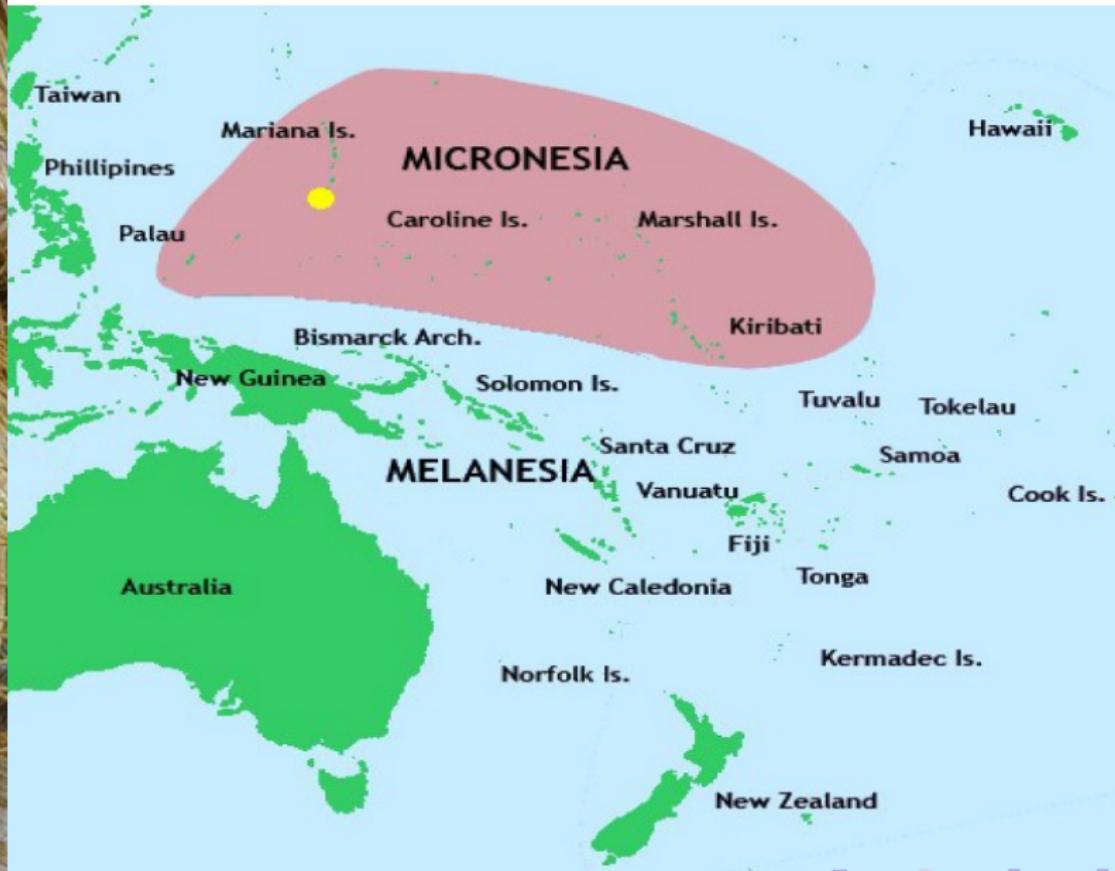


Biological Control of Cycad Scale, *Aulacaspis yasumatsui*, Attacking Guam's Endemic Cycad, *Cycas micronesica*



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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

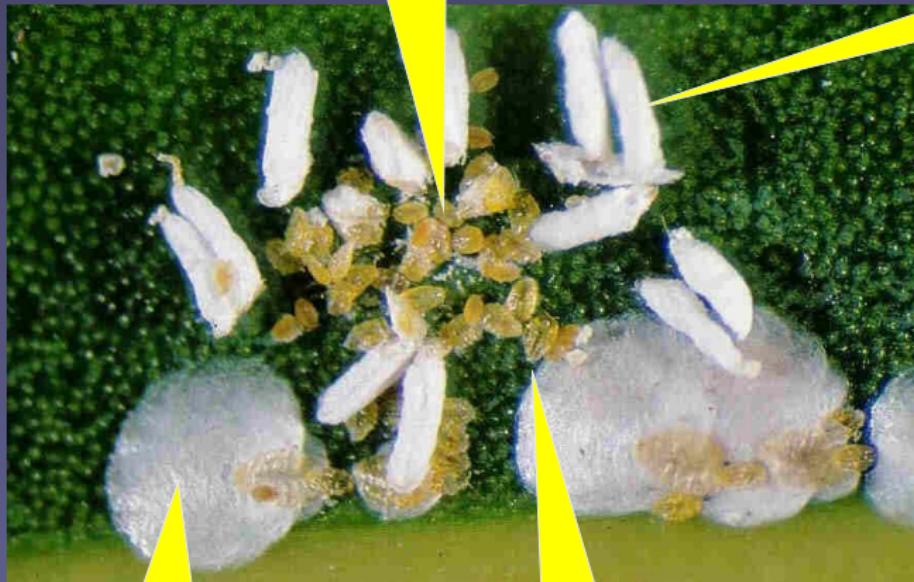
Asian Cycad Scale Chronology

- 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

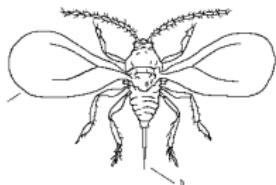


Female scale

Eggs

Crawlers

Male cocoon



Adult male























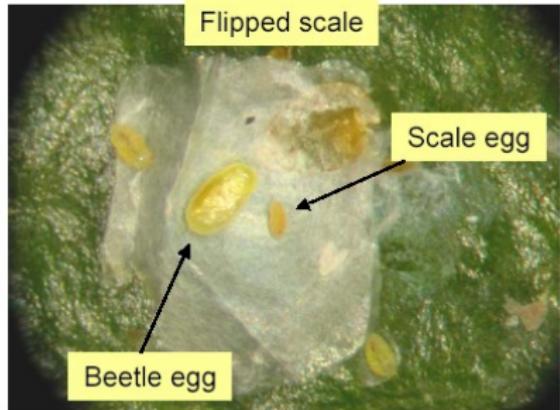
Biocontrol Attempts

- ▶ 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







ANR



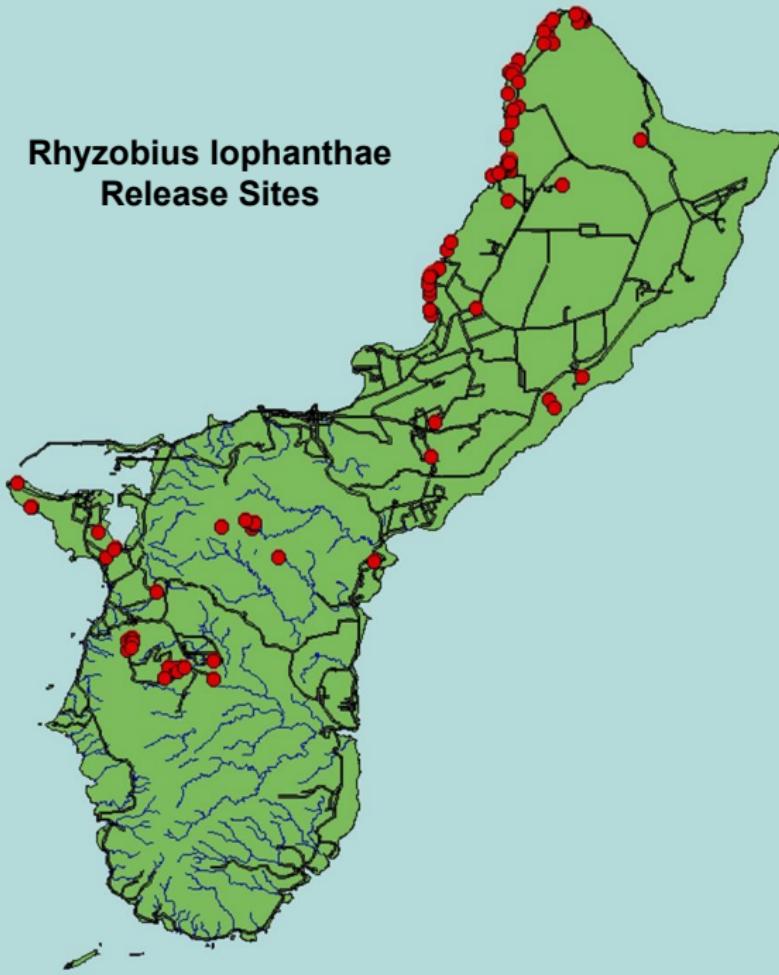








Rhyzobius lophanthae
Release Sites



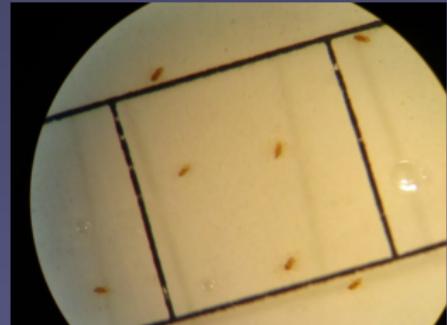


Sticky Traps

Stereoscope



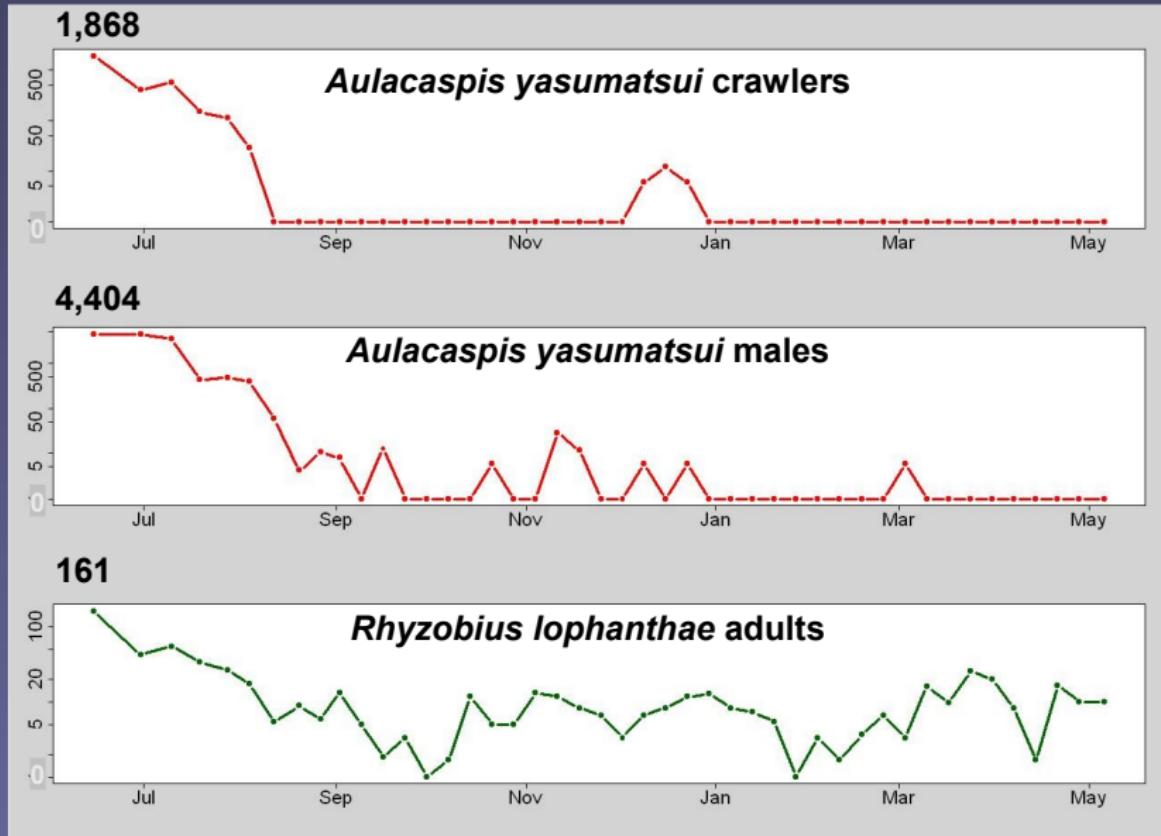
Aulacaspis yasumatsui
Adult males & Crawlers



Rhyzobius lopanthae
Adults

Insects per m² per day on Sticky Traps

Ritidian Pt.; June 2005 - May 2006



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

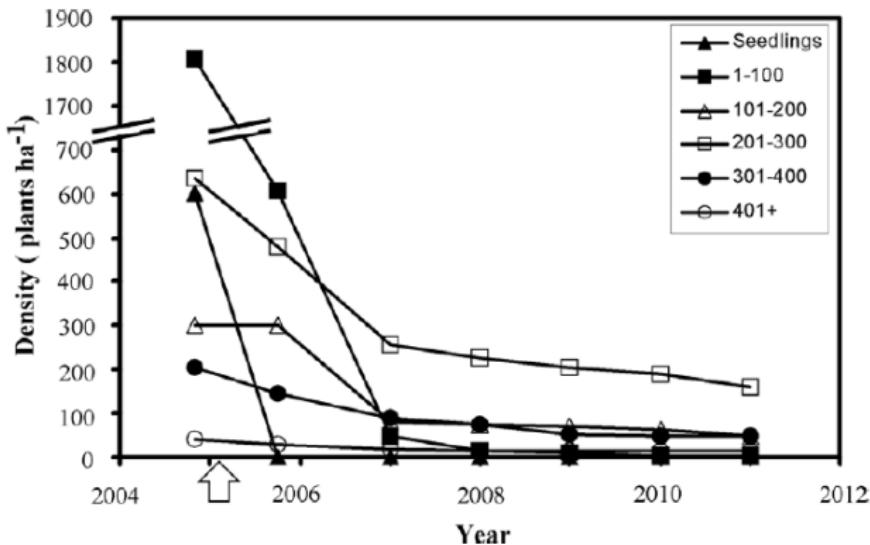


Figure 2. The influence of plant height size categories (cm) on survival of *Cycas micronesica* following the establishment of *Aulacaspis yasumatsui* in western Guam. The x-axis refers to January of each calendar year. Arrow on x-axis marks the initial infestation of *A. yasumatsui* in the study habitat.

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.

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.



A Coalition of Invasive Species

Attacks Guam's Endemic Cycad, *Cycas micronesica*

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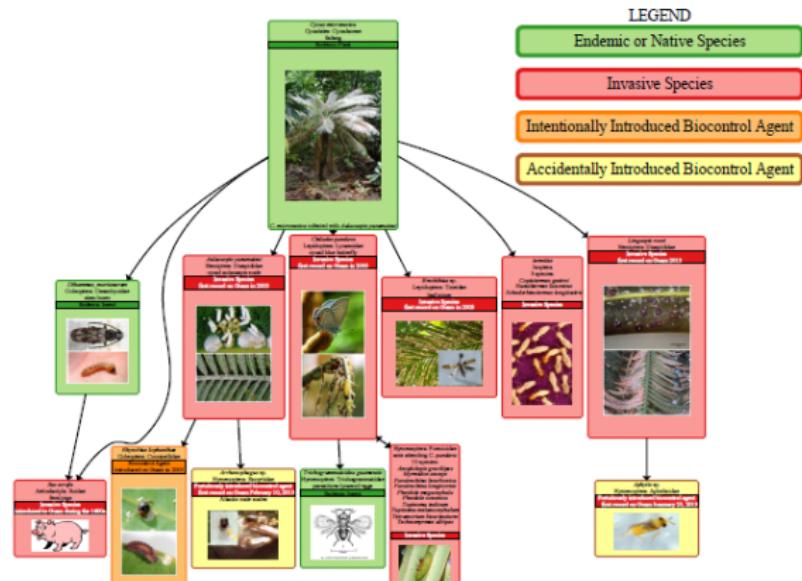


Figure 1: Summary of ecological relationships between *C. micronesica* and invasive species which threaten its existence. Arrows indicate which species benefit from relationships.

A 2002 forest survey listed *Cycas micronesica*, locally known as "Isidang", as the most numerous tree-sized plant in Guam's forests. In 2006 *C. micronesica* was placed on the IUCN Red List of Threatened Species in response to high mortality from simultaneous attack by recently introduced invasive species including the cycad aulacaspis scale (*Aculaspis yasumatsui*), the golden apple snail (*Chrysomelus pandava*), and a lepidopteran leafminers, *Erechthias sp.*. The cockroachid, *Rhyzobius leprosus* was established as an effective biological control agent for CAS. However, the cycads continue to decline due to damage from CAS and other herbivores. In some areas of Guam, 90% of *C. micronesica* have been killed and the plant could be extirpated from the wild by 2019 if current trends persist.

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Invasive species aren't all bad.

They provide job security for biologists.

