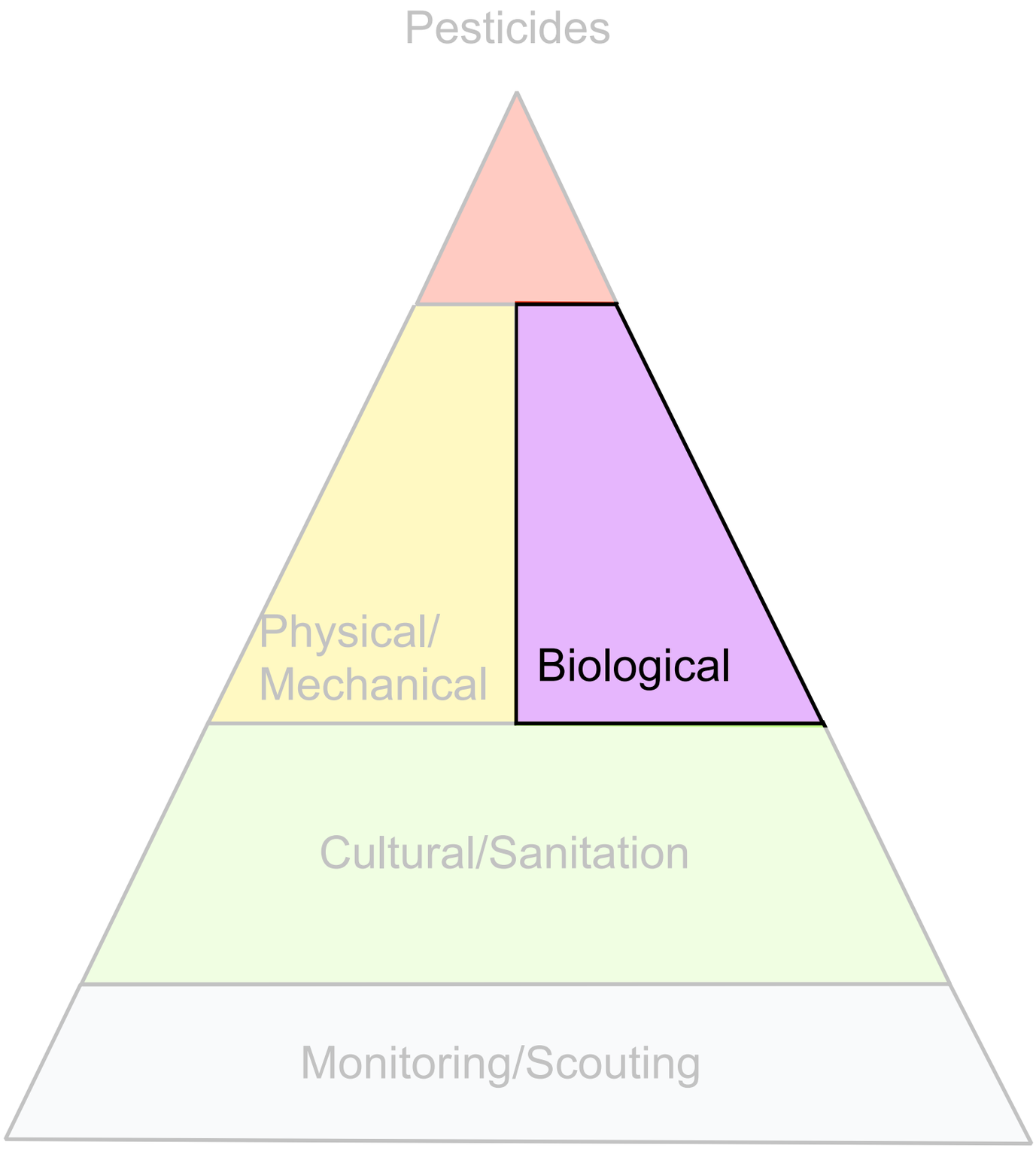
USDA creates nationwide IPM program in Land Grant Universities

TEXAS A&M AGRILIFE EXTENSION

Integrated Pest Management

- Minimize impact on the environment
- Minimize impact on human health
- Maintain or increase soil fertility
- Long-term pest management
- Prevent pesticide-resistant pests
- Strives to maximize long-term returns/savings

IPM Pyramid



Biological

- Insect pathogens (i.e. *Bt*)
- Pheromone traps/mating disruption
- Sterile Insect Release
- Conservation
- Classical
- Augmentation
- Banker plants

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Sterile Insect Release

Photo: John Meyer

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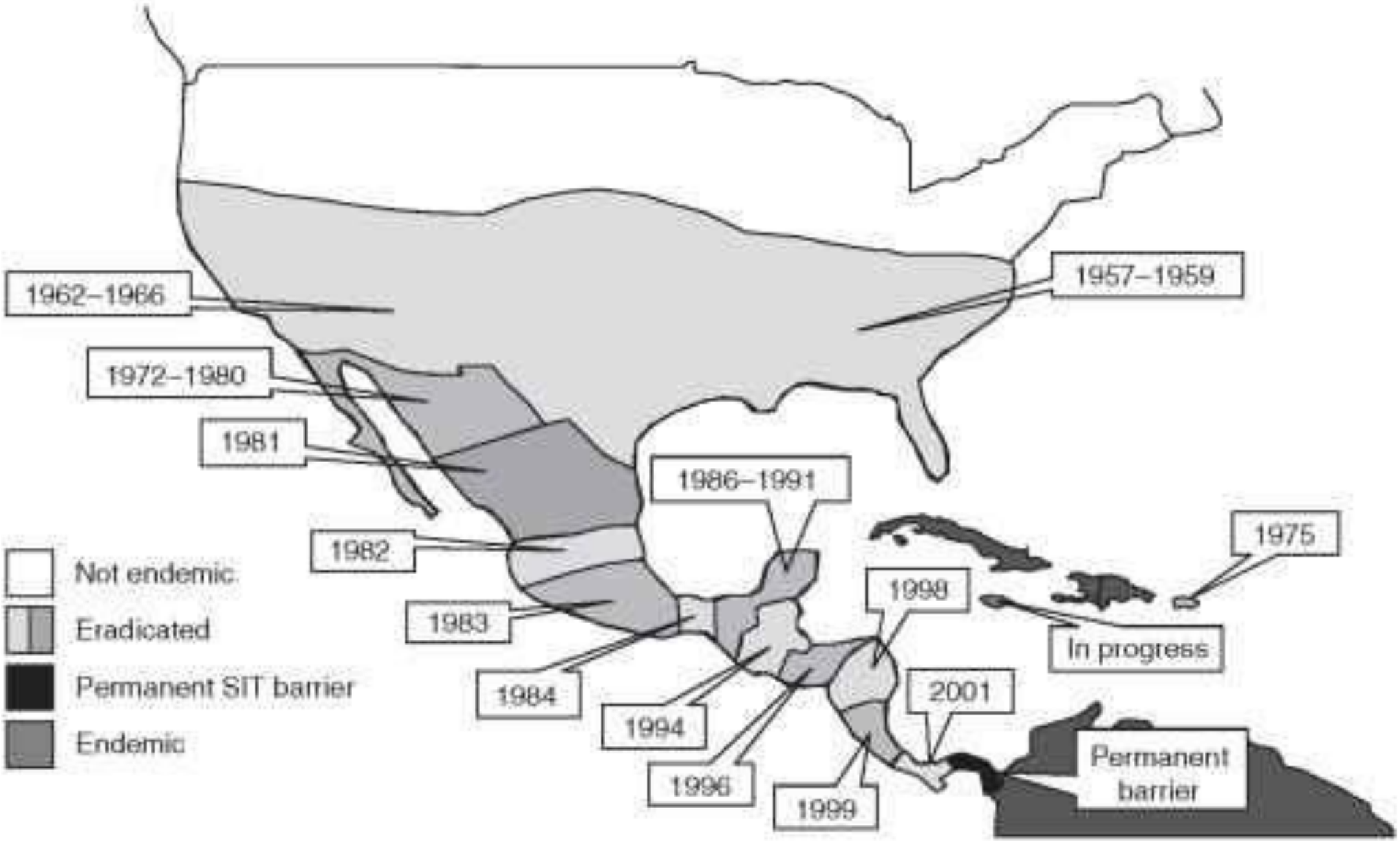
Sterile Insect Release



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Sterile Insect Release

Mosquitoes

Dengue Fever

- 50 - 100 million cases of dengue fever per year
- 500,000 dengue hemorrhagic fever per year
- 22,000 deaths per year (mostly among children)

Malaria

- 216 million cases in 2010
- 655,000 deaths in 2010, mostly in African countries

WHO

TEXAS A&M AGRILIFE EXTENSION

Sterile Insect Release

Categories

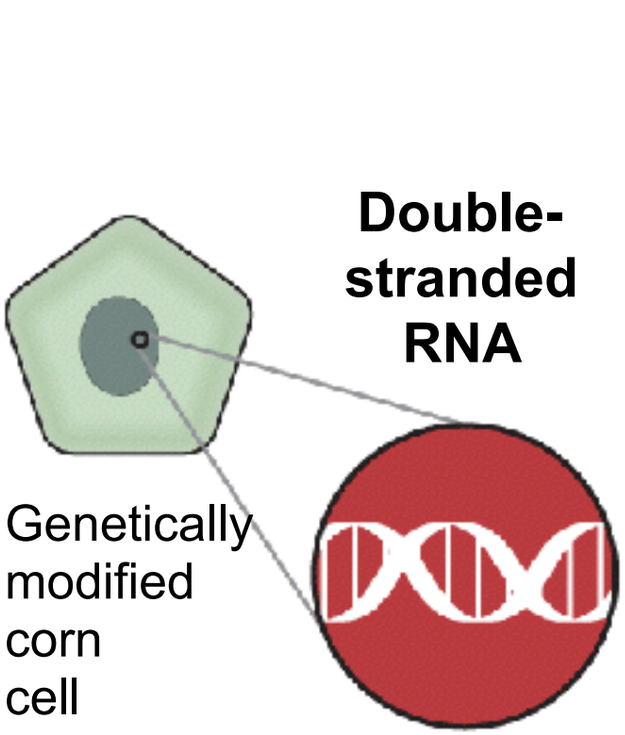
- News
- Newsletter
- Events
- Oxitec in the news
- Resources
  - Documents
  - Presentations

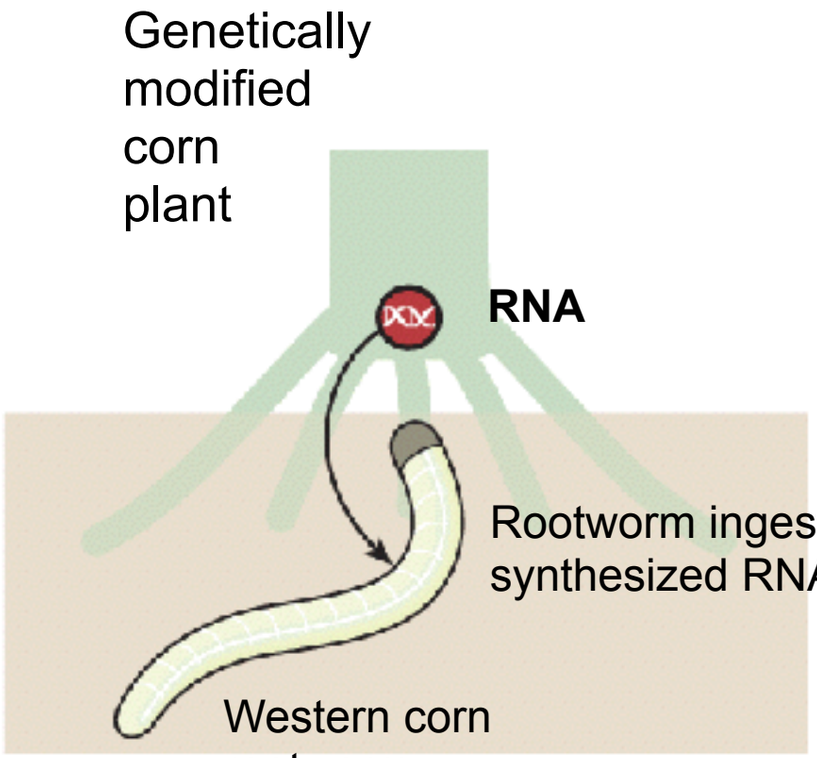
PRESS RELEASE: Oxitec report 96% suppression of the dengue mosquito in Brazilian trials

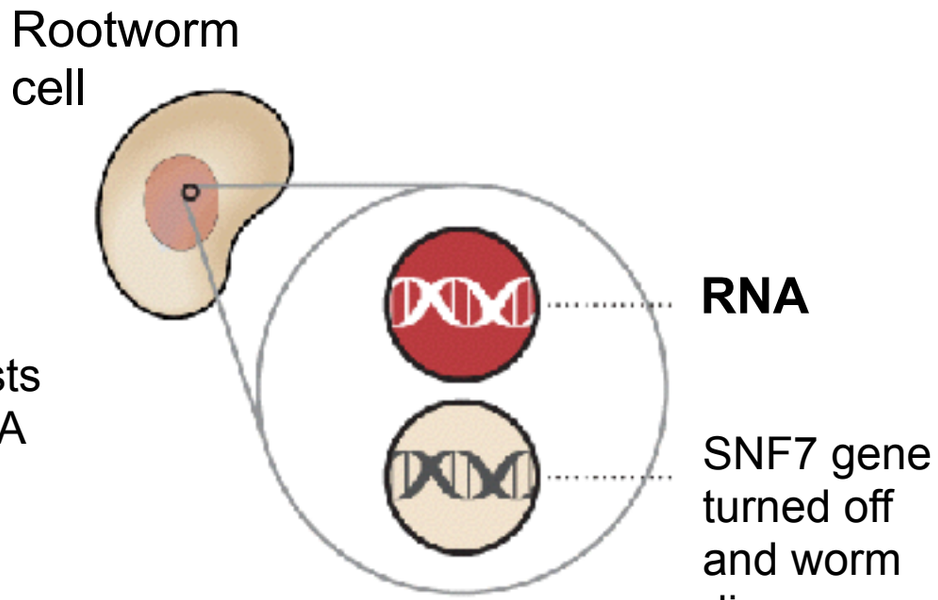
Tracy Thompson *21st May 2013* *News, Oxitec in the news*

Mandacaru field trial report – press summary

RNAi

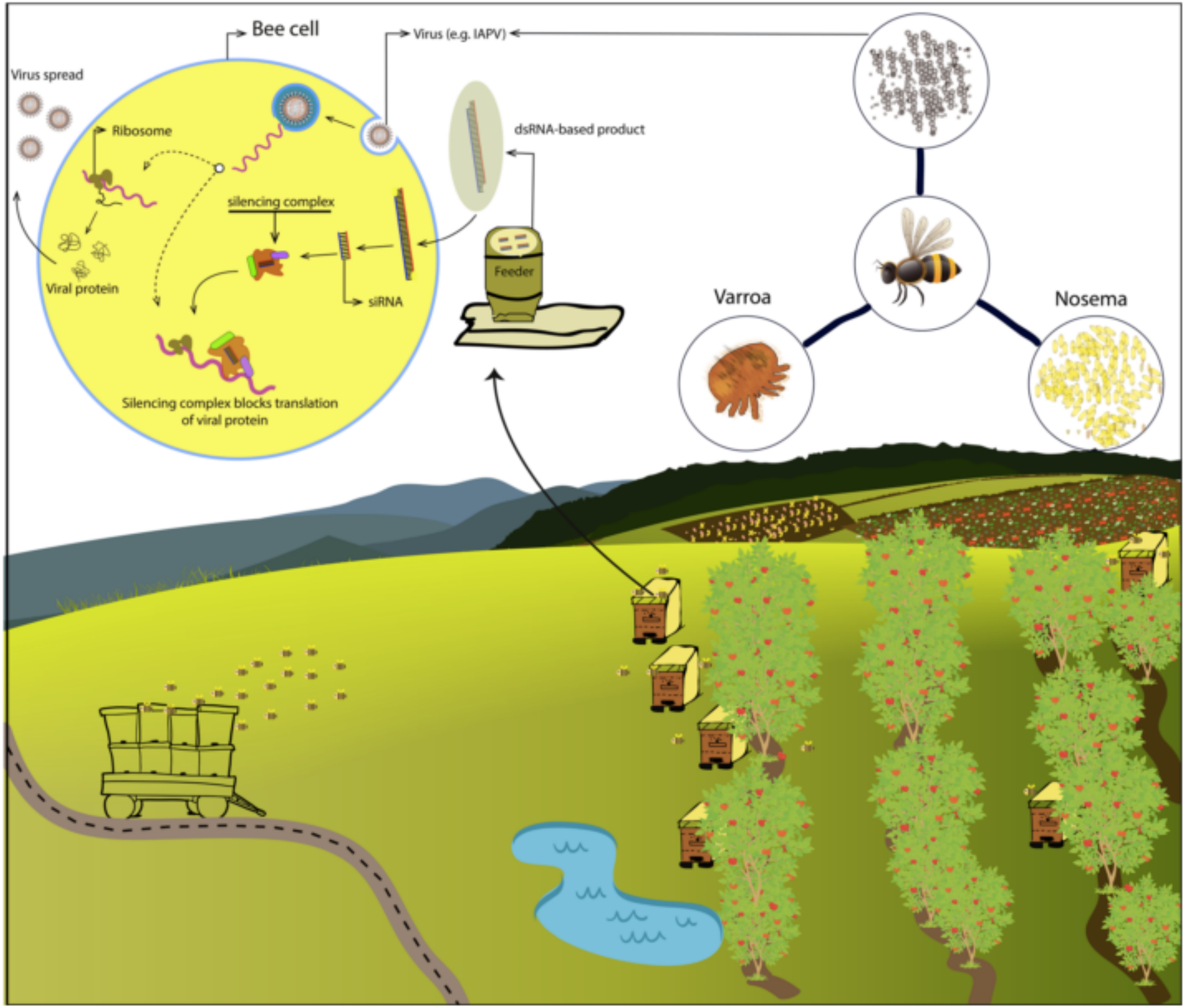






From: Using GMO Crops to Target a Pest

Texas A&M AgriLife Extension


Bee cell
Virus (e.g. IAPV)
Virus spread
Ribosome
dsRNA-based product
silencing complex
Feeder
Viral protein
siRNA
Varroa
Nosema
Silencing complex blocks translation
of viral protein

Biological Control

Biopesticides

US EPA - “naturally occurring substances that control pests (**biochemical pesticides**), microorganisms that control pests (**microbial pesticides**), and pesticidal substances produced by plants containing added genetic material (**plant-incorporated protectants**) or PIPs”

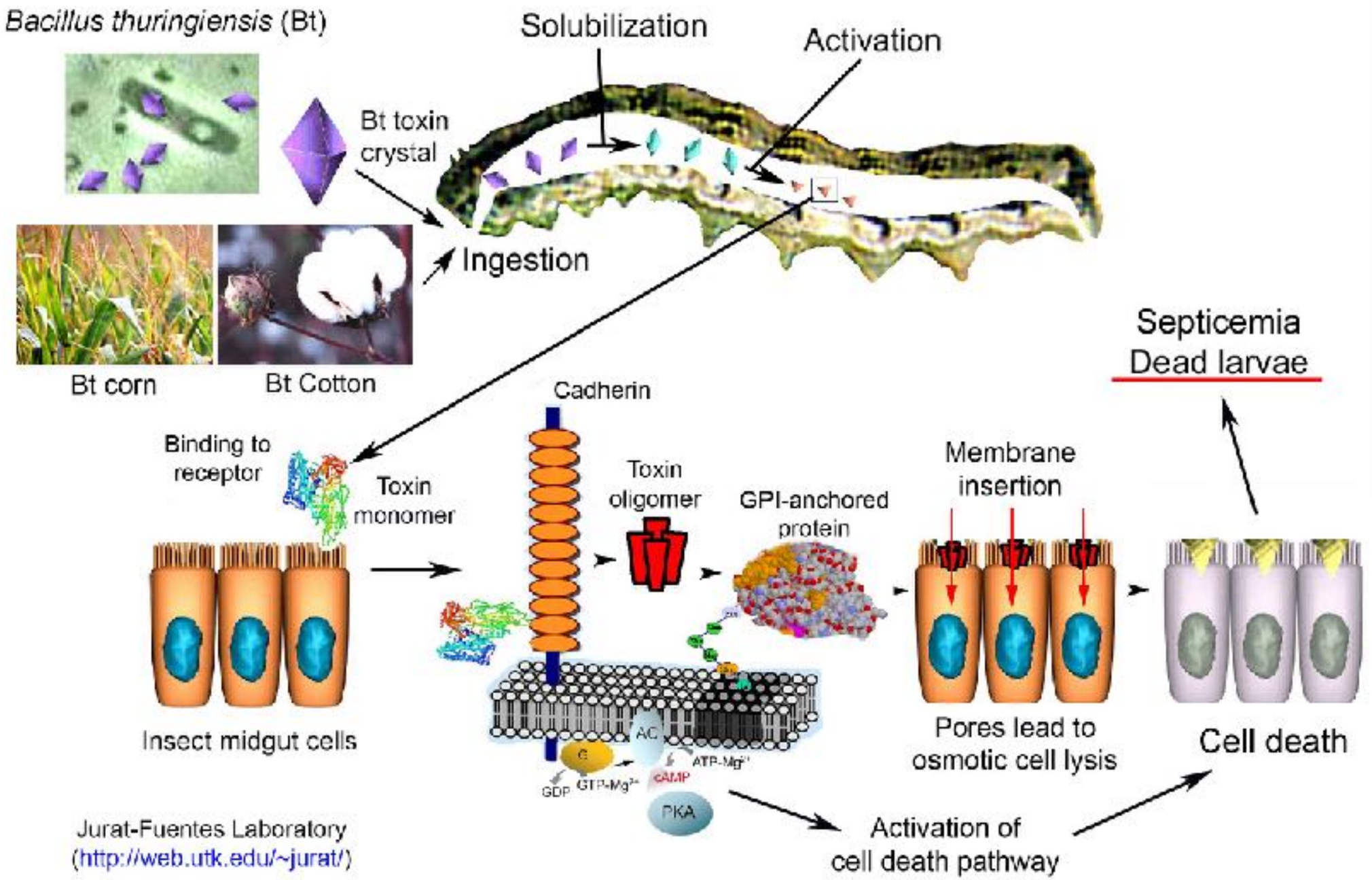
Biochemical pesticides | Horticultural Oils

Microbial pesticides | *Bacillus thuringiensis* (Bt) spray

Plant-incorporated protectants | Bt corn

Biological Control

Bt spray/GMO Bt



Biological Control

Reduction of pests with the use of natural enemies

Good Bug → Kill → Bad Bug

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Biological Control

Conservation, Classical and Augmentation

Conservation	Classical	Augmentation
• ***Conserve natural enemies*** • ***Reduce sprays*** • ***Better timed sprays*** • ***Keep natural enemy habitats and alternative hosts***	• ***Introduce an 'alien' predator for control of an invasive pest*** • ***Establish predator-prey interaction***	• ***Supplemental release of natural enemies*** • ***Inundative vs. inoculative***

Biological Control

Taxonomy and Systematics

Classification system to reflect relationship between species/groups of organisms

Most important factor for evaluating risk: Correct identification of target pest & candidate biological control agent

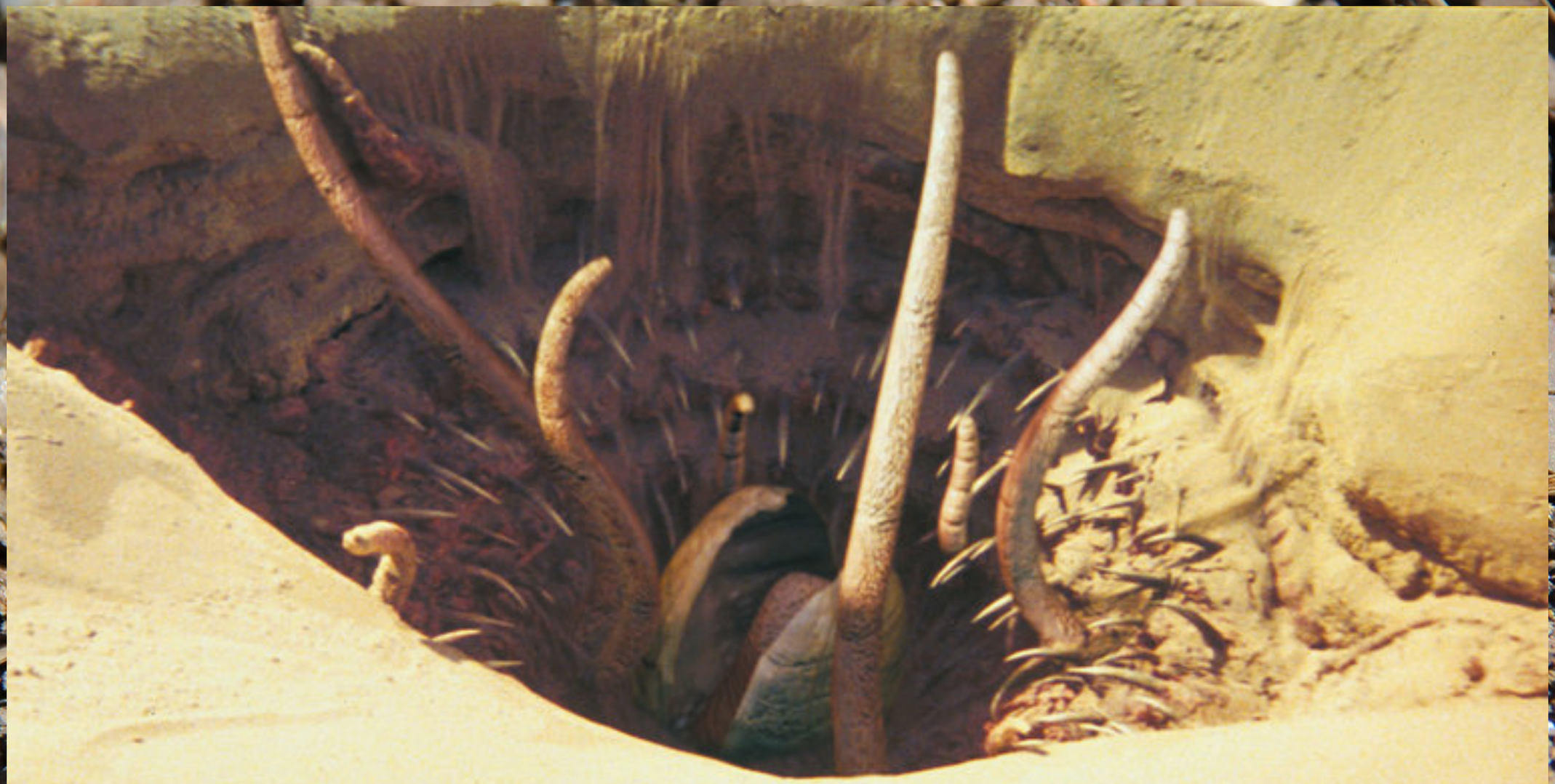
"Modern biological control programs conducted without adequate vouchering are reckless and bad science" (Andersen & Wagner 2016)

Provide case studies involving poor/incorrect identification:

- Target pest:
  - Cryptic species: Cassava mealybug, Phenacoccus manihoti Matile-Ferrero
  - Weed biological control: floating fern, *Salvinia molesta*
- Natural enemy:
  - *Trichogramma* species for *Diatraea saccharalis* control
  - 33 predators released to control the balsam woolly adelgid in Canada and USA
  - Cryptic species of minute pirate bugs for Cuban laurel thrips control
  - *Aleochara biupustulata* (staphylinid beetle) for control of *Delia radicum* (Diptera pest of canola crops in Canada)

TEXAS A&M AGRILIFE EXTENSION


Vafaie 2016



Sarlacc, Star Wars: Return of the Jedi, 1983

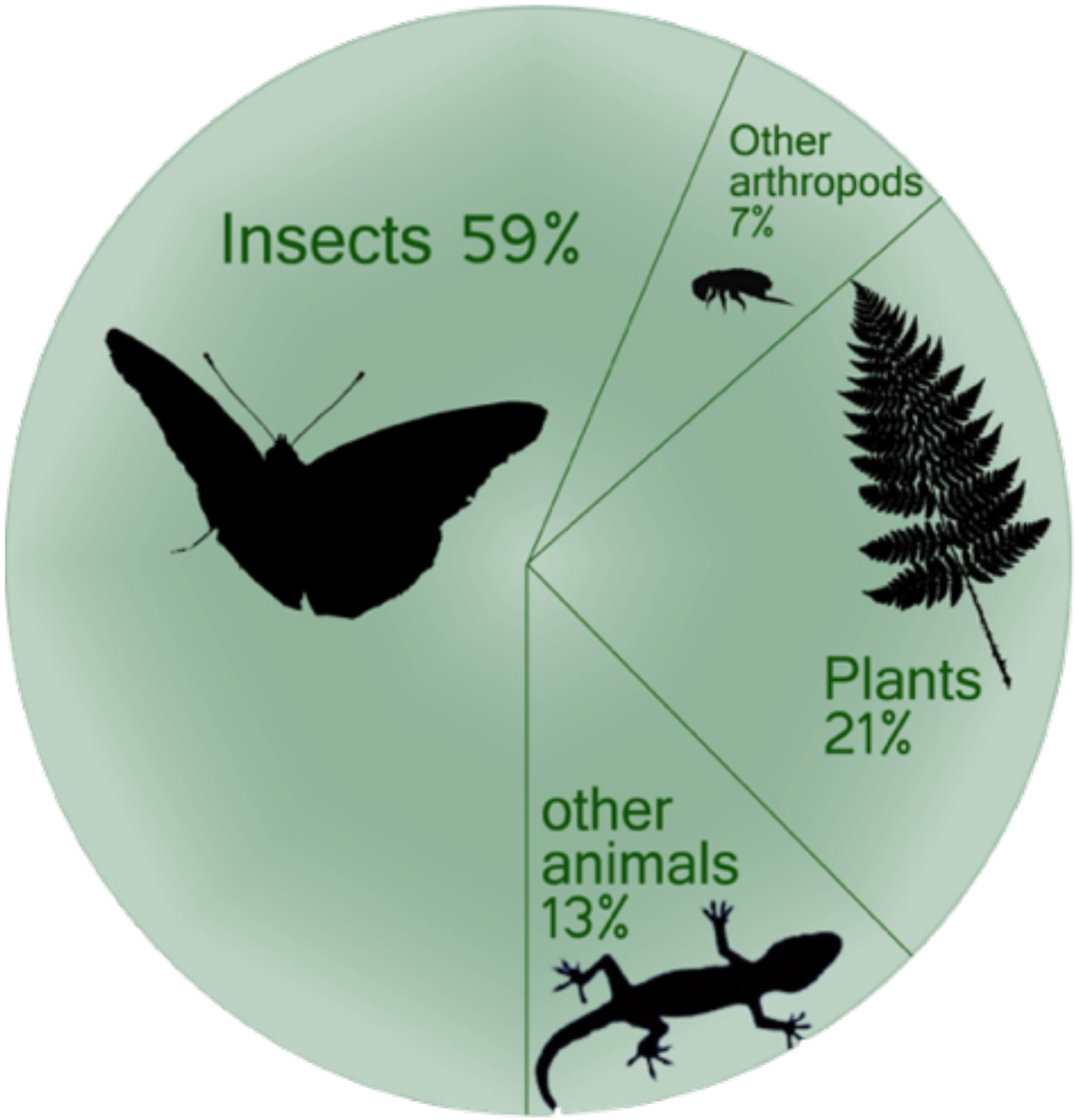
Mini Aliens are diverse!

Recent estimates of species diversity

Total estimated species count: 8.7 million (Eukaryotes)

- 2.2 million marine
- 1.2 million species described
- 86% of existing species undescribed (96% of marine species)

(Mora et al. 2011)



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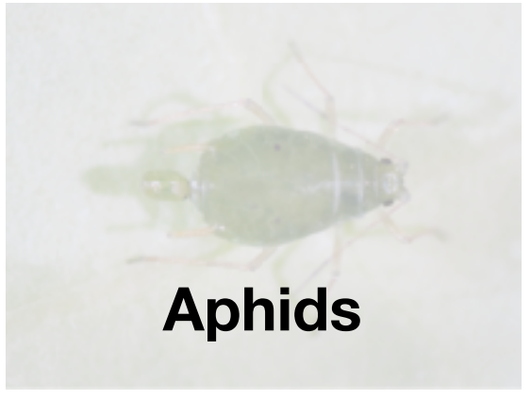


Aphids

Whiteflies

Twospotted spider mites

Thrips

Mealybugs

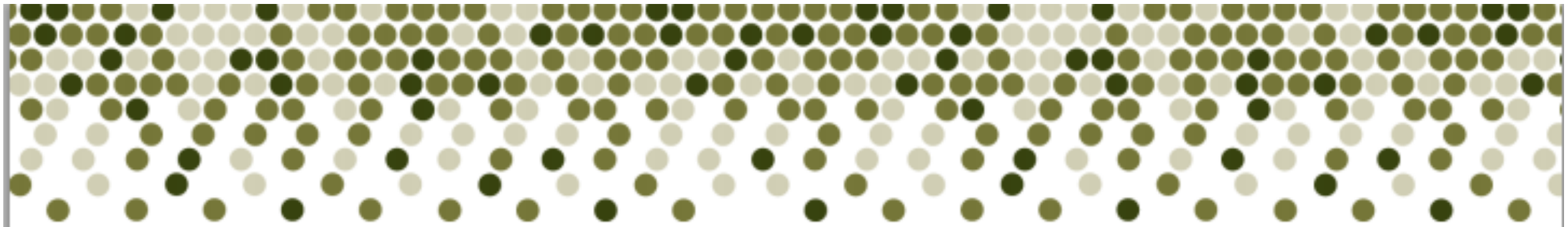
Fungus gnats

Caterpillars & Beetle Larvae

TEXAS A&M AGRILIFE EXTENSION

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

- Macroorganism
- Eat, lay eggs in, or decrease survival of pests
- Typically applied manually/by hand, in specialized release packets
- Quality control:



Grower Guide:
Quality Assurance of Biocontrol Products

Compiled by Rose Buitenhuis, PhD, Research Scientist, Biological Control,
Vineland Research and Innovation Centre, 2014

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Advantages

- Reproduce
- Target & find the pest
- Evolve with the pest
- Can be economic
- No environmental toxicity
- Don’t harm other beneficials
- No pesticide residue
- No phytotoxicity
- Insects are super cool!

TEXAS A&M AGRILIFE EXTENSION

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Disadvantages

- Not immediate
- Requires more human involvement
- Initially more costly; time to establish biocontrol program
- Must tolerate some damage
- Challenging in the face of new invasive pests
- Requires effective monitoring program
- Won’t magically ‘fix’ pest problems

TEXAS A&M AGRILIFE EXTENSION

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Video Credit: Franz Simon

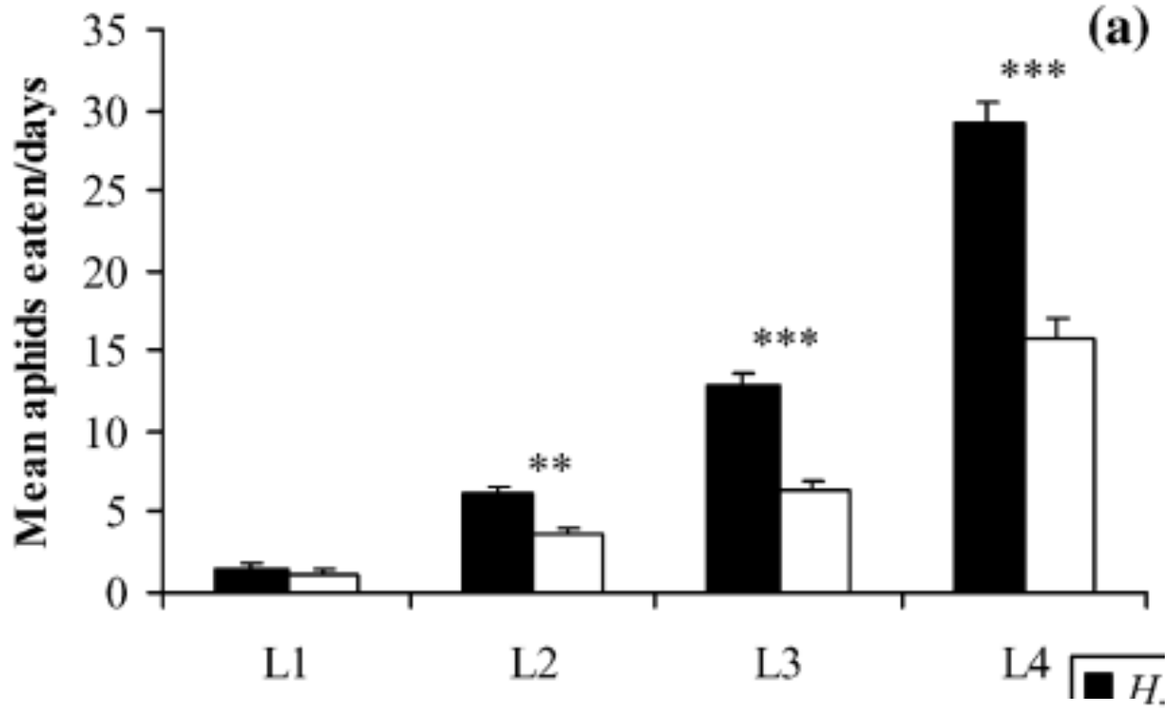
Harmonia axyridis | Multicolored Asian Lady Beetle

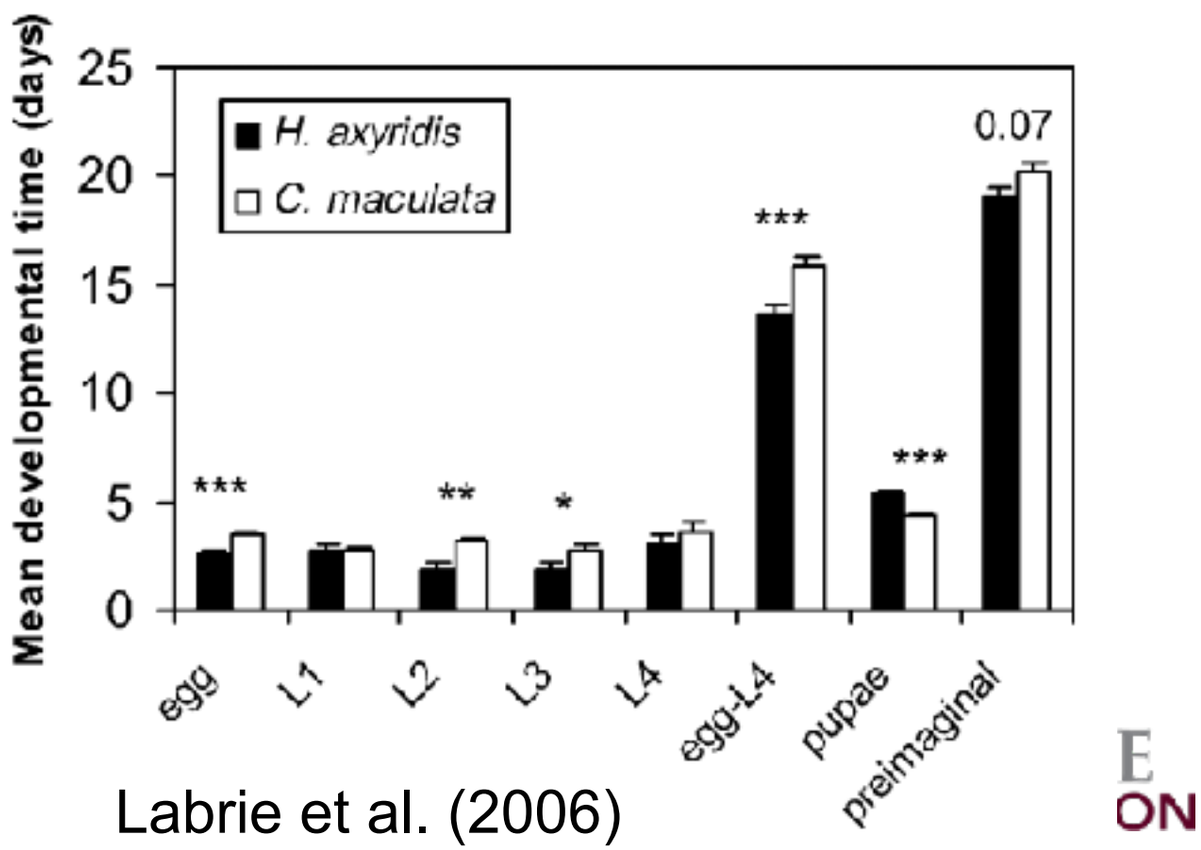
Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Multicolored Asian Lady Beetle

Gerald J. Lenhard, Louisiana State University, Bugwood.org

Multicolored Asian Lady Beetle





Labrie et al. (2006)

Multicolored Asian Lady Beetle

Larva

185 aphids over 11 days

Variable	*M. persicae*	*A. fabae*
Diet		
Daily voracity (V_o)	45·8 ± 3·5a*	35·4 ± 3·3b
Daily relative consumption rate (*RCR*)	21·2 ± 1·6a	37·2 ± 3·4b
Relative growth rate (*RGR*)	3·9 ± 0·4a	4·1 ± 0·4a
Capture efficiency (*CE*)	0·082 ± 0·007a	0·125 ± 0·01b
Reproductive capacity		
Fecundity (Fc)	314·0 ± 42·6a	342·2 ± 32·9a
Fertility (Fr)	244·3 ± 41·3a	251·6 ± 29·1a
Percentage of hatching (Ph)	63·2 ± 7·5a	63·9 ± 7·0a

Soares et al. (2004)

TEXAS A&M AGRILIFE EXTENSION

Multicolored Asian Lady Beetle

Larva

185 aphids over 11 days

Adults

35 - 45 aphids/day
~240 viable offspring
Can live longer than a year

Generalist

Tend to disperse shortly after introduction

TEXAS A&M AGRILIFE EXTENSION

Vedalia beetle

- Introduced to California Citrus groves to control cottony cushion scale in 1889
- Established the practicality of biological control
- Had cleared some orchards (150 acres+) of the cottony cushion scale
- Only takes a few beetles to get a population started
- 8 - 12 generations per year
- Females lay ~150 - 190 eggs in their lifetime

Cryptolaemus | Mealybug Destroyer

Video Credits: YouTube User encyrtid

Cryptolaemus | Mealybug Destroyer

Andrew Allen, Flickr

Cryptolaemus | Mealybug Destroyer

gbohne, Flickr

Cryptolaemus | Mealybug Destroyer

Hosts:
- Mealybugs
- Soft scales

A type of lady beetle

Adult female can lay 10 eggs per day or 500 eggs in her lifetime

Both larvae and adults can feed on mealybugs and scales

Each larva can consume an average of 881 eggs, 259 nymphs or 28 adult female scales (*Maconellicoccus hirsutus*) (Thontadarya & Mani 1987) Kaur & Virk (2012)

Dalotia coriaria (Atheta coriaria) | Greenhouse rove beetle

Hosts:

- Sciarid flies (dark-winged fungus gnats)
- Shore flies
- Western Flower Thrips

Capable of consuming over 150 eggs or 1st instar larvae of *Bradysia impatiens* within 24 hrs

Carney et al. (2002)

Significantly reduces western flower thrips populations in standard roses due to soil-dwelling stage (Teerling and Write, 2000).

Heterorhabditis & Steinernema | Nematodes

Photo: Scott Johnson

- Generalist: Asparagus beetle, Colorado Potato Beetle, Cucumber Beetle, Japanese Beetle, June Bugs, Oriental Beetle, Carrot Weevil, Citrus Weevil, European Chafer, Strawberry Root Weevil, etc.
- Applied using watering can, hose end sprayer, backpack or pump sprayer, or through irrigation system
- Results in 3-7 days

Biological Control | Sprays

Nosema locustae & Beauveria bassiana

Nosema

- Kills over 90 species of grasshoppers, locusts, and some species of crickets
- Infection can build throughout a season

Aphidius colemani

Aphidius colemani

Hosts:

- Cotton aphid or melon aphid | *A. gossypii*
- Cabbage aphid | *B. brassicae*
- Green peach aphid | *M. persicae*
- Corn leaf aphid | *R. maidis*
- Greenbug or wheat aphid | *S. graminum*
- Over 40 aphid species

(Reed et al. 1994; De Conti et al. 2008)

Life-history:

- Female can produce 71 - 105 mummies (Wee Han et al. 2001)
- No mummies formed below 15ºC (59F) or above 30ºC (86F) (Wee Han et al. 2001’ Baniameri et al. 2006)

Aphidius ervi

Nikk, Flickr

Hosts:

- Green Peach aphid | *M. persicae*
- Tobacco aphid | *M. persicae*
- Foxglove aphid | *A. solani*
- Pea aphid | *A. pisum*
- Over 40 species of aphids

Lay 50 - 150 eggs

Produce males and females

Aphidius matricariae

biobest.com

Hosts:

- Over 40 aphid hosts (Schlinger et al. 1963)
- Green peach aphid (*Myzus persicae*)

Optimal temperatures 18-25°C (64-77°F)

Lay ~100 eggs in their lifetime, and attack 200 - 300 aphids in the process

Encarsia formosa

Encarsia formosa

Hosts:
- Sweet potato/silverleaf whitefly (*Bemisia tabaci*)
- Greenhouse whitefly (*Trialeurodes vaporariorum*)
- 15 species of whiteflies

Produce only female offspring (thelytokous)

Above 31ºC (88F), start producing males
(Kajita, 1989; Zchori-Fein et al. 1992)

Cause significant mortality due to “host feeding”

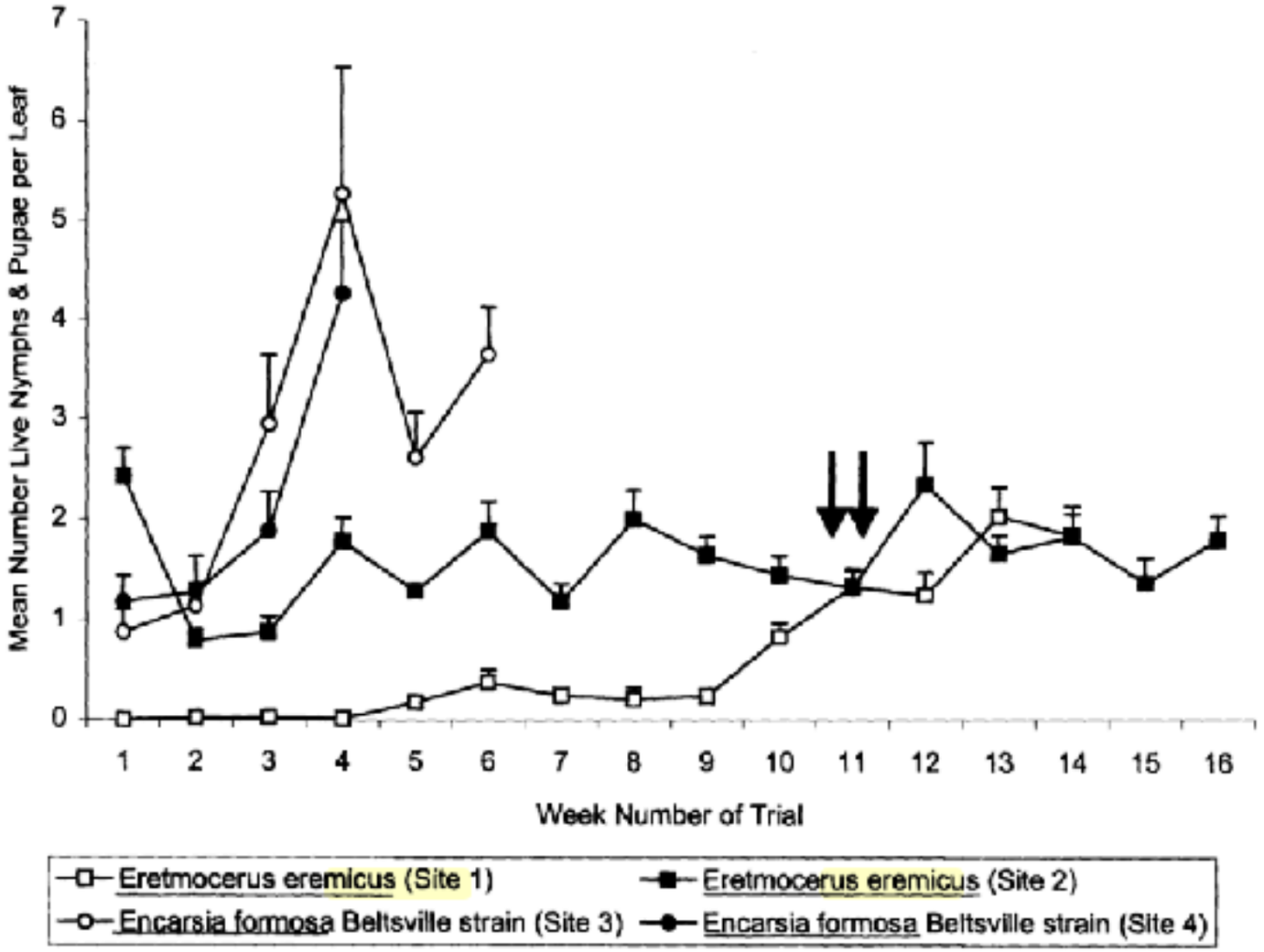
Adult survival: 36.8 days

Lays about 442 eggs in her lifetime

Kills about 101 hosts by “host-feeding”
(Arakawa 1982)

Eretmocerus eremicus

Eretmocerus eremicus



af whitefly

ialeurodes

(*T. abutlonea*)

Fig. 2. The mean number of live *Bemisia argentifolii* nymphs and pupae (± SE) per leaf on uncaged poinsettia plants in the biological control greenhouses treated with *Eretmocerus eremicus* (sites 1 and 2) or *Encarsia formosa* Beltsville strain (sites 3 and 4). Trial duration times at sites 3 and 4 were reduced because growers intervened with chemical treatments to suppress *B. argentifolii* population growth. Arrows indicate times of insecticide applications at site 2.

Hoddle et al. 1999

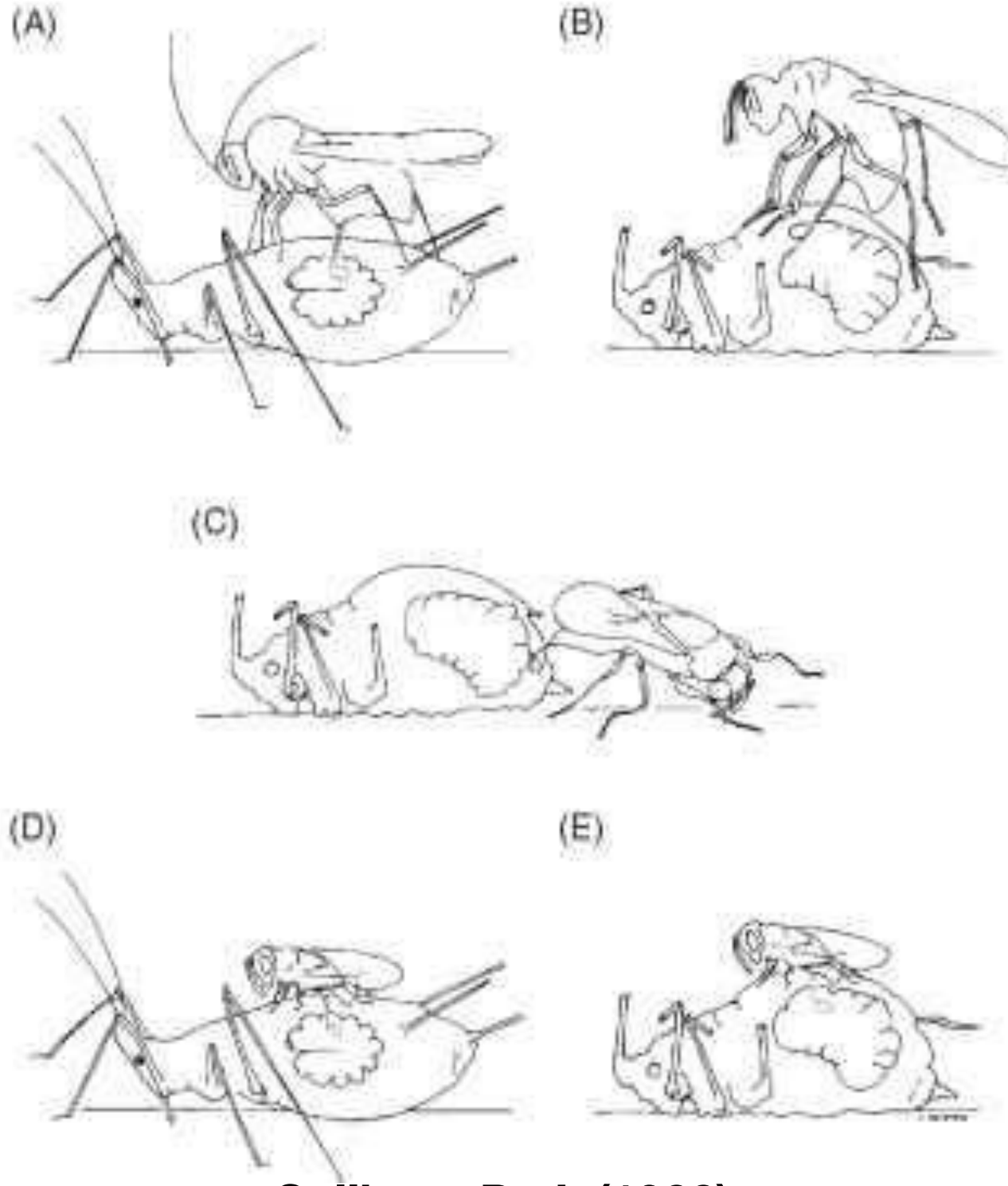
Eretmocerus eremicus

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Dave Govoni, Flickr

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

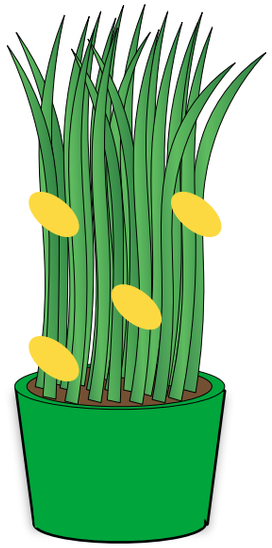
Hyperparasitoids



Sullivan, D. J. (1988)

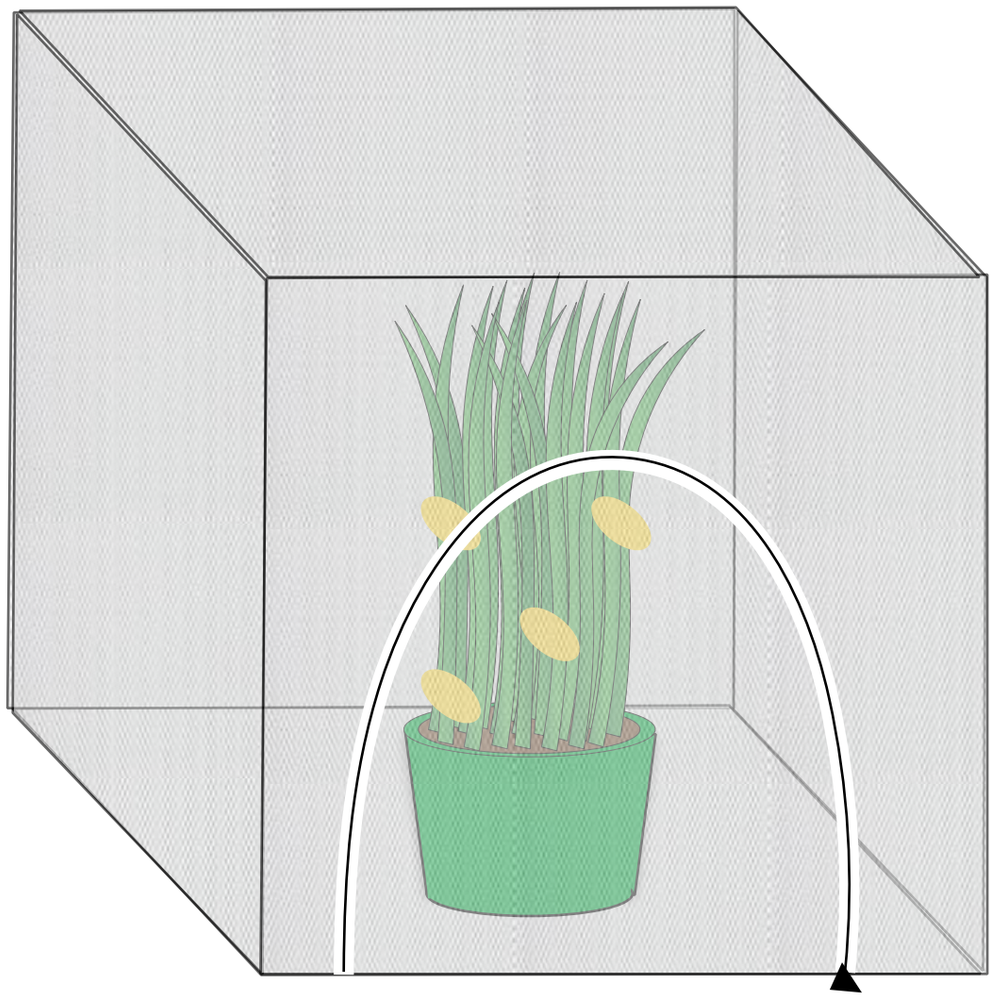
Biological Control | Predators

Banker plants



Biological Control | Predators

Banker plants



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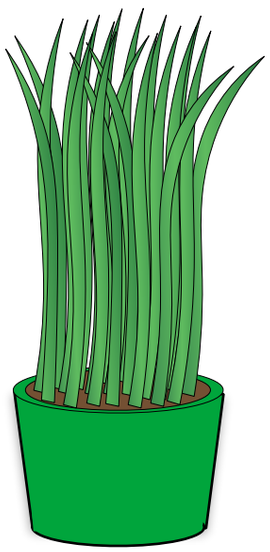
Biological Control | Predators

Banker plants

- Cereal aphids[1], bird cherry oat aphids[2,3], greenbug[5]



Cereal plants: rye[4], wheat[5], barley[5], maize[5], sorghum[5]

Parasitic wasps: *Aphidius ervi*[1,4], *A. matricariae*[2], *A. colemani*[2,3,4,5]

Amblyseius cucumeris

Hosts:
- Thrips
- Cyclamen mites
- Broad mites
- Rust mites

Eat 2 - 3 thrips per day

Lay 2 - 3 eggs per day

Can survive/persist on pollen

Optimal temperature 20 - 25°C (68 - 77°F)

A. swirskii

A. swirskii

Steven Arthurs, University of Florida

Hosts:
- Thrips
- Whiteflies
- Broad mite

First discovered as a predator while investigating the cause of continuous disappearance of *B. tabaci* eggs and larvae in a lab culture (Teich 1966)

Performs in environments where maximum daily temperatures are between 28 – 30ºC (82 - 86F), with peaks up to 40ºC (104F) (Bolkmans et al. 2005)

Can survive on pollen

Bill Lewis, Delray Plants

Amblyseius andersoni

Bioplanet

Amblyseius andersoni

Hosts:
- Two-spotted spider mite
- broad mite
- Carmine mite
- Cyclamen mite
- Tomato russet/rust mite
- European red mite

Can survive on pollen and thrips larvae
Active between 6 - 40ºC (43 - 104ºF)

Amblyseius californicus

Beneficial Insectary

Amblyseius californicus

Hosts:
- Two-spotted spider mite
- Carmine mite

Can survive on pollen and other arthropods

Active in high temperature and low humidity conditions

Phytoseiulus persimillis

Phytoseiulus persimilis

Hosts:

- Two-spotted spider mite

- Voracious feeders of two spotted spider mite eggs and adults

- Effective at temperatures 14 - 30ºC (57 - 86 ºF). Above the upper temperature range, two-spotted spidermites will reproduce faster than *P. persimillis* can eat

Hypoaspis

Jarmo Holopainen, pbase.com

Hypoaspis miles = Stratiolaelaps scimitus

Hosts:
- Sciarids (dark winged fungus gnats)

Can develop between 10 - 29ºC + (50 - 84.2+ F) (Wright & Chambers 1994)

Adults can survive over 24 days if starved from birth and >65 days+ if starved after 6 days (Wright & Chambers 1994)

Produce 26 eggs on average per female mite (Cabrera, Cloyd, & Zaborski, 2005)

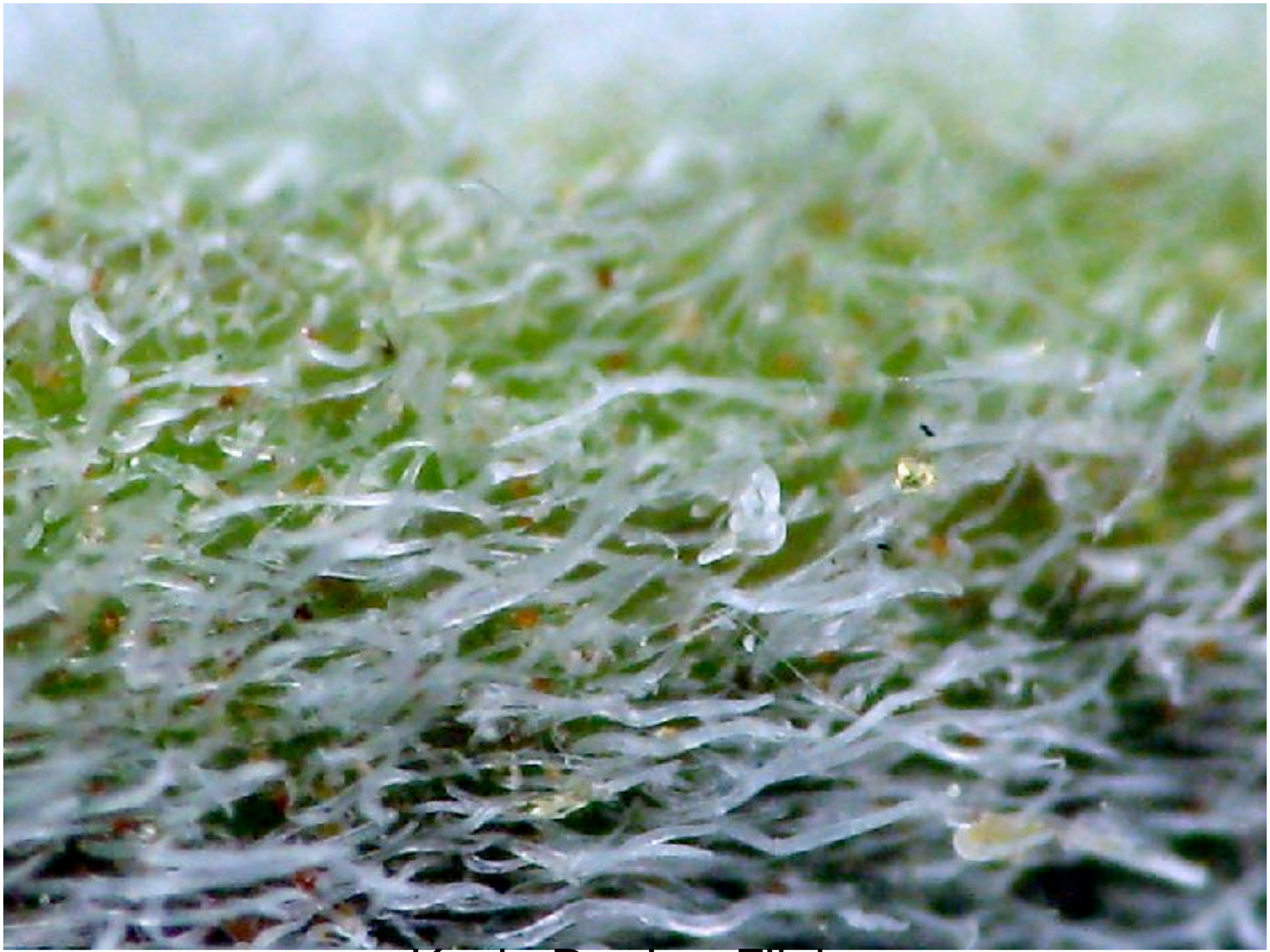
Consume about 7.7 1st instar sciarid larvae per day (Wright & Chambers 1994)

Very active when looking for prey; less active after feeding on 1st - 3rd instar sciarids and lay numerous eggs (Wright & Chambers 1994)

Can develop between 10 - 29ºC + (50 - 84.2+ F) (Wright & Chambers 1994)

Adults can survive over 24 days if starved from birth and >65 days+ if starved after 6 days (Wright & Chambers 1994)

Mites: Caution, beware of hairy plants!



Kevin Dooley, Flickr

Aphidoletes aphidimyza

Bioplanet

Aphidoletes aphidimyza

Whitney Cranshaw, Colorado State University, bugwood.org

Aphidoletes aphidimyza

Hosts:
- Aphids

Feed on over 60 aphid species

Each female can lay about 70 eggs on leaves among aphids

Eggs hatch (2-4 days) and midge larva paralyses each aphid and then sucks it dry

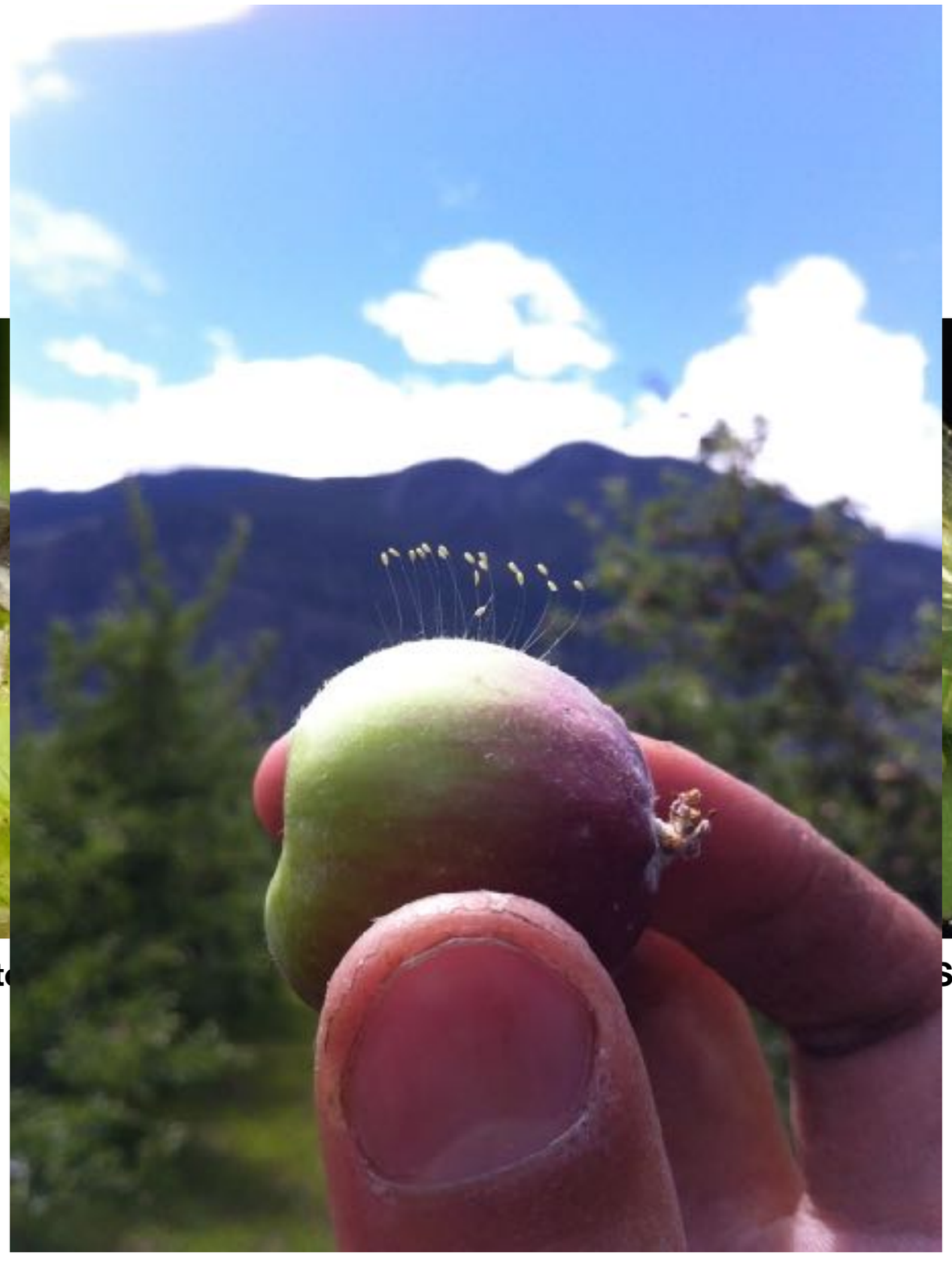
Larvae pupate in the soil below the plant

Economic mass production

Most effective between 20 - 26°C (68 - 78.8 F)

Video Credits: YouTube User Pests and Natural Enemies

Chrysoperla spp. | Green lacewings



David Cappaert, Michigan State University, bugwood.org

Chrysoperla spp. | Green lacewings

- AKA Aphidlion
- Consumes ~200 aphids/ week
- Female lays up to 300 eggs over 3 - 4 weeks

- Generalist: insect eggs, aphids, thrips, mealybugs, immature whiteflies, and small caterpilliars.
- Released aphidlions can move 80 - 100 feet in search of prey.

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Syrphidae | Hoverflies

Consume soft-bodied insects, such as aphids and thrips

Adults can lay up to 1,500 eggs (Scott & Barlow 1984)

Adult females can live up to three weeks in lab controlled settings

Larvae can consume over 1,000 aphids (Tenhumberg 1992)

Longevity of adults can be increased with floral resources (Pinheiro 2013)

"M. sylvestris and *A. azurea* allow an easy exploitation of nectar by hoverflies because they have open corollas with 20 - 60 mm and 8 - 15 mm in diameter, respectively"

Pinheiro et al. 2013

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Orius

John Ruberson, Kansas State University, Bugwood.org

Orius

- Feed on virtually any small soft-bodied insect: thrips, mites, aphids, whiteflies, leafhoppers, and many insect eggs.
- Adult lifespan: 3 - 4 weeks
- Consume numerous prey daily (~30 mites per day)
- Can feed on pollen when no prey available
- Like purple flash pepper plants

Steinernema | nematodes

Photo: Scott Johnson

Steinernema | nematodes

Hosts:

- Fungus gnats
- Thrips (soil and foliar)
- Asparagus beetle
- Cucumber Beetle
- Japanese Beetle
- June Bugs
- Oriental Beetle
- Carrot Weevil
- Citrus Weevil
- European Chafer
- Strawberry Root Weevil
- And more

Applied using watering can, hose end sprayer, backpack or pump sprayer, or through irrigation system

Results in 3-7 days

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Cryptolaemus | Mealybug
Trichogramma | T. pretiosum
Steinernema | Caterpillars/Grubs/fungus gnats/Thrips
Atheta coriaria | Fungus Gnats
Hypoaspis | Fungus Gnats
Amblyseius cucumeris (breeding sachet or bran) | Thrips
Orius | Thrips, aphids, whiteflies, mealybugs, two spotted spider mites
Amblyseius swirskii (breeding sachet or tube) | Thrips, whitefly
Amblyseius andersoni (breeding sachet or tube) | two-spotted spider mites
Amblyseius californicus (breeding sachets or tube) | two-spotted spider mites
Amblyseius fallacis | two-spotted spider mites
Phytoseiulus persimillis (tube/bottle) | two-spotted spider mites
Encarsia formosa | whitefly
Eretmocerus eremicus | whitefly
Aphidius colemani | aphids
Aphidoletes aphidimyza | aphids
Chrysoperla carnea | aphids
Aphidius ervi | aphids
Aphidius matricariae | aphids

Aphids	Thrips	Whiteflies	Mealybugs	Fungus gnats	Twospotted spider mites	Caterpillars & Beetle Larvae

Main Suppliers to Consider

Beneficial Insectary
PROVIDING A NATURAL BALANCE IN PEST MANAGEMENT

Applied Bio-nomics Ltd.

bioline

KOPPERT
BIOLOGICAL SYSTEMS

ipmlabs

biobest®
SUSTAINABLE CROP MANAGEMENT

Additional Resources

UC Davis Pest Management Guidelines | http://ipm.ucanr.edu/PMG/r280390111.html

TABLE 1. Pesticide Use Compatibility with Biological Control.[1]

Chemical name (trade name)	Range of activity (affected groups)	Immediate impact on natural enemies[2]	Duration of impact on natural enemies[2]
abamectin (Avid)	intermediate (mites, leafminers)	high to predatory mites, low for many insects	long to predatory mites and affected insects
acephate (Acephate) (Orthene 75WP) (PT 1300 Orthene TR)	broad (insects & mites)	high	intermediate
acetamiprid (Tristar 70WSP)	broad (insects)	moderate	intermediate
azadirachtin (Azatin XL) (Ornazin)	broad (insects & mites)	moderate	short
Bacillus thuringiensis# (Gnatrol) (Dipel DF) (Xentari)	narrow (larvae of flies such as fungus gnats, mosquitoes) narrow (caterpillars) narrow (caterpillars)	none	none
Beauveria bassiana# (BotaniGard WP) (BotaniGard ES)	narrow (kills some soft-bodied predators)	low	short
bifenthrin* (Attain TR) (Talstar Flowable)	broad (insects & mites)	high	long
bifenazate (Floramite)	narrow (mites)	low	short
carbaryl*	broad	high	long

Additional Resources

International Organisation for Biological and Integrated Control | https://www.iobc-wprs.org/

Additional Resources

BioControls Conference | https://www.biocontrolsconference.com/

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organized by MEISTERMEDIA

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organized by MEISTERMEDIA in conjunction with bpia

More Info ›

AFRICA
July 12-13, 2017

BIO CONTROLS AFRICA CONFERENCE & EXPO

organized by AgriBusiness Global in conjunction with SABO

More Info ›

Thank you!

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