Biological Control, Systemic Insecticides & Insect Growth Regulators against Landscape Pests in Hawaii

Maui Association of Landscape Professionals
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What will this presentation cover?

* Biological Control
  - Classical
  - Fortuitous
  - Augmentative
    - Inundative - flood
    - Inoculative - inoculate
* Biological Control in Hawaii
* Conservation of Natural Enemies
  - Minimize Use of Broad-Spectrum Insecticides
  - Environmental Conditions detrimental to natural enemies
* Biological or Microbial Insecticides
* Summary

* What are Neonicotinoids?
* History of Neonicotinoids
* Properties of Neonicotinoids
  - UV sensitivity
  - Water solubility
  - Residual Activity
  - Systemic Movement to leaves and flowers
* Spectrum of Insect Control

  Sucking Insects: aphids, scale insects, mealybugs, whiteflies, lacebugs

  Chewing Insects: beetles, caterpillars, grubs
* Application Methods
* Insect Growth Regulators
* Spiraling whitefly outbreak in West Hawaii
* Conclusions

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"; natural enemies unintentionally arrive with pest to new locality or already in new locality.

Augmentative 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 Hawaii

* The mynah bird was brought to Hawaii 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, a 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 Hawaii

* The 1800's was a huge century for sugarcane plantations and many were started on tropical islands, including Hawaii 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 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 Hawaii

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, Kauai, and Maui in July 2005.

A Successful Example of 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.

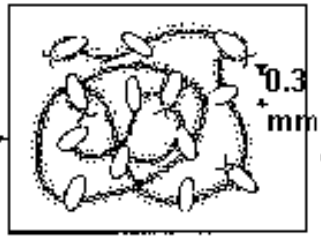
Spiraling Whitefly (SWF)

Aleurodicus dispersus

Egg to adult
34 to 41 days

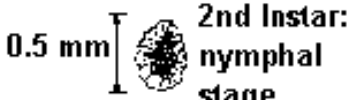
eggs 9 to 11 days

>1549 eggs
in 37 days



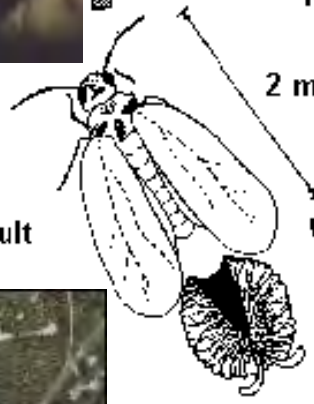
Eggs laid in spiral

1st instar 6 to 7 days



2nd instar 4 to 5 days

3rd instar
5 to 7 days



Adult stage
39 days

Pupal stage
10 - 11 days

Nymphal stage

Spiraling Whitefly (SWF)

* First discovered in Hawaii in 1978.
* Spiraling whitefly has been recorded on 38 genera of plants belonging to 27 plant families and more than 100 species.
* Specific plants that are attacked include annona (cherimoya, atemoya, sugar-apple), avocado, banana, bird-of-paradise, breadfruit, citrus, coconut, eggplant, guava, kamani, Indian banyan, macadamia, mango, palm, paperbark, papaya, pepper, pikake, plumeria, poinsettia, rose, sea grape, ti and tropical almond.
* Plumeria is probably the most preferred host of SWF.
* SWF usually starts building up in June and continue through September. From October, population starts decreasing and by December is very low (Kumashiro, HDOA).
* Prolonged drought may have accounted for the weakening of trees has led to the higher than usual SWF population during this past summer (Kumashiro, HDOA).

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

Heavy Spiraling Whitefly Infestation Mauna Lani 09/2010

Stems infested with White Peach Scale →

Spiraling Whitefly in West Hawaii

Parasitized Whitefly Nymph

Parasitic wasp very effective against spiraling whitefly in windy, coastal areas in Hawaii
(Kumashiro HDOA)

Eulophid parasitic wasp, *Aleuroctonus vittatus*

Parasitoid Emergence Hole

Spiraling Whitefly heavily parasitized by parasitic wasps

(Note 4th Instar pupae with round exit holes)

Plumeria at Keahole Ag Park (09/2010)

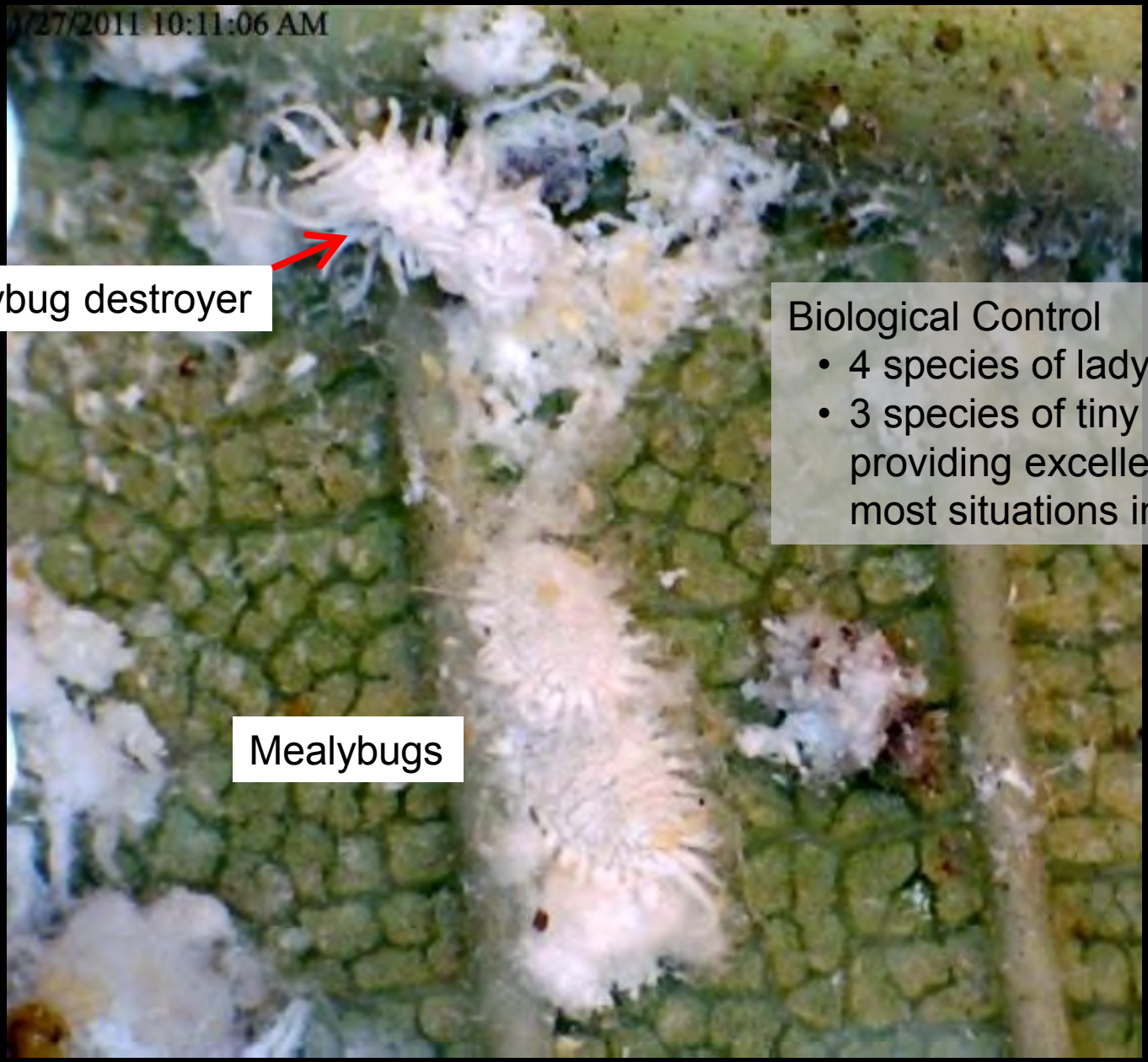
Immature Lady Beetle

Adult Lady Beetle

Biological Control of Mealybugs

http://www.youtube.com/watch?v=l69sItGaZW0

Mealybug Destroyer, Ladybeetles, Parasitic wasps working on Papaya Mealybug on Plumeria



Biological Control

- 4 species of ladybeetles.
- 3 species of tiny parasitic wasps providing excellent control in most situations in Hawaii.

4/26/11

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 nsects)	-	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

Parasite for aphids

Parasite for whiteflies

Ladybeetle for mealybugs

Nematodes for root weevils

Predatory Mite

* Inundative releases work best in totally enclosed greenhouses.
* Most of these parasites, predators already occur naturally in HI
* Importation and sale in HI requires HI Dept of Ag permit, 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:

Bacteria	(*Bacillus thuringiensis*) (Bt)
Fungi	(*Paecilomyces fumosoroseus*)
Nematodes	(*Steinernema carpocapsae*)
Viruses	(*No products registered in Hawaii*)

Summary

* Don’t blame mongoose and mynah bird on Hawaii Dept. of Ag.
* Biological Control in Hawaii 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 OP’s 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.

Evolution of Insecticides

1940-50's

Chlorinated hydrocarbons

DDT, Chlordane, Dieldrin, Mirex

1960-70's

Organophosphates & Carbamates

Dimethoate, Diazinon, Dursban, Orthene

1980-90's

Pyrethroids (synthetic)

Mavrik, Tame, Tempo, Decathlon, Talstar

1990-2000's

Reduced-Risk Insecticides

Naturalytes

Conserve, Avid, Ultiflora, Neem

Insect Growth Regulators

Distance, Enstar, Talus

Neonicotinoids

Merit, Marathon, Flagship, Safari, TriStar

NEONICOTINOID INSECTICIDES

Acetamiprid

Arena®
INSECTICIDE

clothianidin

Optigard Flex Gel
Flagship

thiomethoxan

Dinotefuran

imidacloprid

Marathon

imidacloprid

Premise

imidacloprid

ADMIRE® PRO
Systemic
Protectant

imidacloprid

* **Neonicotinoids** act on the nervous system of insects with very low toxicity to mammals and minimal environmental impact and therefore, considered a reduced-risk pesticide.

* Neonicotinoids are among the most widely used nsecticides worldwide.

*The mode of action of neonicotinoids is similar to the natural insecticide nicotine, In insects, neonicotinoids cause paralysis which leads to death, often within a few hours.

* They bind at a specific site, the nicotiniic receptor, and there are no records of cross-resistance to the carbamate, organophosphate, or synthetic pyrethroid insecticides, thus making them important for management of insecticide resistance.

Neonicotinoid Insecticides

Spectrum of Insect Control

Sucking insects

- Aphids
- Lace Buzgs
- Leafhoppers
- Mealybugs
- Plant Bugs/ Hoppers
- Psyllids
- Scale Insects
- Spittlebugs
- Thrips
- Whiteflies

Chewing insects

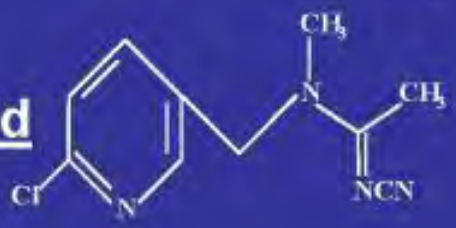
- Beetles
- Borers
- Mole Crickets
- Gall Wasps
- Grubs
- Leafminers
- Termites
- Weevils

Neonicotinoids

Chloronicotinyls

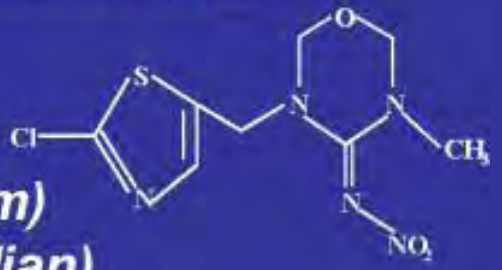
Imidacloprid
Many…

Acetamiprid
(Assail)
(Tristar)

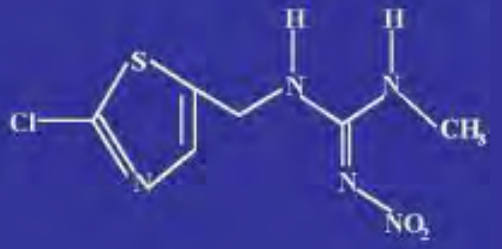


Thianicotinyls

Thiamethoxam
(Actara, Platinum)
(Flagship, Meridian)

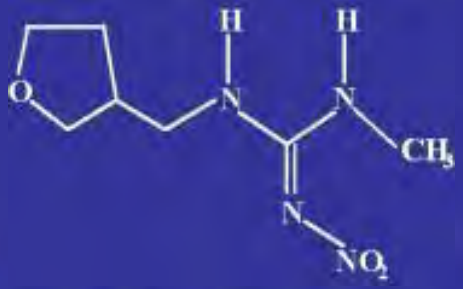


Clothianidin
(Poncho)
(Arena)



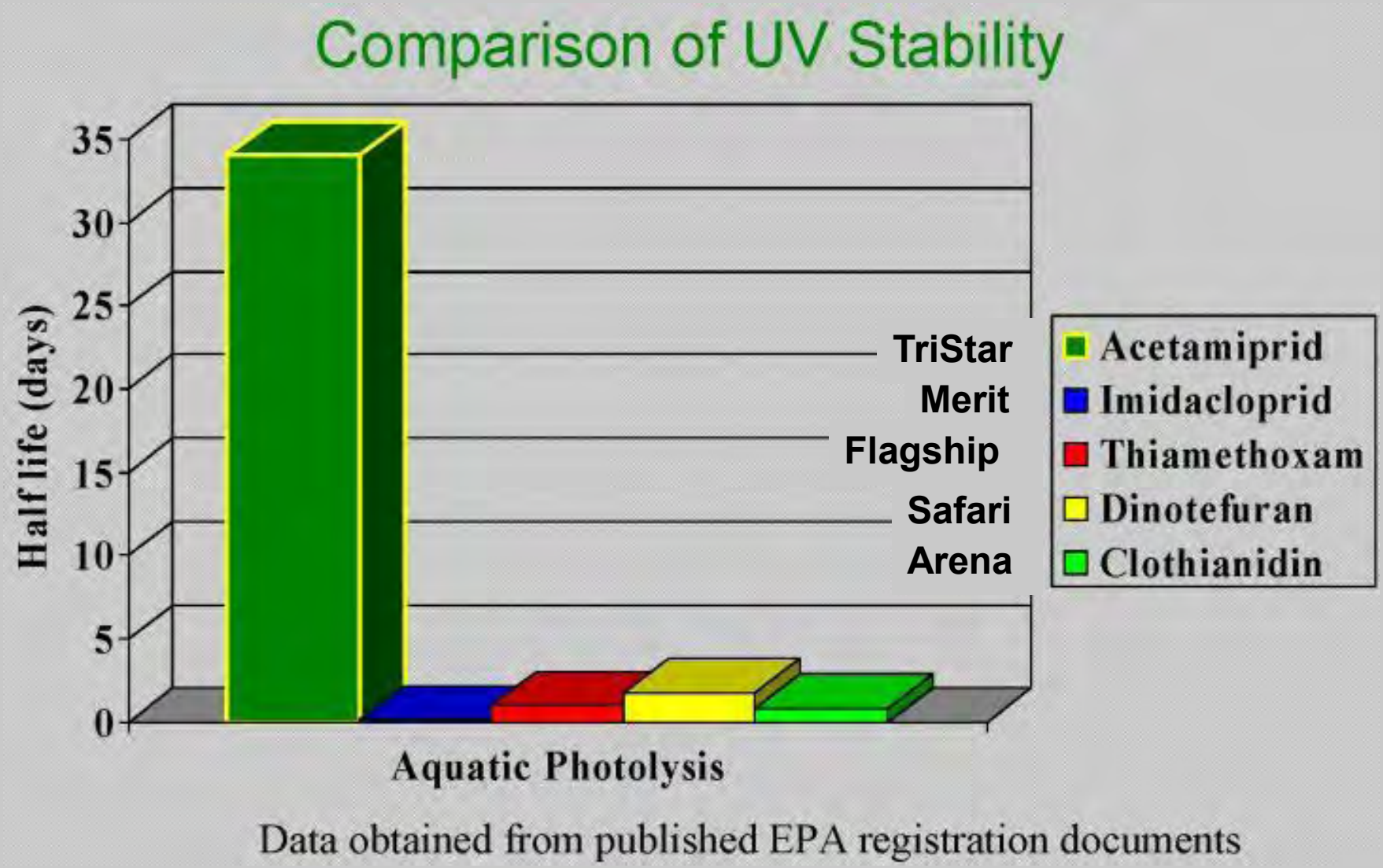
* Different types of neonicotinoids have unique *UV* resistance, water solubility, binding with soil, and pest spectrum characteristics.

Furanicotinyl



Dinotefuran
(Venom)
(Safari)

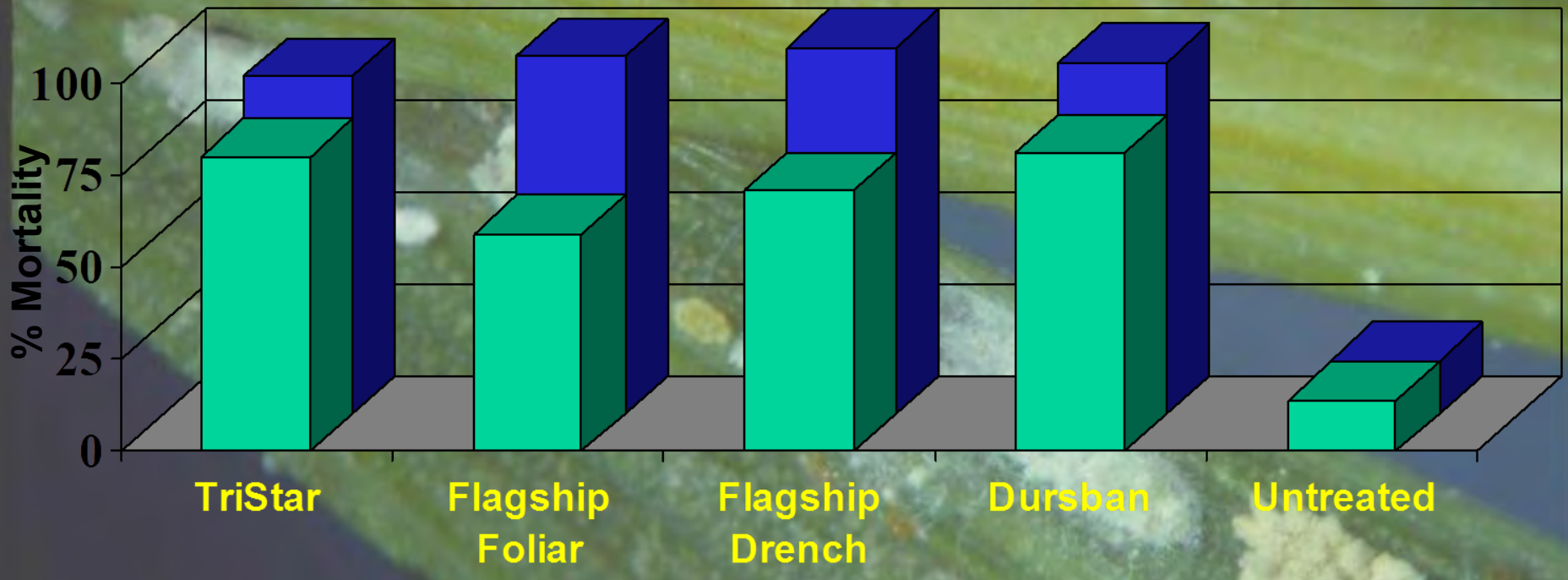
Slide info from F. Byrne



TriStar is registered for foliar use only, and the most UV stable of all neonicotinoids.

Slide Credit: R. Fletcher

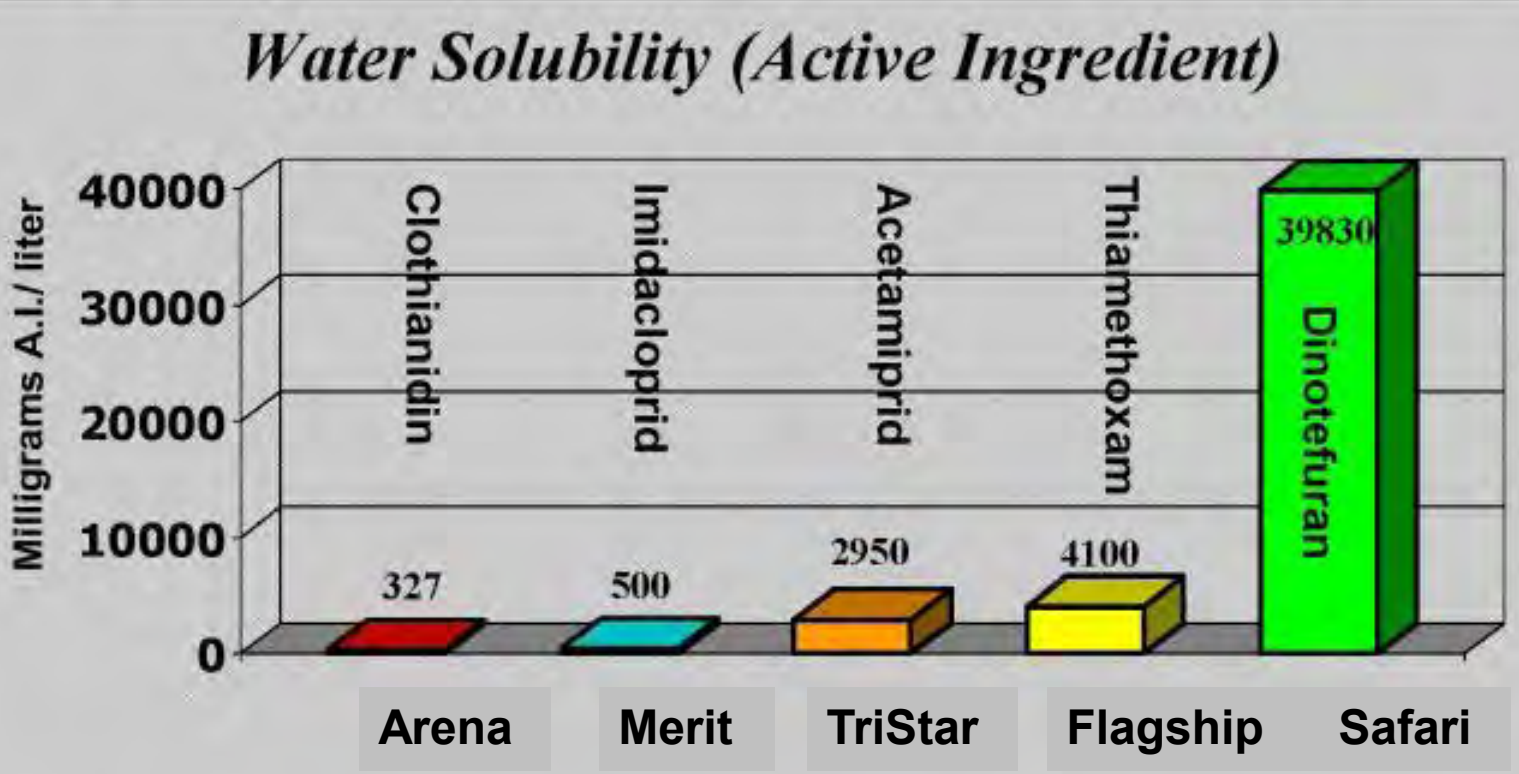
TriStar and Flagship Against the Coconut Mealybug, *Nipaecoccus nipae*



TriStar = acetamiprid

Flagship = thiamethoxam
(Not sold in Hawaii)

Relative Water Solubility of Neonicotinoids:

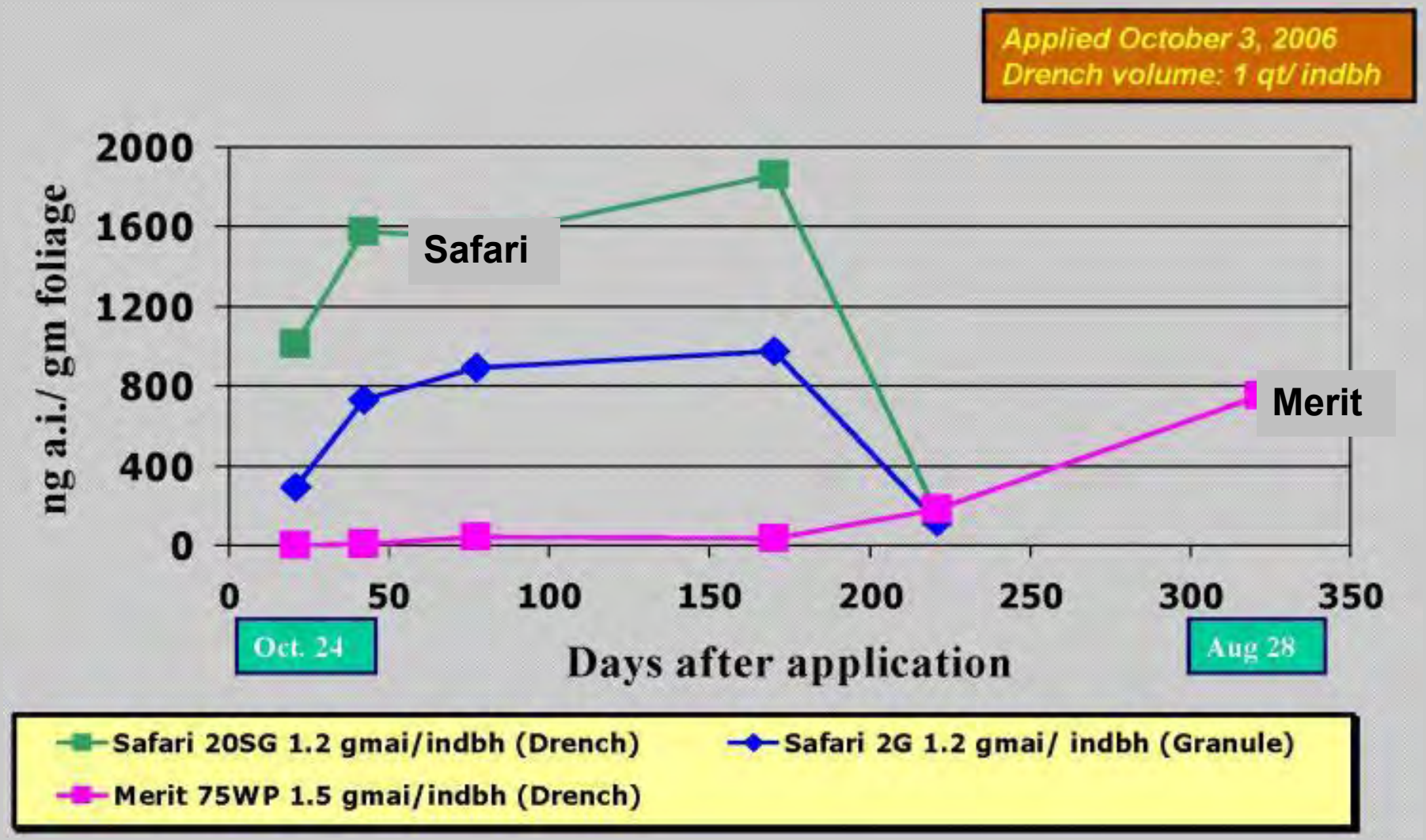


Information sources
Clothianidin (Celero), Acetamiprid (Tristar), Dinotefuran (Safari) – EPA Pesticide Fact Sheet
Imidacloprid (Marathon), hiamethoxam (Flagship) – MSDS for Products

Slide information courtesy J. Chamberlin

Neonicotinoid Uptake in Hemlock

12-24”DBH Hemlock, Cashiers, NC



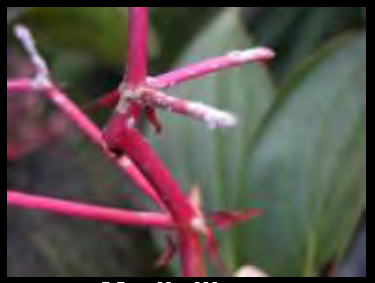
Safari (dinotefuran) as compared with Merit (imidacloprid)

* Safari is similar to Merit/Marathon, but more water-soluble for quicker systemic uptake in plants.
* Systemic activity is not as long-lasting.
* Effective against whiteflies, aphids, soft scale. wax scales, thrips, fungus gnats, similar to Merit.
* Also effective against armored scales and mealybugs.
* Apply as a foliar or drench application.

Safari (dinotefuran) against Mealybugs at a Hilo nursery


Brassia


Begonia Escargot


Medinilla


longtail mealybug


Ming Aralia


Dracaena


Dwarf fishtail fern


citrus mealybug


Leather leaf fern


Xanthosoma


Dieffenbachia


Osmoxtlon


Cissus

Foliar and drench applications of Safari tested at the labeled rate on these infested plants.

Results of Safari Trial

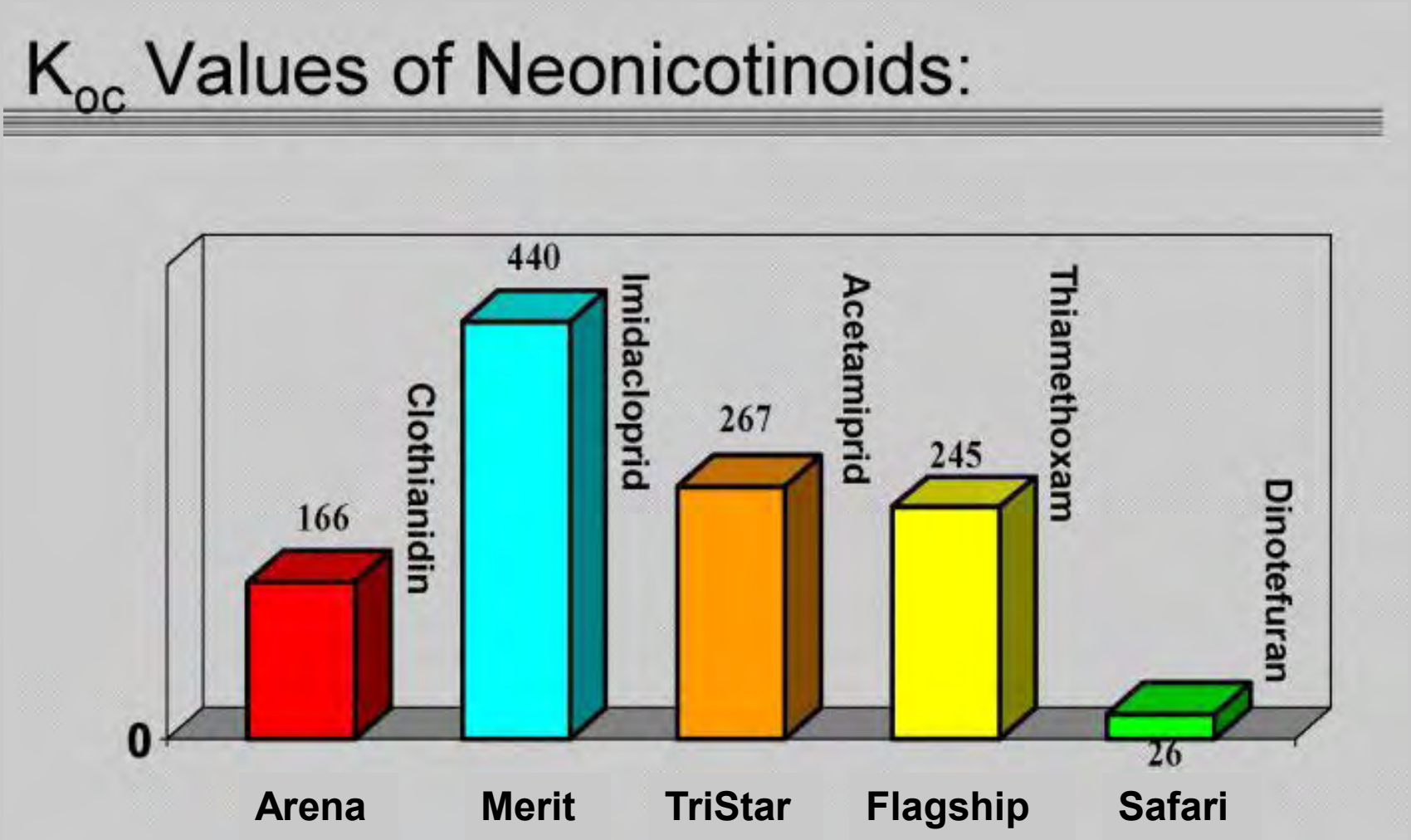
Jan 2005

* Foliar application resulted in mealybug-free marketable plants 6 weeks after application in 8 of 10 plant cultivars tested.

* Drench application resulted in mealybug-free marketable plants 6 weeks after application in 10 of 10 plants cultivars tested.

Soil Adsorption Coefficient

A measure of how tightly the pesticide binds or sticks to soil particles.

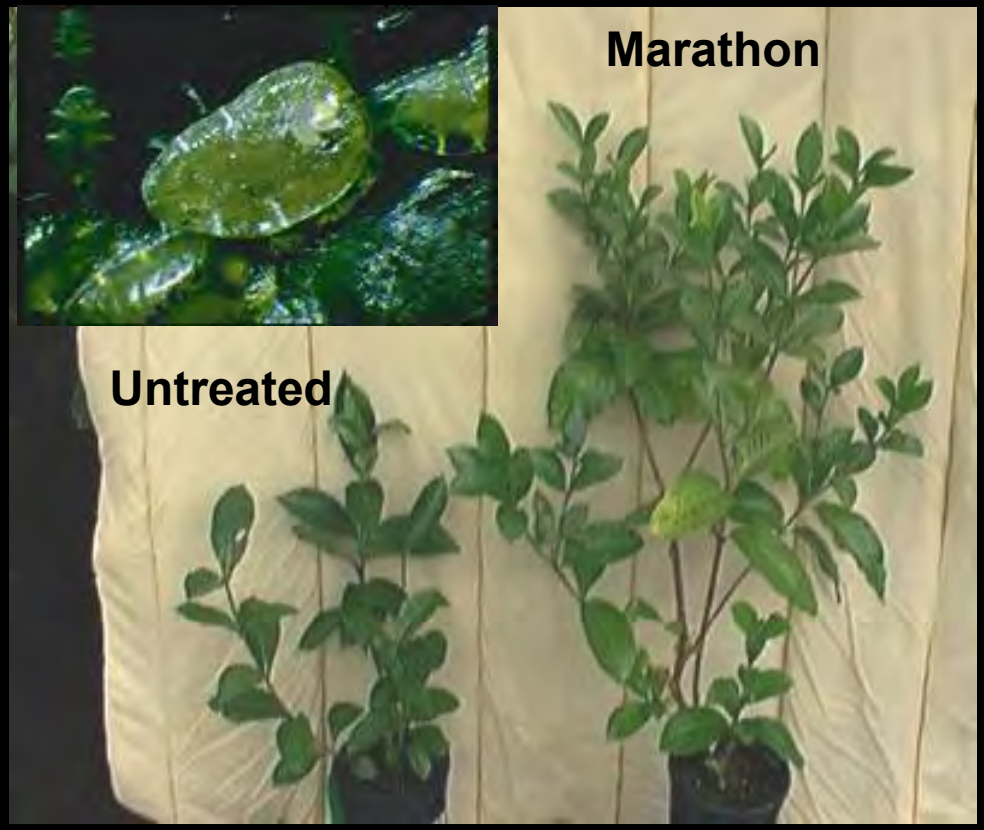


High value means it is strongly adsorbed onto soil and organic matter and does not move throughout the soil (Source: EPA Pesticide Fact Sheets).

Merit (Marathon) is highly effective against aphids, Chinese rose beetle, azalea lacebug, soft scales and whiteflies. Moderately effective against mealybugs.

Green scale, *Coccus viridis*

- Applied as a drench, by 21 DAT >90% mortality of green scales observed on gardenia plants. Control lasted for approximately one year.
- Growth difference of gardenia due to control of green scale.



Imidacloprid against Red Ginger Pests

WEEKS OF EFFECTIVE CONTROL (>95%):

FIELD TREATMENT	MEALYBUGS	BANANA APHIDS
MERIT (1 APPL.)	17	53
DURSBAN (3 APPL.)	3	4

Imidacloprid against Chinese Rose Beetle

Chinese rose beetles dying after feeding on rose plant drenched with Merit about 2 weeks earlier.

New growth with no beetle damage

Application Methods for Systemic Insecticides

Injecting – invasive to trees; create wounds for entry of pathogens.

Drenching – Must reach feeder roots with adequate moisture.

Bark Treatment – Must penetrate bark to move into the vascular system.

Tablets – More suitable for potted plants

Drilling

Injecting

Applying Treatments

Trenching

Drenching

* Drench application must be applied to the feeder roots that have adequate soil moisture.
* Subsequently must be irrigated to assure uptake.
* Liquid fertilizer added to insecticide may assist uptake.
* Competition by groundcovers or turf contributes to effective uptake.

“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.

Injection Systems Evaluated


Sidewinder Tree Injector


Mauget Tree Injectors

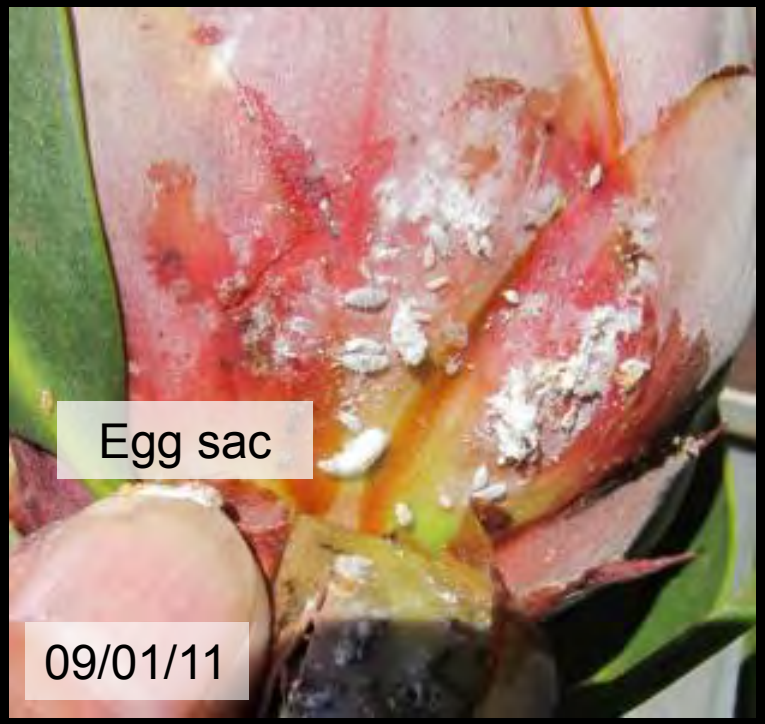
Bark Application of Safari to King Protea for mealybugs at 18 oz/ gallon

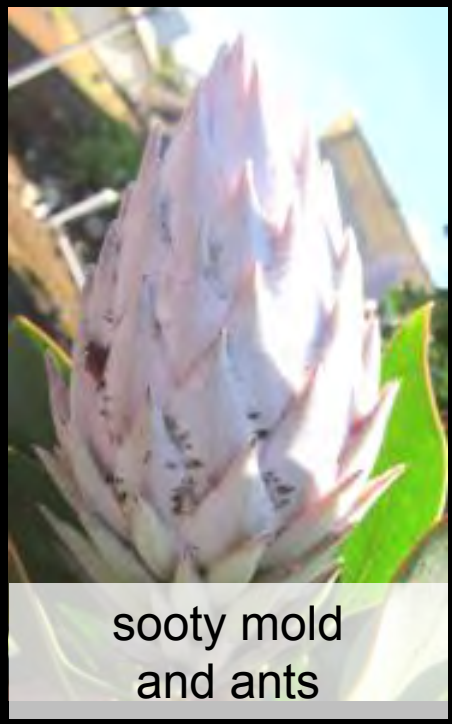
Bark application of Safari to Telopea sp. for armored scales,

Pseudaulacaspis brimblecombei

A mealybug *Delottococcus confusus* infesting King protea, *Protea cynaroides,* Kula, Maui, HI

* First discovered in CA in Nov. 2006 on *Leucadedron argenteum* tree and soon after in Hawaii (2009).
* Infestations also on mink protea in Kula, HI.
* Infested flowers are unmarketable due to sooty mold and feeding damage to bracts.
* Mealybug destroyer, *Cryptolaemus* observed under bracts with mealybug infestations.
* Control strategies: Control ants & systemic insecticides: Safari, Kontos, Tri-Star, Discus as a drench, bark, or foliar (Kontos) application for mealybugs





Papaya Mealybug

Paracoccus marginatus

* First discovered in HI in June 2004 on Maui.
* Native to Mexico and found on Guam, Florida, Caribbean Islands.
* Mealybug injects a toxin as it feeds and causes chlorosis, stunting, deformation, leaf and fruit drop.
* Heavy infestations observed on papaya, hibiscus, jatropha; also, avocado, citrus, tomato, eggplant, peppers, beans, peas, sweet potato, mango, plumeria.
* Lady beetles found feeding on the papaya mealybug on Maui and the Big Island.
* A parasitic wasp, *Anagyrus loecki,* has provided excellent biological control on in HI.

Papaya Mealybug 2004

Reduced-Risk Insecticides Against Papaya mealybug

Foliar applications

- Applaud (buprofezin; 12 oz/acre)
- Provado (imidacloprid;8oz/acre)

Drench Application

- Admire (imidacloprid; 32 oz/acre) was applied in 5 gal of water to the tree roots by applying the solution to the area 3ft in all directions from the base of the tree.

Bark Application

- Pentra-Bark surfactant (2% of solution) and Admire (imidacloprid; 32 oz/acre), which was applied to the tree trunks with a sprayer until runoff (200ml/tree).

PENTRA-BARK®

BARK PENETRATING SURFACTANT

PRINCIPLE FUNCTIONING AGENTS:

CAUTION

KEEP OUT OF REACH OF CHILDREN

FIRST AID

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DIRECTIONS FOR USE

MIXING

STORAGE AND DISPOSAL

NOTICE TO BUYER

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Louisburg, Kansas 66053
Ph: 913-837-3089
Fax: 913-837-5389
www.questproducts.us

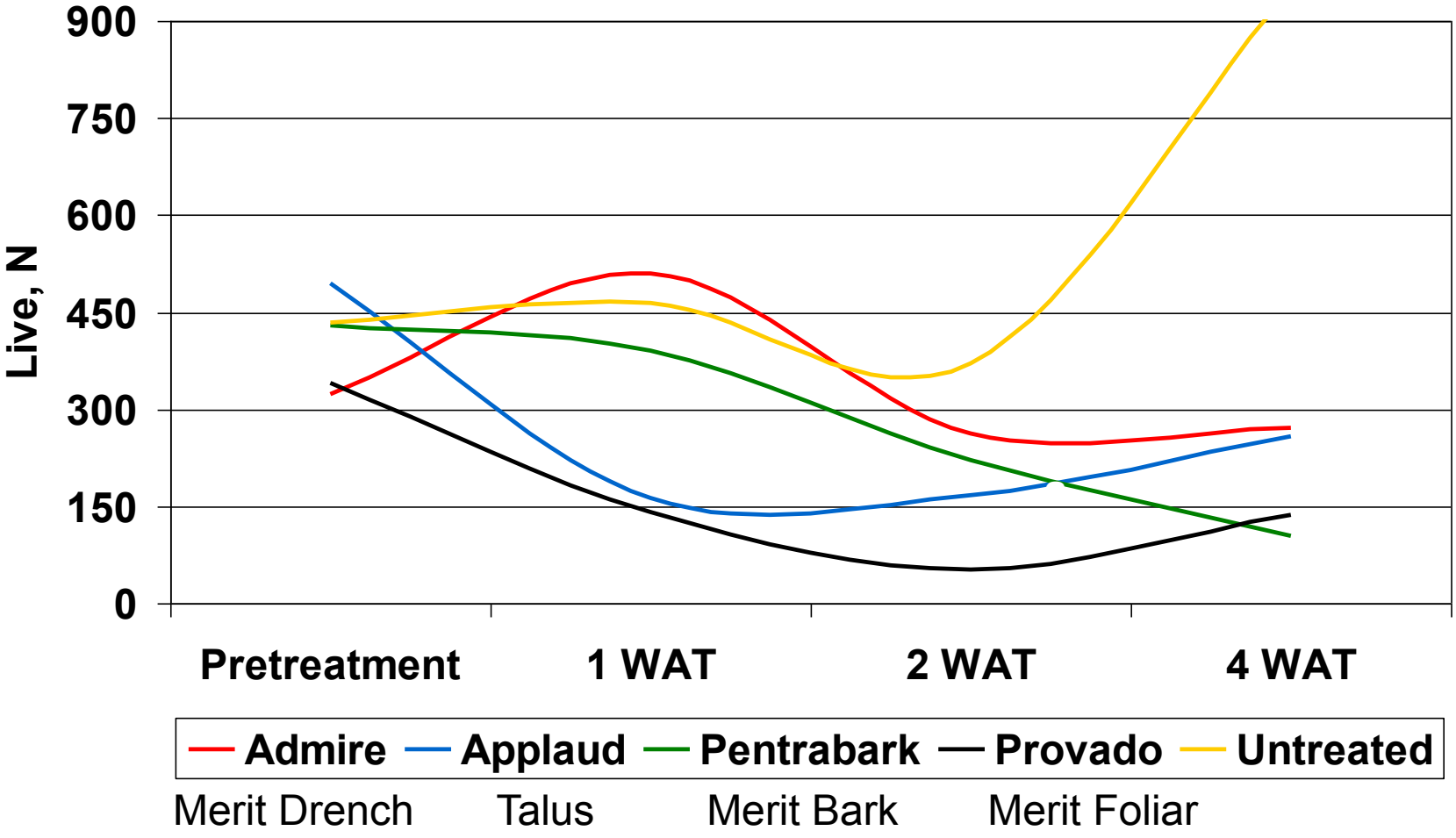
* Pentra-Bark surfactant (2% of solution) & Admire (imidacloprid; 32 oz/acre)

* Applied to the tree trunks with a hand sprayer until runoff (200 ml/tree)

http://www.questproducts.us/

Live Papaya Mealybugs On Leaf Subsection

Samples consisted of one “finger” (approx 12 inch^2) from mature palmate papaya leaves.



Application of Merit as a "Tablet"

* Insert the "pill" in the pot media and solve your pest problem.

Placing tablet 2" below media surface

* >20 weeks of whitefly control
* >12 weeks of thrips control

Types of Insect Growth Regulators

1. Juvenile hormone (JH) mimics

Enstar (kinoprene)
Distance (pyriproxyfen)
Precision (fenoxycarb)?

2. Ecdysone inhibitors

Azadirachtin = Aza-Direct, Azatin and Ornazin

3. Chitin synthesis inhibitors

Citation (cyromazine)
Adept (diflubenzuron)
Pedestal (novaluron)
Talus (buprofezin)

Buprofezin

Insect growth regulator
Talus = ornamentals, Sepro
Applaud = food crops, Nichino

* Inhibits chitin synthesis which interrupts molting, suppresses oviposition, and reduces egg viability.
* High level of activity against most homopteran insect pests including whiteflies, mealybugs, soft scales, armored scales, leafhoppers and planthoppers.
* Vapor activity allows buprofezin to reach the undersides of leaves and new growth.

Whiteflies	Mealybugs	Soft Scales	Armored Scales
Silverleaf	Longtailed	Black	Coconut
Greenhouse	Citrus	Brown	Cockerell
Sweet potato	Mexican	Hemispherical	Fern
Ash	Obscure	Wax	Boisduval
	Comstock	Tessellated	White peach
			Cycad

Pests of Ornamentals in Hawaii

Distance (Juvenile Hormone mimic) is effective against whiteflies

Untreated 27 Days After Treatment Treated

Also effective against fungus gnats and armored scales

New Class of Insecticide

Tetronic / Tetramic Acid

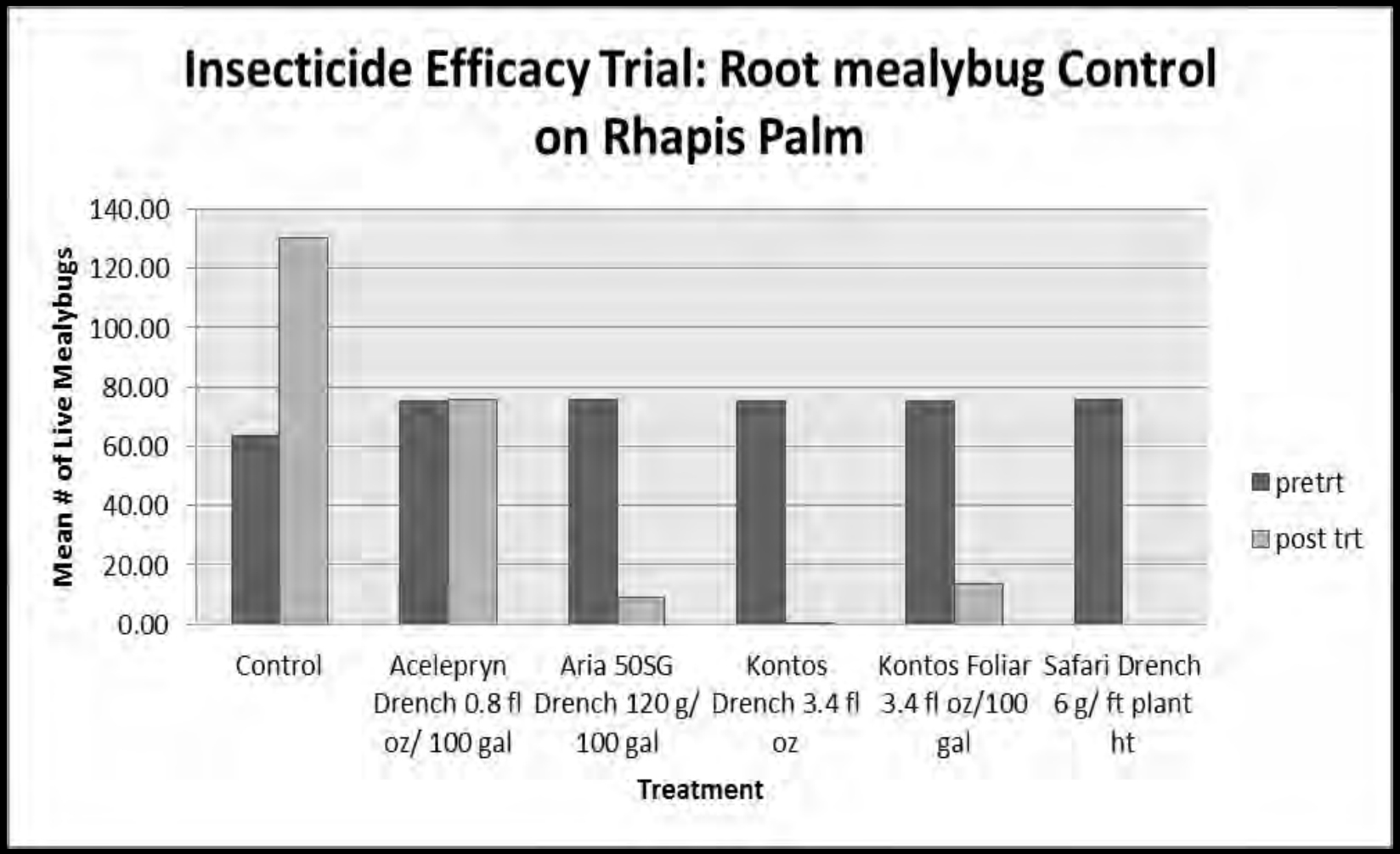
MOVENTO

Crop Use
Vegetables
Fruits
Nuts

Key Pests:
Aphids
Mealybugs
Whiteflies
Scales
Spider mites
Psyllids/Psylla

Ornamental use:
Greenhouse
Field grown ornamentals
Outdoor ornamentals

* Movento or Kontos (spirotetramat) moves up and down within the plant to provides excellent pest control in dense crop canopies and on plant roots.
* High level of residual efficacy and protection of new plant growth.
* Minimal risk to natural predators when used as directed, making it an ideal addition to Integrated Pest Management (IPM) programs.



Acelepryn (chloranthraniliprole) = grubs, weevils, cateripillars
Aria (flonicamid) = aphids, mealybugs, thrips
Kontos (spirotetramat) = aphids, leafhoppers, mealybugs, whiteflies, mites
Safari (dinotefuran) = aphids, whiteflies, scale insects, mealybugs, midges, thrips, cateripillars

Summary

* Most Importantly, recognize natural enemies (parasitic wasps and predators) of whiteflies.

* Avoiding the use of broad-spectrum insecticide, such as OP's 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), 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.

* Continuously monitor whitefly infestations for natural enemies.

Conclusion

Comments from Insect Taxonomist, Bernarr Kumashiro, HDOA

"Plumeria is probably the most favorite host of Spiraling Whitlefly (SWF)."

"Plumeria is also a favorite host of papaya mealybug, many other mealybugs, scales, whiteflies, and aphids which love to feed on plumeria."

"We should encourage resort landscapers to choose other plants, since planting plumeria is just asking for trouble."

A BIG THANK YOU!

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