Biological Control of Insect Pests in Hawaii

Crop Protection Services
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What will this presentation cover?

* Biological Control
    - Classical
    - Fortuitous
    - Augumentative
        - Inundative - flood
        - Inoculative - inoculate
* Biological Control in Hawaii
* Conservation of Natural Enemies
    - Minimize use of broad-spectrum insecticides
    - Environmental vonditions detrimental to natural enemies
* Biological or Microbial Insecticides
* Summary

Definition of Biological Control

Biological Control - reduction of pest populations by natural enemies (predators, parasites or diseases).

Classical Biological Control - introduction of natural enemies (from the pest's native home) to a new locality where they do not occur naturally.

Fortuitous Biological Control – Do nothing biological control; natural enemies unintentionally arrives with pest to new locality or already in new locality.

Augumentative Biological Control - Supplemental release of natural enemies.

Innoculative Release: Release mass numbers of natural enemies to prey or parasitize target pest

Inundative Releases: Release a few individuals and rely on their natural reproduction by preying or parasitizing target pest.

Biological Control in Hawaii

* Hawaii's government has been practicing classical biological control by purposely introducing and liberating natural enemies, for over a 100 years.
* Attempts to control pests through the introduction of animals into Hawaii were made by private citizens as early as 1865 (mongoose and mynah bird).
* In 1890, 25 years later, procedures of biological control were regulated and supported by the Hawaiian government.
* Of the 243 natural enemies purposely introduced (1890-1985), 86.4% have been recorded to prey on or attack about 200 pest species.
* No purposely introduced species, approved for release in the past 21 years, has attacked any native or other desirable species.

Funasaki et al. 1988

Factual Story about the Mynah Bird in Hawai‘i

*The mynah bird was brought to Hawai‘i from India in 1865 by Dr. William Hillebrand, a physician-naturalist to feed on armyworms in pastures.

*Accused as a major factor in the extinction of many native Hawaiian birds (based on speculation). Other scientists believed that the mynah had little or nothing to do with the extinction of native birds.

*Also implicated as playing a role in the dissemination of noxious weeds, e.g., Lantana (pasture weed), by feeding on berries and spreading undigested seeds via droppings.

Funasaki et al. 1988 PHES 28

True Story of the Mongoose and Rat in Hawai‘i

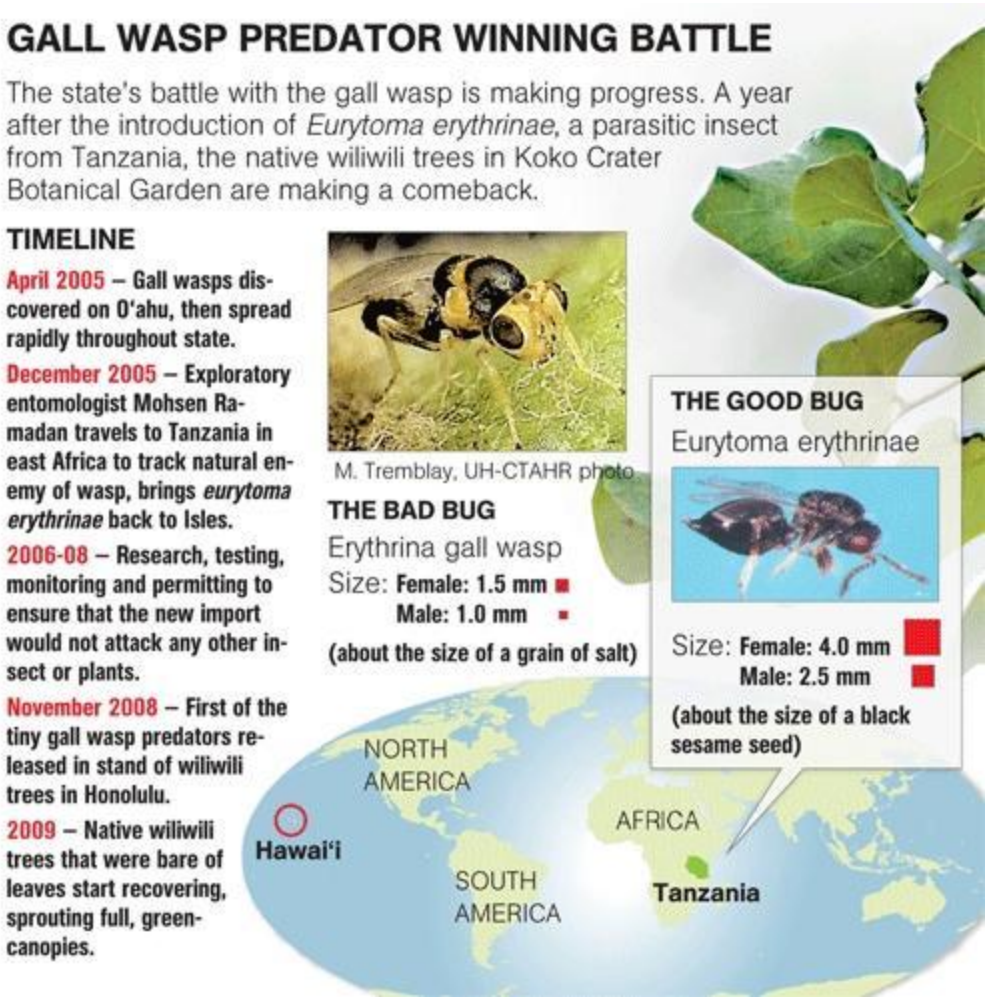
* The 1800's were a huge century for sugarcane plantations and many were started on tropical islands, including Hawai'i and Jamaica.
* With sugar cane came rats and lots of crop loss.
* Attempt to control the rising rat populations, a manager introduced the Indian Mongoose from Calcutta to the Jamaica in 1872.
* The manager praised the results and local Hawaiian plantation owners, in 1883, brought 72 mongooses from Jamaica to the Hamakua Coast on the Big Island.
* Issue: Mongoose are diurnal and rats are nocturnal.
* Diet of mongoose includes insects, small cats, frogs, seeds, nuts, fruit, ground nesting bird eggs.

http://www.instanthawaii.com/cgi-bin/hawaii?Animals.mongoose

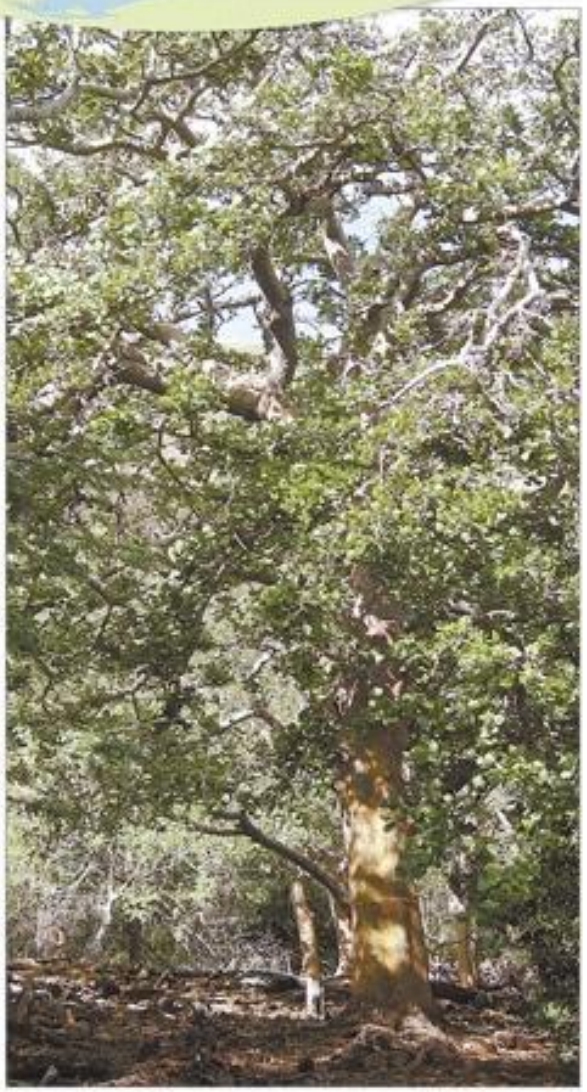
Erythrina Gall Wasp, A Successful Biological Control Project in Hawai‘i

On O'ahu alone, nearly 2,000 trees died at city parks and golf courses

***First described in 2004 causing severe damage in Taiwan and Singapore.**
***First found on Oahu in April 2005.**
***Found in Big Island, Kaua‘i, and Maui in July 2005.**



A Successful Classical Biological Control



Hawai'i Dept. of Agriculture photos

BEFORE INTRODUCTION: This photo taken on Dec. 3, 2008, shows a wiliwili tree infested by gall wasps. Most of the tree's leaves are gone.

1 YEAR AFTER INTRODUCTION: A year later, after introducing *eurytoma erythrinae*, a natural gall wasp predator, the leaves are back.

Classical Biological of the Spiraling Whitefly

* First discovered in Hawaii in 1978.

* Heavy Infestations in Hawaii on over 100 plant species, of which guava, banana, plumeria, mango, and sea grape were most preferred.

* Importation of ladybeetles and whitefly parasites from Trinidad brought it under control.

*Heavy infestations are now only observed where these natural enemies are not present due to insecticide or windy, ocean salt condition.

Nephaspis

Encarsia

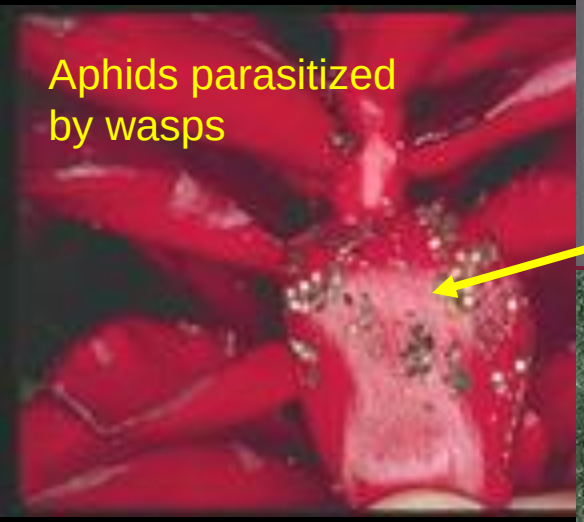
http://www.youtube.com/watch?v=UNaHRG34edA

Biological Control of Mealybugs

http://www.youtube.com/watch?v=l69sltGaZW0

Biological Control of Aphids

* No male aphids occur in Hawai‘i.
* One aphid develops into an entire colony of aphids.
* Aphids are under excellent biological control in HI by:



Mummified aphids

Ladybug

http://www.youtube.com/watch?v=bIyEVN_wAwA&N

Biological Control in Spider Mites

Spider mites attack by predator mites

http://www.youtube.com/watch?v=2mFyBxldl-Q

“Is doing something better than doing nothing?”

Giant Whitefly, *Aleurodicus dugesii*

* First discovered in HI heavily infesting hibiscus, fiddlewood, plumeria in May 2002.

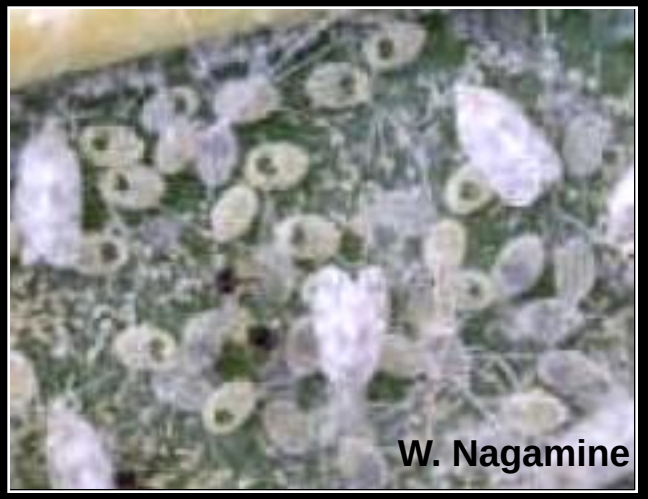
Merit drench – (Best Guess)

* Applied to infested fiddlewood trees by City in Chinatown.
* Not effective (improper application at base of trunk and not canopy drip line to feeder roots).
* No reports of Merit being highly effective.

R. Heu, HDOA

Is doing nothing more cost effective?

Successful Fortuitous Biological Control: Giant Whitefly



* In March 2003 (10 months later), a pteromalid wasp, *Idioporus affinis* was found attacking GtWF and providing excellent control.

* This wasp apparently arrived in Hawaii along with the GtWF from California.

* Surveys indicate that the wasp is widespread on all islands attacking GtWF and providing excellent control of the whitefly.

* GtWF is scarce in Hawaii today and only present where the wasp failed to establish.

(Heu *et al*. 2004)

Fortuitous Biological Control of Cycad Scale

* First discovered on Oahu 1998 and has spread to Kaua i, Maui, and the Big Island.

* Rhyzobius lady beetle, already in Hawaii voraciously attacked the cycad scale and was under control in most areas on Oahu & Maui but not Big Island and Kaua‘i.
* In 2004, about 200 Rhyzobius beetles introduced to the Big Island from Maui and effectively controlled cycad scales in most areas.

Innoculative Biological Control of the Cycad Scale on the Big Island

Rhyzobius lady beetles control cycad scale on new growth.

Lady beetles released on this plant with old damage.

* However, beetle and cycad scale populations are not always in balance.
* Parasite has better balance with pest population.
* In March 2009, a parasite of the cycad scale was discovered on O‘ahu.
* This parasite was already present in Hawai‘i but for some reason is now providing high mortality on cycad scales (Kumashiro pers. comm.).

Conservation of Natural Enemies

* Recognize the natural enemies and know when the pest is parasitized. Most Important!!!

* Avoid plantings in windy or ocean front areas, or extremely hot environments. Modify conditions to encourage natural enemies.

* Avoid use of broad spectrum insecticides:
    Organophosphates: Dursban, Malathion
    Carbamates: Sevin (carbaryl)
    Pyrethroids: Talstar (bifenthrin)

Insecticide Toxicity to Natural Enemies

Common name (trade name)	Class	Selectivity (affected groups)	Predator Mites	General Predators	Parasites	Duration of impact to natural enemies
carbaryl (Sevin)	carbamate	Broad (insects, mites)	Moderate/ High	High	High	Long
chlorpyrifos (Dursban)	OP	Broad (insects, mites)	Moderate	High	High	Moderate
fenpropathrin (Tame) similar to (Talstar)	Pyrethroid	Broad (insects, mites)	High	High	High	Moderate Long for Talstar
imidacloprid (Merit as a drench)	Neonico-tinoid	Narrow (sucking, insects)	-	Low	Low	-
imidacloprid (Merit as a foliar)	Neonico-tinoid	Narrow (sucking, insects)	-	Moderate	High	Short to moderate
Insecticidal Soap (M-Pede)	soap	Broad (insects, mites)	Moderate	Moderate	Moderate	Short to none

http://www.ipm.ucdavis.edu/PMG/r302900111.html

Inundative Biological Control

Live Biological Control Agents for Sale in Mainland U.S.

Parasite for Aphids

Parasite for whiteflies

Ladybeetle for mealybugs

Nematodes for Root weevils

Predatory Mite

* Inundative releases works best in totally enclosed greenhouses.
* Most of these parasites and predators already occur naturally in HI
* Importation and sale in Hawaii requires HI Dept. of Ag permit and approval.
* Expensive, e.g. 3,000 whitefly parasites for $97.95 (ARBICO Organics)

Biological or Microbial Insecticide

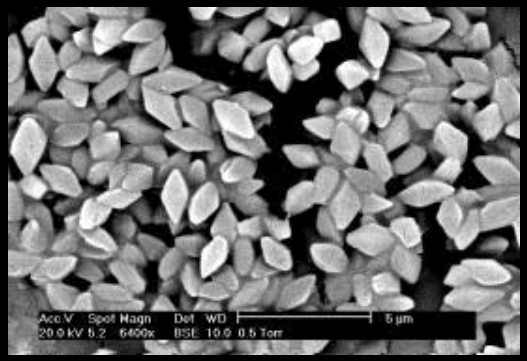
- an *insecticide* in which the *active Ingredient* is a microorganism.

Biological insecticides include products based on:

Bacterium (*Bacillus thuringiensis*)
Fungi (*Paecilomyces fumosoroseus*)
Nematodes (*Steinernema carpocapsae*)
Viruses (*No products registered in Hawai‘i*)

Insect Parasitic Bacterium

Bacillus thuringiensis (Bt)



* Bt is a naturally occurring bacterial disease of insects.
* Bt acts by producing proteins that paralyze the gut, and the infected insect stops feeding within hours and dies from starvation.
* The most common strain of Bt (*kurstaki* strain) will kill only leaf-feeding caterpillars (moths and butterflies).
  - Bt is susceptible to degradation by sunlight.
  - Bt is the only "microbial insecticide" in widespread use.
  - Commercially available products: Biobit, Dipel, MVP, Steward, Thuricide
* The other strain of Bt (*israelensis* strain, or Bti) is specifically effective against larvae of mosquitoes and fungus gnats.
  - To control mosquito larvae, formulations containing the *israelensis* strain are placed into the standing water of mosquito breeding sites.
  - Use of Bt (*israelensis*) for control of fungus gnat larvae involves drenching the soil.
  - Commercially available products: Vectobac, Gnatrol, Bactimos

Insect Pathogenic Fungus

Paecilomyces fumosoroseus
PFR-97
Certis U.S.A. L.L.C

* *Paecilomyces fumosoroseus*, is a naturally occurring soil fungus that infects several insect pests, including whitefly, aphid, thrips and spider mites.
* Under proper environmental conditions, spores of the fungus attach to and penetrate the cuticle of the insect pest.
* The fungus grows inside the insect causing its death.
* The fungus then emerges from the dead insect to release more spores to infect other insects.

Optimal Environmental Conditions Needed:

- Applications are best made in late evening or early morning when insects are sedentary and temperatures are moderate and humidity is high.
- Cloudy, rainy days are optimal times to apply PFR-97.
- Humidity: A relative humidity of 80% must be achieved and maintained for 8-10 hours for PFR-97 to be effective.
- Air Movement: High air movement has been found to decrease the effectiveness of PFR-97. Reduce air movement in the treated area.

Insect Parasitic Nematode

Steinernema carpocapsae

* A naturally-occurring soil nematode that infects insects via natural openngs (mouth, anus, spiracles).
* Requires constant moisture for nematode survival and for effectiveness.
* Must be stored at refrigerated temperatures (40-50°F).
* Two related species of *S. carpocapsae* discovered in Hawai‘i occurring naturally sandy soils, near ocean front beaches.

Millenium® Becker Underwood
Biocontrol for Ground-Dwelling Insects and Certain Borers

- **Flea larvae, pupae**: Controls flea larvae and pupae in outdoor premises (turf, sand, gravel).
- **Cutworms, Armyworms, Webworms**
- **Banana Moth**
- **Shore Flies**

http://ucdnema.ucdavis.edu/imagemap/nemmap/ent156html/slides/fromCD/1939/64B.GIF

Summary

* Don’t blame mongoose and mynah bird on Hawaii Dept. of Ag.
* **Biological control** in Hawai‘i has controlled over 200 invasive pests.
* **Biological control** has provided sustainable control of many invasive pests with no negative environmental impact.
* Avoiding the use of broad-spectrum insecticide, such as OPs, carbamates and pyrethroids, will conserve natural enemies.
* Use more selective insecticides and application methods, such as drench application of neonicotinoids (Merit, Safari), insect growth regulators (Distance,Talus), biological insecticides (Bt) to avoid negative effects on natural enemies.
* Use of commercial biological control agents in mass numbers is only effective in enclosed greenhouses and requires permit.
* Biological or microbial insecticides (fungi, nematodes) require very specific environmental conditions (very humid, moist conditions) for effectiveness.