



Paradise Lost? Tipping the Scales against Guam's *Cycas micronesica*

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Photos by Thomas Marler.

Fig. 1. Guam part of the Mariana Islands, located east of the Philippines and north of Papua New Guinea.

Following its sterile volcanic inception some 30 million years ago, the island of Guam has attracted as its native inhabitants flora and fauna that boat, float, fly or drift aerially from nearby Asian and Asian Pacific locations. Included in the early denizens of Guam and other islands of the Mariana Archipelago chain (Fig. 1) is the now seriously threatened *Cycas micronesica*. This beautiful arborescent cycad (Fig. 2), known locally as *fadang*, is endemic to this part of the world. Geographic distribution of the species has been enabled by aquatic dispersion of seeds due to ocean currents and the buoyancy provided by a specialized spongy seed tissue. This distinctive flotation tissue coexists with the embryo and gametophyte tissues within the protective sclerotesta (Fig. 3). The species resides taxonomically within the *C. rumphii* species complex.

All inhabitants of these islands have been immigrants at some time in the past. However, recent foreign invasions from world wars and increased maritime and air travel have caused devastating ecological disasters on this island paradise. The alien brown tree snakes and cane toads that have been disrupting island ecology for decades have recently been joined by another alien invader. The current

ecological disaster that is unfolding rapidly on Guam is due to the human introduction of the cycad aulacaspis scale (CAS), *Aulacaspis yasumatsui* Takagi. This introduction was undoubtedly a result of the inadequately regulated importation of king sago (*Cycas revoluta*) plants to satisfy the commercial and home landscape industry. This pest was first detected in the landscaped cycads of Guam's hotel district in 2003 and has subsequently become a major threat to the native, stately cycads. Fortunately, as of October 2005, the scale has not been found on any

other of the nearby islands that have this cycad species, including the islands of Palau, Yap, and Rota. Can the plants on those islands be saved? Only if strong preventive measures are put into place immediately.

This insect is able to thrive on numerous species of cycads in various genera (Jody Haynes, pers. comm.), but the members of the genus *Cycas* seem to be extremely vulnerable to the scale. The tiny insects feed on the sap or juices of most plant parts,



Fig. 2. *Cycas micronesica* is an arborescent species in the *C. rumphii* complex.

including leaves, female sporophylls, seeds, male cones, and even roots and stems.

Two truly sad commentaries are revealed by the telling of this island invasion story. First, despite clear and strong warnings from scientists in newspaper and popular articles in 2000 that this potentially devastating insect pest could easily get into Guam through importation of cycads for landscaping, no action was taken to prevent it from happening. A temporary local import ban on king sago plants would have undeniably kept this disaster from happening. Moreover, it would have created an instant demand for local nursery production of this popular landscape plant. This sad commentary mirrors the fact that Florida growers could have prevented the current disaster by placing a voluntary ban on export of king sago plants when the pest was found in the Florida landscape. Now the national value of the king sago trade is a frac-



Fig. 3. Eleven-month-old *Cycas micronesica* seed has a flotation layer that allows ocean dispersal.



Fig. 4. Less than one year after CAS enters a population, large *Cycas micronesica* plants are dying.

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Fig. 5. *Cycas revoluta* plants in cultivation typically flush three times after initial CAS infestation before dying in Guam's climate: A) initial infected flush; B,C) two subsequent infected flushes, each smaller than the last; D) plant ultimately succumbs.

tion of what it was a decade ago. Second, the spread of this insect and its deadly effect on a particularly vulnerable cycad has been especially swift, while the subsequent human response after the invasion was verified has been particularly slow. This polarity of speed following the initial reporting of the scale insect has brought the island to the present day situation where the elimination of this pest from Guam is impossible without a massive intervention. October 2005 marks two years since the initial infestation was spotted. During those two years the pest has advanced to all urban landscaped areas and most forest habitats of the western, northern, and northeastern parts of the island. Many fadang plants throughout the natural landscape have already died or are dying (Fig. 4). Small forest pockets in southern Guam are realistically the only habitats that can boast of scale-free fadang plants as of this date. These forests occur on top of Guam's highest mountain peaks in limestone soil outcrops, and deep in the riparian vegetation that stabilize vulnerable valley slopes.

Our recent habitat surveys indicate disjunct cycad habitats that are isolated from large populations of cycads are the most at risk following localized scale invasion. In these isolated habitats with low cycad plant

density, death of infested individuals seems to occur more rapidly than in heavily populated cycad habitats. Yet many of the genes we may need to safeguard in order to adequately preserve genetic diversity of the species may reside in these very habitats that hold sparse cycad populations.

Why has this pest had such a remarkable spread and devastation across almost all of the island habitats? No one knows for sure, but there are several contributing factors. First, if heaven is the quintessential smorgasbord, then this scale found heaven when it found Guam. According to a recent forest inventory, the endemic cycad was the most abundant arborescent species (defined as plants

with a stem diameter at breast height of greater than five inches) on Guam. The invasion of Guam marks the first time since the scale's arrival on American soil in the early 1990s that this pest has been able to explode from cultivated landscapes into native forests to find an endless supply of hosts to devour. Unfortunately, the ongoing rampage of cycad deaths has surely already altered these pre-invasion demographic descriptors of Guam's forest habitats. Second, the scale has no known endemic natural enemies on this isolated island. Unabated eating and reproducing and migrating occurred from the moment the pest entered native forests. Third, Guam is buffeted with gentle trade winds year-round. Local wind and weather patterns allow for easy spread of the crawlers (the immature stage that disperses aerially or by crawling). Fourth, a warm, humid climate throughout the year with no seasonal cold periods to bring ephemeral unfavorable weather that limits insect growth allows the scale reproduction and migration to proceed unchecked. Fifth, Guam's typical monsoon weather patterns impose an annual dry season that increases plant stress and actually aids crawler dispersal due to paucity of rain. In addition to these factors favoring the scale insect, the native cycad is especially vulnerable to CAS in that a mature plant can die within a year of initial infestation.

Cycas revoluta is also quite vulnerable in Guam's environment, as demonstrated by this deadly photographic journal (Fig. 5). The initial flush of leaves dies shortly after becoming heavily infested (Fig. 5a). Two subsequent flushes of leaves, each being smaller than the last, emerge



Fig. 6. Mature strobili of *Cycas micronesica* are highly susceptible to CAS damage. A) male; B) female.

and subsequently die (Fig. 5b,c). Ultimate death occurs (Fig. 5d) as the plant sequentially depletes vital resources without the ability to recover those resources through prolonged leaf function.

While pictures can reveal the damage that CAS imposes on a single plant, it is even more shocking to see large numbers of tall mature trees that have much of their trunk and all of their leaves, cones, and developing seeds completely covered with the pallid scale (Fig. 6). Or, equally saddening, to stand among plants killed by the scale and watch millions of airborne crawlers and flying adult males glinting in the setting sun on their way to wreak more destruction. Most people refrain from crying when viewing plants in distress. But a first glimpse of the widespread destruction of such a beautiful plant that has been a defining component of Guam's environment for eons brings tears to one's eyes. This is especially true when one acknowledges that *Cycas micronesica* was a dominant forest plant on an island that has as its only native gymnosperm this beautiful cycad, and that further ecological damage is inevitable.

Seeing this rapidly unfolding devastation of an ancient, unique species brings several questions to mind. Will we ever know much about its biology and poorly understood mode of pollination before most plants are lost or altered forever? If there are obligate insect pollinators as suspected, will they also be lost before we can answer crucial biology questions by studying their behavior? Do Guam's mycorrhizae and cyanobacteria populations that benefit the native cycads via root symbioses represent unique ecotypes? Will these microorganisms also be lost forever before we have a chance to learn from them?

One aim of this article is to alert all who are interested in the preservation of cycads. If your enthusiasm entails conserving cycads in their native habitats (which is crucial to the long-term survival of each cycad species), this news should move you. Or if design and management of habitat-based germplasm collections in botanical gardens is your cup of tea, the details herein should incite concern as genetic erosion proceeds. Or maybe you just enjoy cycad conservation by their inclusion in commercial and

homeowner landscaping. Regardless of your level of cycad enthusiasm, this human-caused ecological disaster should provoke you in some manner. It was, after all, entirely avoidable.

CAS is devastating to many cycads, and some like *Cycas micronesica* are extremely susceptible. Once the invasion has been detected in a new area, an eradication program may be ineffectual. As a result, the goal at this stage is to deploy a multi-pronged approach to "manage" the scale. Such an approach entails the use of chemical (pesticides), biological, and mechanical (destroy / burn infested leaves or entire plants) methods to limit the effects and spread of the pest. This is not a trivial conundrum, nor is it easily achievable logistically. For example, in Guam there are no adequate control solutions in the natural populations because plants are widely dispersed and are found along cliffs, in dense forests, and in other areas that are inaccessible. The best solution is to stop the insect at the border, before it can get a foothold in new geographic locations. Among the most at-risk areas where the scale has not been detected are Australia and India, both of which are blessed with an abundance of *Cycas* species. Other regions of concern are some locales of southern Africa and many islands of the Pacific and Indian Ocean (see accompanying article).

Now that CAS is well established on Guam, all the mentioned control measures have begun, including introduction of two biological control agents. The lady beetle, *Rhyzobius lophanthae*, was introduced from Maui and the wasp, *Coccobius fulvus*, was introduced from Florida cultures. This miniscule wasp was originally collected in cycad habitat in China. Both of these scale consumers are now established on the island. In addition to monitoring their populations, an ongoing management program of insecticide treatments and mechanical destruction/removal in landscaped areas is being implemented. The success of these measures is still in question.

We plead with all cycad lovers—whether they be landscapers, importers, collectors, enthusiasts, or cycad biologists—in geographic areas where this pest has not found a residence. Educate yourself and take action to ensure that policies are put into place to prevent further spread of this in-

sect pest. Without strict regulation and constant vigilance at the borders, further deadly CAS infestations and loss of numerous endemic cycad species will continue unabated.