

Protecting Endangered Plants in the Galápagos: Biocontrol of *Icerya* with *Rodolia*



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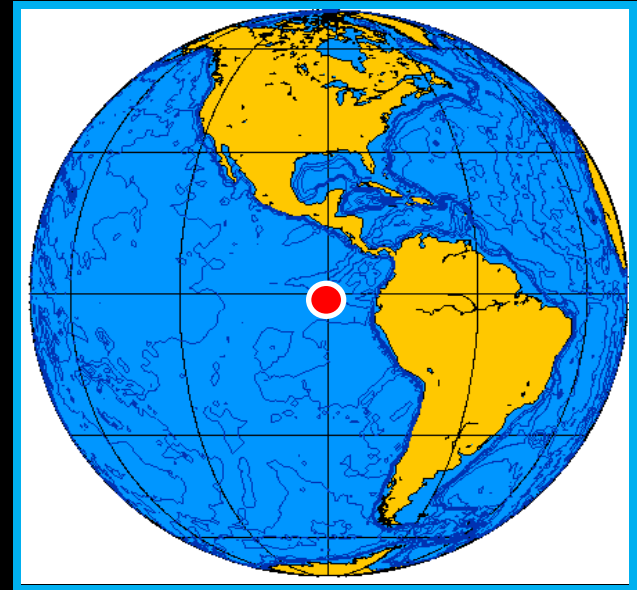
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Talk Outline

- Brief review of the Galápagos Islands
- Overview of insect invasions into the Galápagos Islands
- Biocontrol of *Icerya* species
 - The citrus program in California
 - **Case study:** development of a biocontrol program for *Icerya* with *Rodolia* in the Galápagos
 - Assessment of *Rodolia's* efficacy: non-target and target impact studies
- Conclusions

Where in the World Are We?

- Galápagos (tortoise) islands are an archipelago of volcanic islands on the equator 972 km west of Ecuador
 - 15 main islands (> 1 km²)
 - 3 small islands & 107 rocks
- Discovered by Spanish around 1535
- UNESCO World Heritage Site
- Famous for its wildlife & Darwin's visit on the Beagle in 1835
- 25,000 habitants increasing by 5.8% annually!



Invasive Pests in the Galápagos

- Galápagos not immune to invasive species
- Invaders are the principal threat to the islands
 - 463 exotic insect species
 - 23% of the insect fauna
 - At least 6 insects are serious invaders
 - 52 predicted to be serious
- **Transportation statistics**
 - 6 cargo boats arrive/month
 - 80+ plane flights/month
 - 100,000+ tourists per yr



HELP US TO PROTECT THE GALAPAGOS ISLANDS FROM THREATS

The native animals and plants of Galapagos Islands are most vulnerable to the arrival of pests and diseases. The entry of any foreign agency would risk to the economy human health and biodiversity of the Galapagos Islands.

To avoid this, the Ecuadorian Service for Animal and Plant Health (SESA) through its Inspection and Quarantine System to Galapagos (SICGAL), is responsible for the inspection of people, luggage and cargo arriving in the Islands.



The SESA, through the SICGAL is the first line of defense against the invasion of pests and diseases that could devastate this internationally recognized World Heritage Site.

www.sesa.gov.ec

SICGAL

Biocontrol of *Icerya* Species with *Rodolia* Species

- Hemiptera

- Coccoidea
- Monophlebidae
- Iceryini



- *Icerya*
 - ~44 species

- At least three have become invasive pests of conservation importance

- *I. purchasi* (Galápagos)
- *I. seychellarum* (Aldabra in the Seychelles)
- *I. aegyptiaca* (Islands in the western Pacific e.g., Mariannas)

- Coleoptera

- Cucujoidea
- Coccinellidae
- Noviini



- *Rodolia*
 - ~13 species

- At least three have been used as biocontrol agents

- *R. cardinalis*
- *R. chermesina*
- *R. limbata*

Biocontrol of *Icerya* Species with *Rodolia* Species

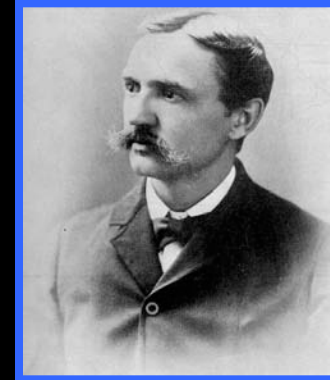
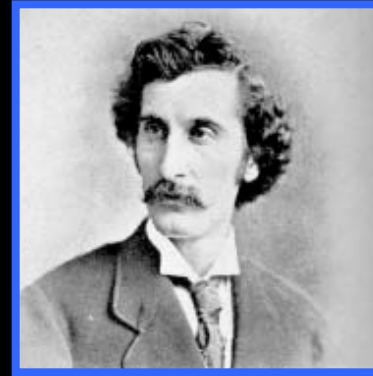
- In 1868, cottony cushion scale, *Icerya purchasi*, was found in Menlo Park CA on *Acacia*
- Pest crippled the fledgling citrus industry
- Trees being killed and ripped out “...white scales incrusting our orange trees with a hideous leprosy.” (Channing 1891)
- Trees are covered in “snow”
- Cyanide fumigation & washing ineffective



Charging Tents Covering
Trees with HCN

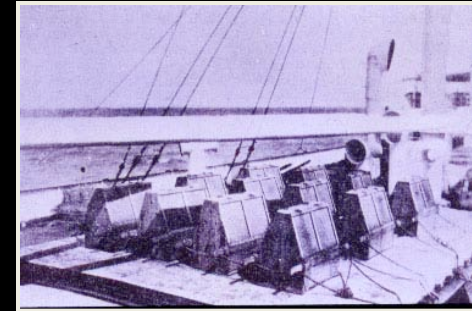
The Cottony Cushion Scale Story

- Charles Valentine Riley (“The General”), Chief of the USDA Division of Entomology saw biological control as the solution
- 1885 Arthur Koebele recruited for project
- 1888 Koebele left San Francisco on foreign exploration in Australia & N.Z. for natural enemies
- Pest very rare in Australia & difficult to find
- Two natural enemies found in Australia: *Cryptochaetum iceryae* (fly) and *Rodolia cardinalis* (ladybug)



The Cottony Cushion Scale Story

- Boxes of natural enemies with branches infested with scales were shipped to San Francisco on ice and caged on potted orange & *Pittosporum*
- Beginning Nov. 1888-March 1889 4 shipments of vedalia from SF to LA occurred
- Coquillet reared vedalia on a caged orange
- April 1889 vedalia populations exploding and spreading rapidly with human assistance
- Dec. 1889 Cottony cushion scale was no longer a pest
- 514 beetles used to establish the CA population
- Koebele a hero – gold watch and his wife diamond earrings



Initial Field
Cage

The *Icerya* Problem in the Galápagos

- *Icerya purchasi* invaded the Galápagos in 1982
 - Humans and wind moved it to 15 islands
 - Infested 62 native or endemic plant species
 - Killed some plants, *Darwiniothamnus tenuifolius*, jeopardizing native insects that relied on these plants
 - Causton, Session 12, Thursday
- **What was done about this problem????**



The *Icerya* Problem in the Galápagos

- The Charles Darwin Foundation (CDF) and Galápagos National Park Service (GNPS) decided that *Icerya* could not be managed with insecticides
- 1996 CDF & GNPS developed a technical advisory committee to evaluate the biocontrol option
 - Committee composed of 8 non-resident scientists, 1 resident scientist, 2 senior GNPS staff
 - **Recommendation** – undertake risk evaluation studies for *Rodolia cardinalis* while impacts of *Icerya* on native flora quantified



The Biocontrol Initiative Starts

- March 1999, *Rodolia* imported from CSIRO, Brisbane Australia
- Host range testing conducted in new quarantine facility at the Charles Darwin Research Station
- Larval and adult *Rodolia* tested against species of native and exotic homopterans

This project was the first biocontrol program for the Galápagos!

- Could intraguild predation occur between *Rodolia* and native predators of scale insects?

- [Causton et al., 2004. Biological Control 29: 315-325](#)



Results of the Quarantine Studies

- *Rodolia* could not complete development on any prey species offered to it
- It did feed on *Margarodes similis*, a Monophlebidae
 - This insect is a subterranean root feeder
 - Protected within a cyst & must emerge to be attacked!
- Toxicity trials against birds suggested minimal impact
- Conclusions
 - Very narrow prey range
 - No non-target impacts or intraguild predation expected
 - 2002 *Rodolia* released onto 11 islands



Orthezia insignis,
a soft wax scale



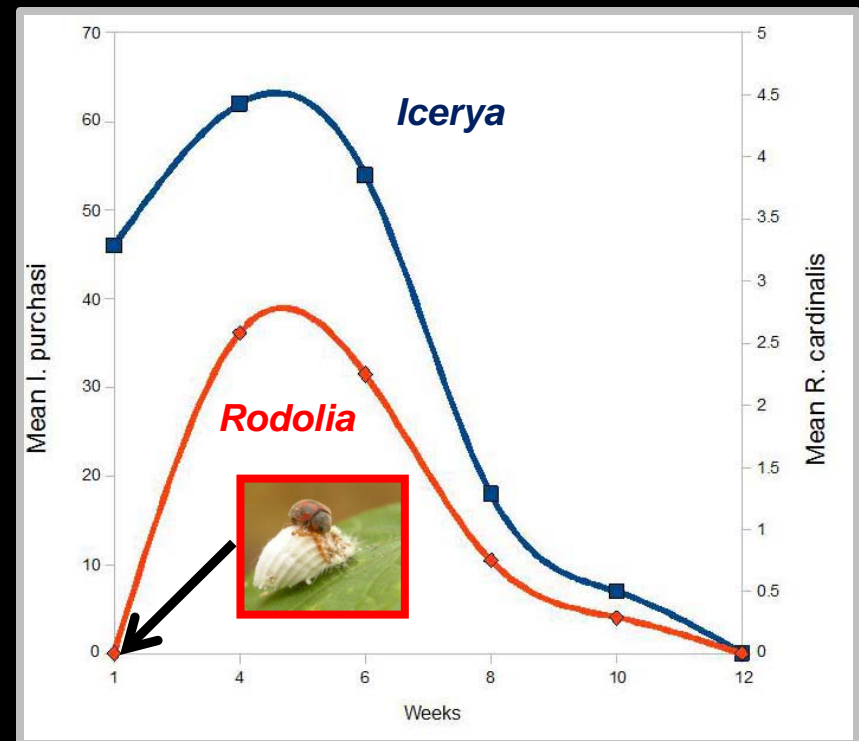
Margarodes similis



Geospiza fuliginosa

What Happened After *Rodolia* was Released?

- As predicted from quarantine studies and 121 years of observations, *Rodolia* did not destroy the native insect fauna of the Galápagos!
- *Icerya* populations diminished rapidly as *Rodolia* populations grew and spread



The Situation Seven Years Later

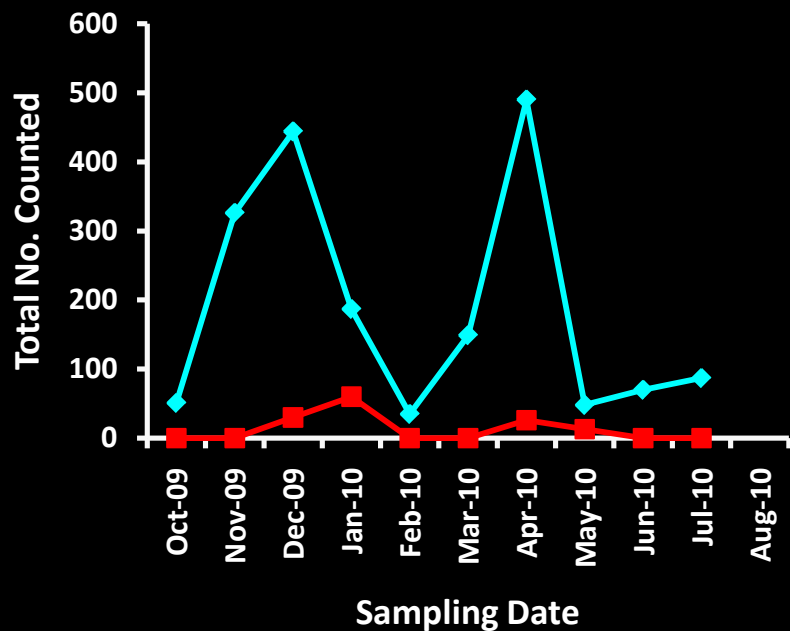
- In 2009, a two year post-release evaluation was initiated to evaluate the *Icerya-Rodolia* biocontrol project in the Galápagos
 - Field monitoring of four distinct habitats on two islands
 - White mangroves – coastal/rocky
 - **Acacia/Pakisonia dry scrub habitat**
 - **Mixed xeric vegetation**
 - **Uva de mar – sandy/beach**
 - Walk-in-cage behavioral studies & field observations
 - Sticky card monitoring



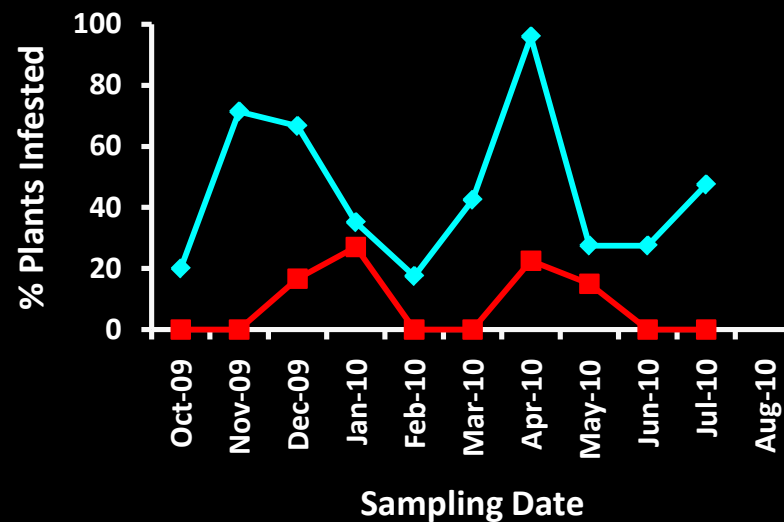
Field Survey Results



Total *Icerya* & *Rodolia* Counted



% Plants Infested with *Icerya* & *Rodolia*



◆ Total *Icerya* Counted ■ Total *Rodolia* Counted

◆ % Plants infested with *Icerya*
 ■ % Plants Infested with *Rodolia*

Behavioral Observations

>30 hours of observations on ~36 foraging *Rodolia*. No non-target attacks observed

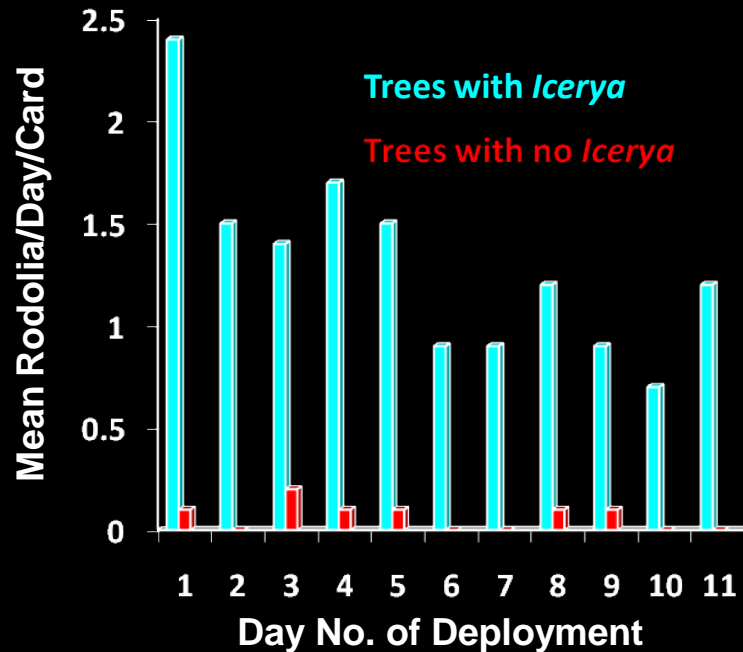


~ 12 hrs of field observations with mixed prey. No non-target attacks observed



Yellow Sticky Card Monitoring

- *Rodolia* concentrating search effort in areas with *Icerya*
 - Semiochemicals (?) may mean search patterns are not random
 - 30 sticky traps (15 in trees with *Icerya* and 15 in trees that are not host plants of *Icerya*). Checked daily for 11 days

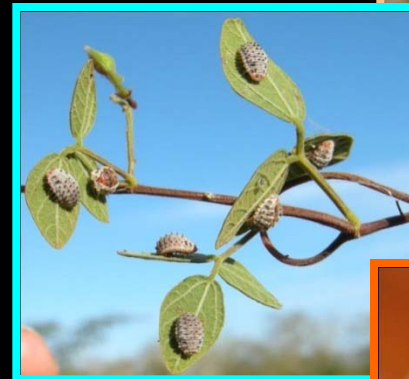


Conclusions

- *Rodolia* is present in all areas with *Icerya*. It has spread onto at least 2-3 additional islands on its own
- Control is exceptional in most areas
 - Likely prevented invasion onto other islands (e.g., Española)
 - Exceptions tend to be areas with uva de mar and *Rhyncosia*.

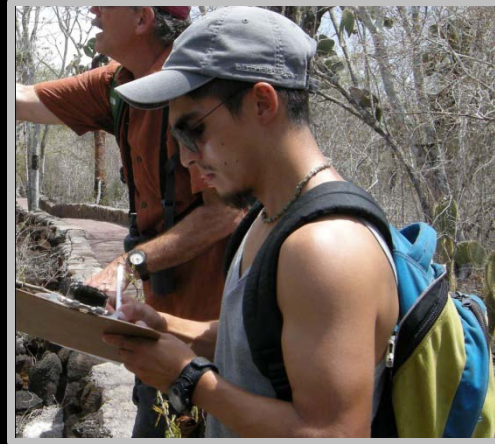
WHY?

- Absolutely no evidence for non-target effects in the Galápagos
- Riley and Koebele could never have foreseen biocontrol in support of conservation!



Acknowledgements

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- Henri Herrera



For More Information

- Google: *Icerya* & Galápagos to take you this web site
- http://www.biocontrol.ucr.edu/rodolia/rodolia_icerya_biocontrol_galapagos.html