

Biological Control of Cycad Scale, *Aulacaspis yasumatsui*, Attacking Guam's Endemic Cycad, *Cycas micronesica*

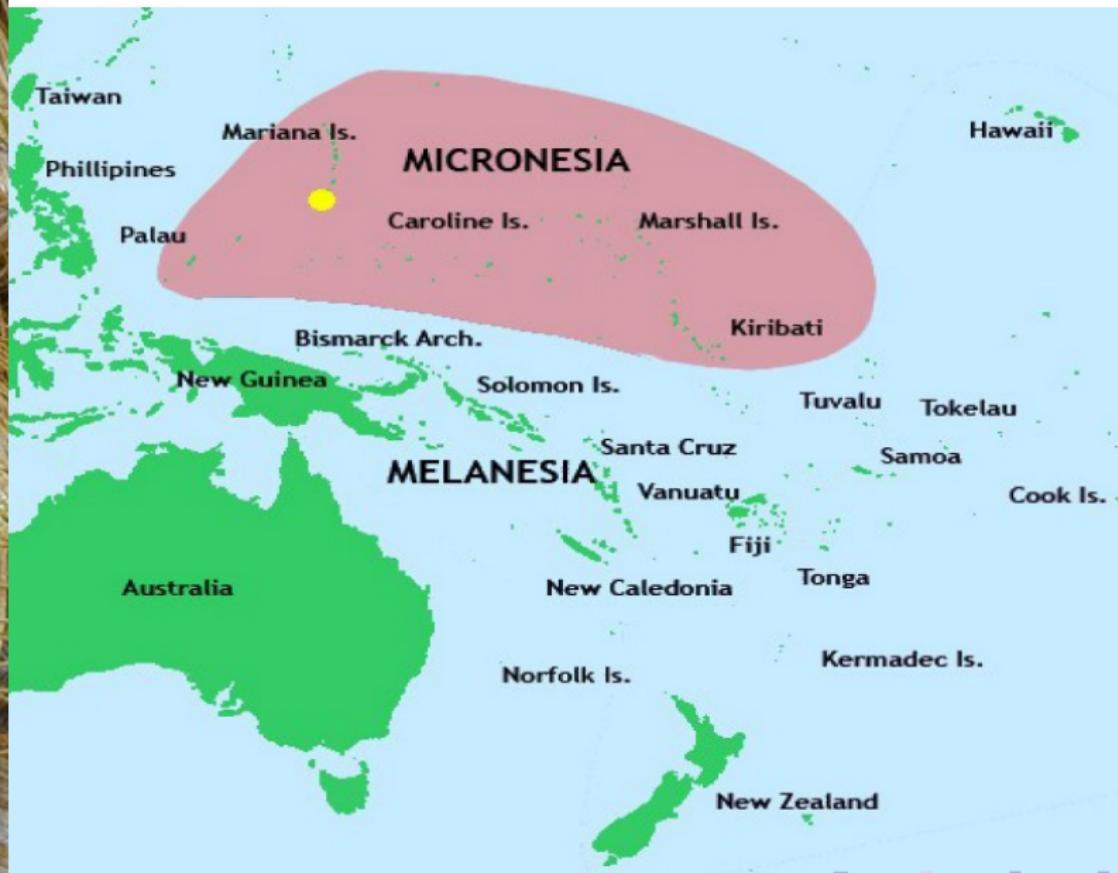


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Where is Guam?



Major Biological Invasions on Guam

- ▶ Brown Treesnake (arrived around 1945)
 - ▶ Killed most of Guam's birds and small mammals. Caused 7 bird extinctions.
- ▶ Asian Cycad Scale (detected 2003)
 - ▶ Threatens survival of Guam's endemic *Cycas micronesica*, listed as most numerous tree in the 2002 Guam Forest Survey
- ▶ Coconut Rhinoceros Beetle (detected 2007)
 - ▶ Threatens Guam's coconut palms, listed as 2nd most numerous tree in 2002 Guam Forest Survey
- ▶ Little Fire Ant (detected 2011)
 - ▶ Threatens most animals remaining in Guam's forests

A close-up photograph of several palm fronds, showing their characteristic pinnae and rachis. The fronds are a mix of green and yellowish-brown colors, suggesting some age or seasonal change.

Asian Cycad Scale

Aulacaspis yasumatsui Tagaki 1972

DIASPIDIDAE

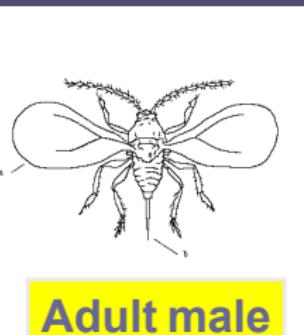
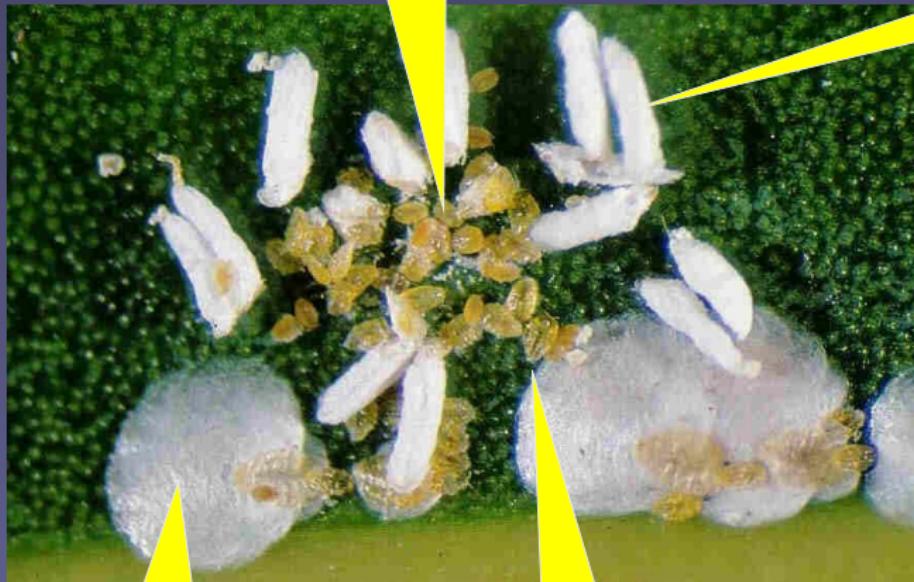
Asian Cycad Scale Chronology

- 1996 – Scale detected in Florida on cycads growing in a botanical garden
- 1998 – Scale detected in Hawaii
 - 2003 – Scale detected on cycads used for landscaping in Tumon hotel district on Guam
 - 2004 – Scale spreads to *Cycas revoluta* and *C. micronesica* throughout of Guam
 - 2006 – Scale infests *C. micronesica* on Rota





Scale Morphology & Life History



Adult male

Female scale

Crawlers























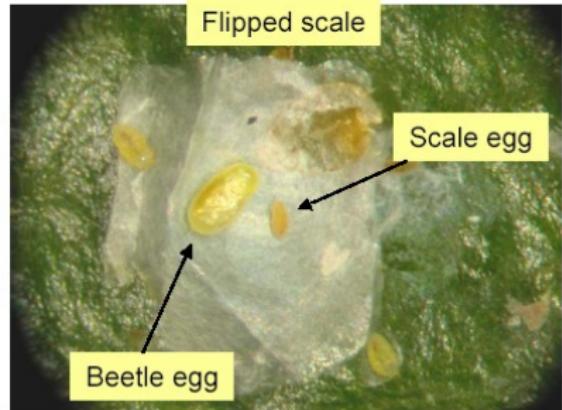
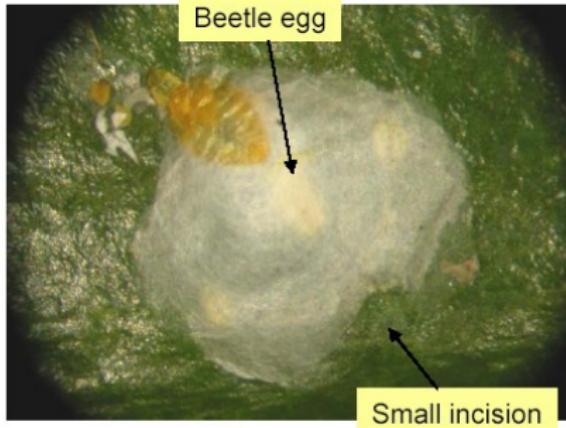
Biocontrol Attempts

- ▶ COCCINELLIDAE: *Rhyzobius lophantheae* imported from Hawaii 2004
 - ▶ Single attempt; Established Immediately
- ▶ APHELINIDAE: *Coccobius fulvus* from China via Florida starting in 2005
 - ▶ Several attempts; lab colony died; field releases did not establish
- ▶ APHELINIDAE: *Aphytis lignanensis* imported from Hawaii 2012
 - ▶ Single attempt; lab colony died prior to field release

Rhizobius lophantheae (COCCINELLIDAE), 'purple scale destroyer'

- ▶ both adults and larvae feed on Diaspidids (armored scales)
- ▶ introduced from Australia to California in 1892; from California to Hawaii in 1894
- ▶ Released on Guam in 1925 & 1926, but was never recovered

Top view of the Asian Cycad scales



Photos courtesy of Stacey Chun, University of Hawaii, Hilo







Rhyzobius lophantheae

Chronology

- 10 June 04 – Import permits requested
 - 17 Aug 04 – Permits approved
- 12 Nov 04 – ~100 adults collected on Maui were hand-carried to Guam; quarantined for 1 month
- 16 Feb 2005 – First field releases at Ritidian Pt.
- 20 May 2005 – First adults recovered
- 7 July 2005 – High density of beetles observed within 1 km radius of release sites
- 12 Aug 2005 – Live scales very hard to find at Ritidian Pt.



ANR



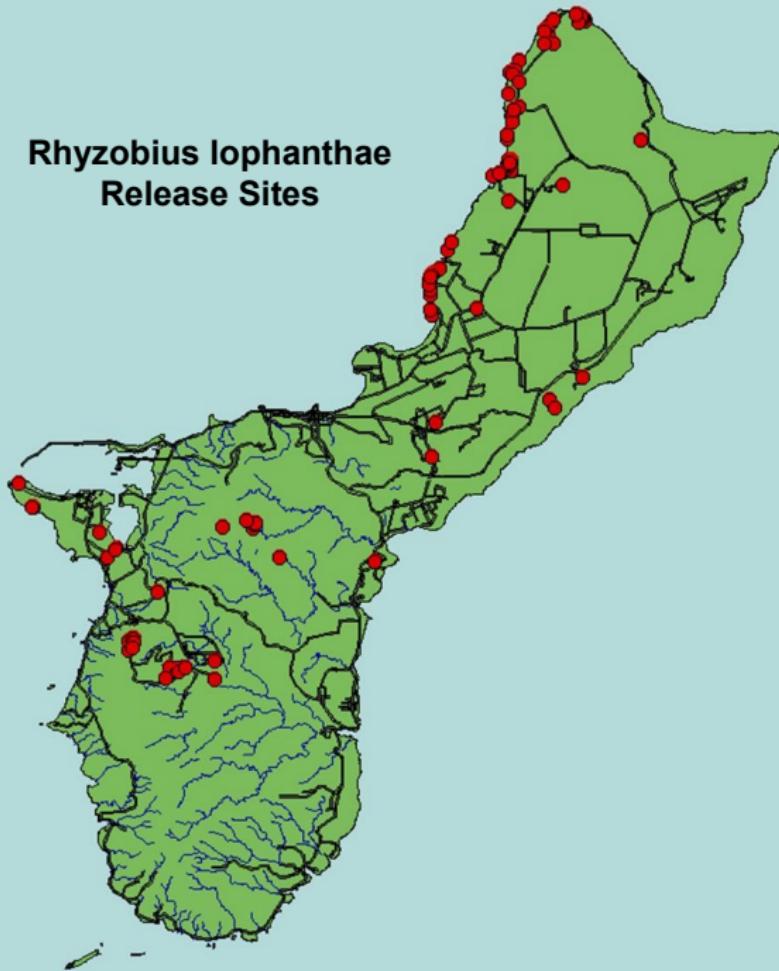








Rhyzobius lophanthae
Release Sites



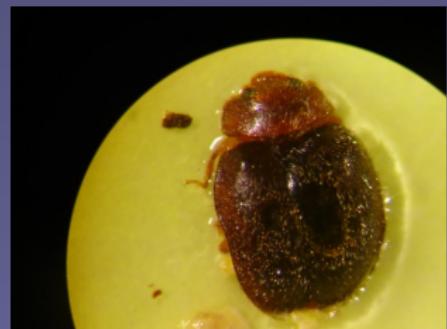
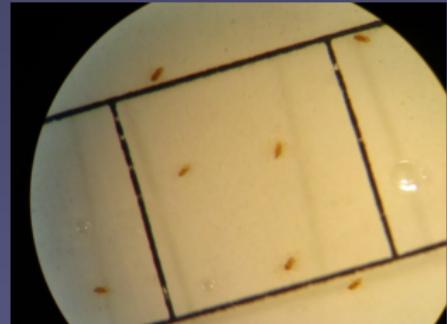


Sticky Traps

Stereoscope



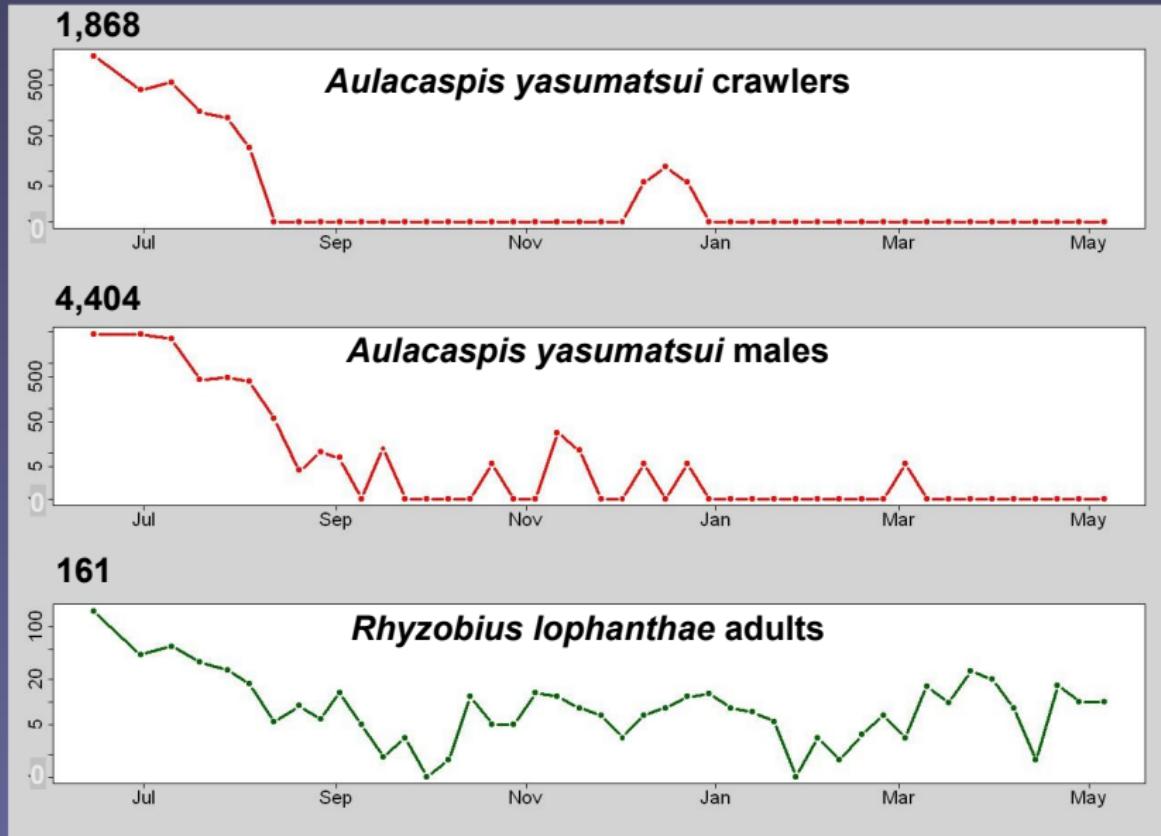
Aulacaspis yasumatsui
Adult males & Crawlers



Rhyzobius lopanthae
Adults

Insects per m² per day on Sticky Traps

Ritidian Pt.; June 2005 - May 2006



Longterm Field Monitoring of *Aulacaspis yasumatsui* and *Rhyzobius lophanthae*

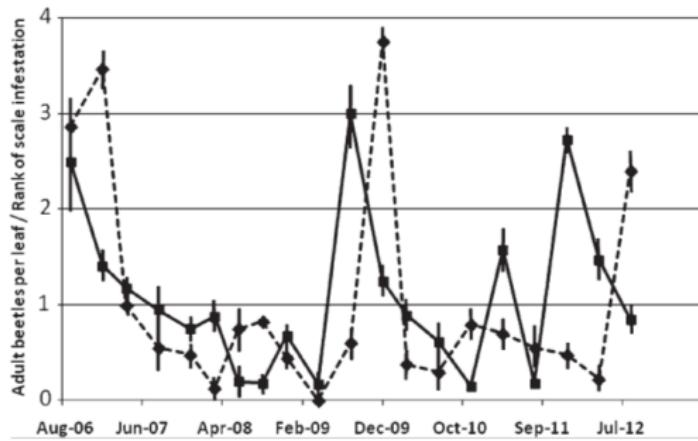


Fig. 2. The extent of *Aulacaspis yasumatsui* infestation on *Cycas micronesica* trees within an east coast habitat on Guam (square; 0 = no scales, 5 = heavy infestation) and the number of adult *Rhyzobius lophanthae* adults observed per leaf (diamond) on the same trees (from Sept. 2006 until Aug. 2012). Mean \pm SE.

Source: Marler, T.E., R. Miller, and A. Moore. 2013. Vertical stratification of predation on *Aulacaspis yasumatsui* infesting *Cycas micronesica* seedlings. HortScience 48:60–62.

Current *Rhyzobius lophantheae* Status

- ▶ *R. lophantheae* is ubiquitous on Guam. It is almost impossible to find Asian cycad scale which is not being attacked by larvae and adults.

So the biocontrol program was a success and the cycads must be recovering by now, right? ...

Current *Cycas micronesica* Status

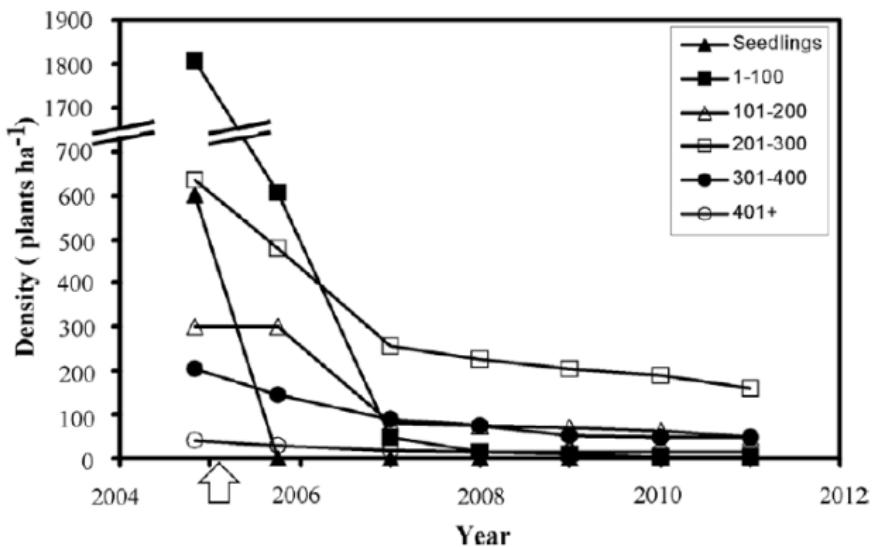


Figure 2. The influence of plant height size categories (cm) on survival of *Cycas micronesica* following the establishment of *Aulacaspis yasumatsui* in western Guam. The x-axis refers to January of each calendar year. Arrow on x-axis marks the initial infestation of *A. yasumatsui* in the study habitat.

Marler, T.E. and J.H. Lawrence. 2012. Demography of *Cycas micronesica* on Guam following introduction of the armoured scale



Current *Cycas micronesica* Status

The *C. micronesica* population is still in decline.

- ▶ In 2006, *C. micronesica* was placed on the IUCN Red List of Threatened Species and it remains on this list
- ▶ No reproduction on Guam has been observed since 2005.
- ▶ Only 7% of the original plants survive as of January 2013.
- ▶ Local extirpation predicted in 2019 if current trend persists.

Failure Analysis

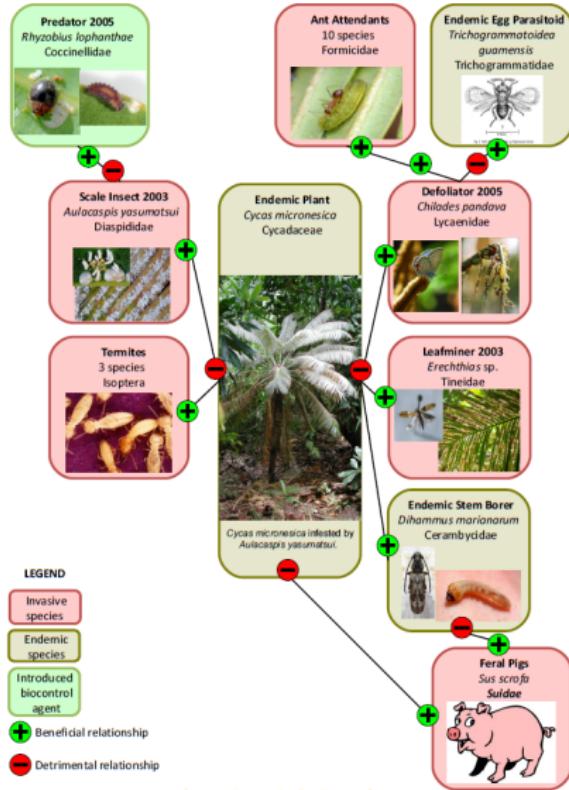
R. lophantheae fails as a stand-alone biocontrol agent for Asian Cycad Scale because:

- ▶ *R. lophantheae* is too big to reach a significant proportion of the scale insects which live in small cracks and voids within plant structures
 - ▶ Marler, T.E. and A. Moore 2010. Cryptic scale infestations on *Cycas revoluta* facilitate scale invasions. Hort. Sci. 45: 837-839.
- ▶ *R. lophantheae* does not prey on scale insects living beneath trichomes on *C. revoluta*
 - ▶ Marler, T.E. 2012. Boomeranging in structural defense: Phytophagous insect uses cycad trichomes to defend against entomophagy. Plant Signaling & Behavior 7:1484 –1487.
- ▶ *R. lophantheae* predation decreases with proximity to the ground.
 - ▶ Marler, T.E., R. Miller, and A. Moore 2013. Vertical stratification of predation on *Aulacaspis yasumatsui* infesting *Cycas micronesica* seedlings. HortScience 48: 60–62.

Current Cycad Scale Biocontrol Objectives

- ▶ We are currently attempting to introduce a parasitoid in the hope that its smaller size will allow it to attack scale insects which escape beetle predation by hiding in small spaces within the plant structures.
- ▶ *Aphytis lignanensis* has been chosen as a candidate because it coexists with *R. lophnathae* in Hawaii and Texas.

A. yasumatsui is Not the Only Invasive Species Attacking Cycads on Guam

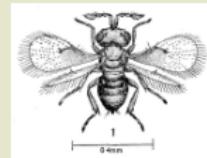


Chilades pandava

Ant Attendants
10 species
Formicidae



Endemic Egg Parasitoid
Trichogrammatoidea guamensis
Trichogrammatidae



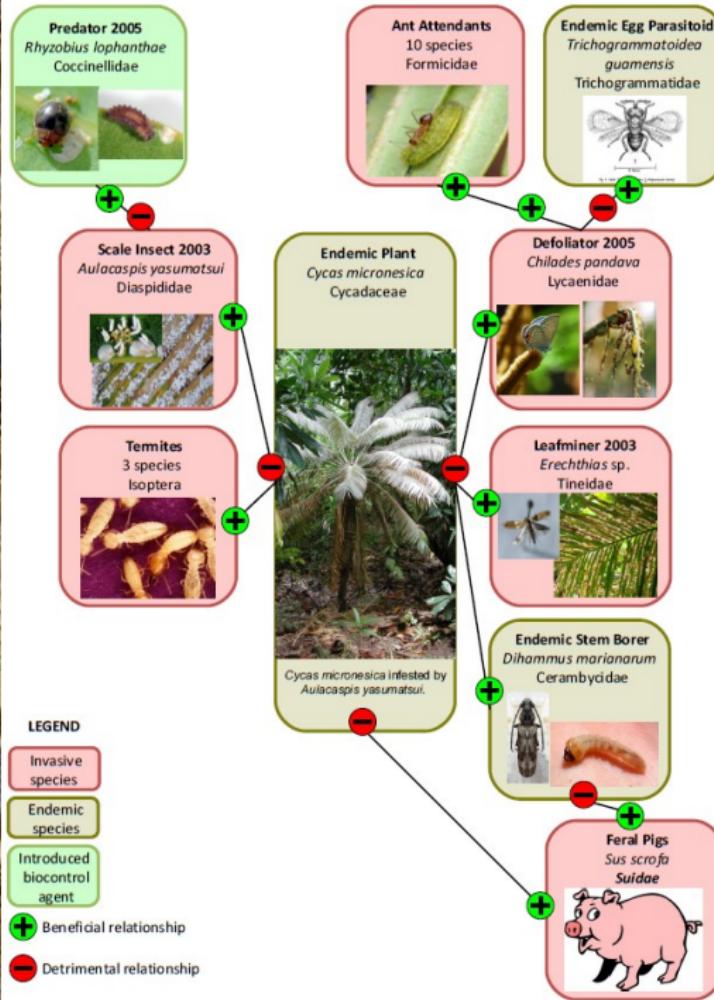
Endemic Plant
Cycas micronesica
Cycadaceae



Defoliator 2005
Chilades pandava
Lycaenidae



And They are Still Arriving ...



Recent New Island Records for Cycad Associates on Guam

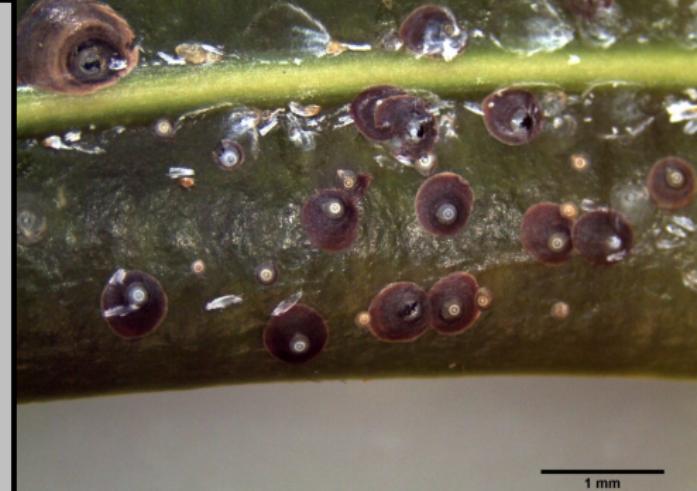
2013-01-25 DIASPIDIDAE
Lingaspis rossi infesting *Cycas micronesica*

2013-01-25 APHELINIDAE
Aphyitis sp.? parasitizing
Lingaspis rossi

2013-01-25 DIASPIDIDAE
Pseudaonidia sp. infesting
Cycas revoluta

2013-02-10 ENCYRTIDAE
Arrhenophagus? sp.
parasitizing male *Aulacaspis yasumatsui* infesting *Cycas micronesica*

2013-01-25 DIASPIDIDAE
Lingaspis rossi infesting
Cycas micronesica



2013-01-25 APHELINIDAE
Aphytis? sp. parasitizing
Lingaspis rossi



2013-01-25 DIASPIDIDAE

Pseudaonidia sp. infesting
Cycas revoluta



2013-02-10

ENCYRTIDAE

Arrhenophagus? sp.

parasitizing male

Aulacaspis ysumatsui

infesting *Cycas*

micronesica



Concluding Comments

- ▶ The predaceous lady beetle, *R. lophantheae* has failed as a stand-alone biocontrol agent for Asian cycad scale, even though it established readily and has become ubiquitous.
- ▶ Presence of *R. lophantheae* has thwarted our attempts to establish parasitoids as biocontrol agents for Asian cycad scale.
- ▶ If you wish to introduce predators and parasitoids, it may be easier to establish parasitoids first, then predators.

Invasive species aren't all bad.

They provide job security for biologists.

