Pseudophoenix sargentii on Mona Island: Conservation Survey and a New Discovery

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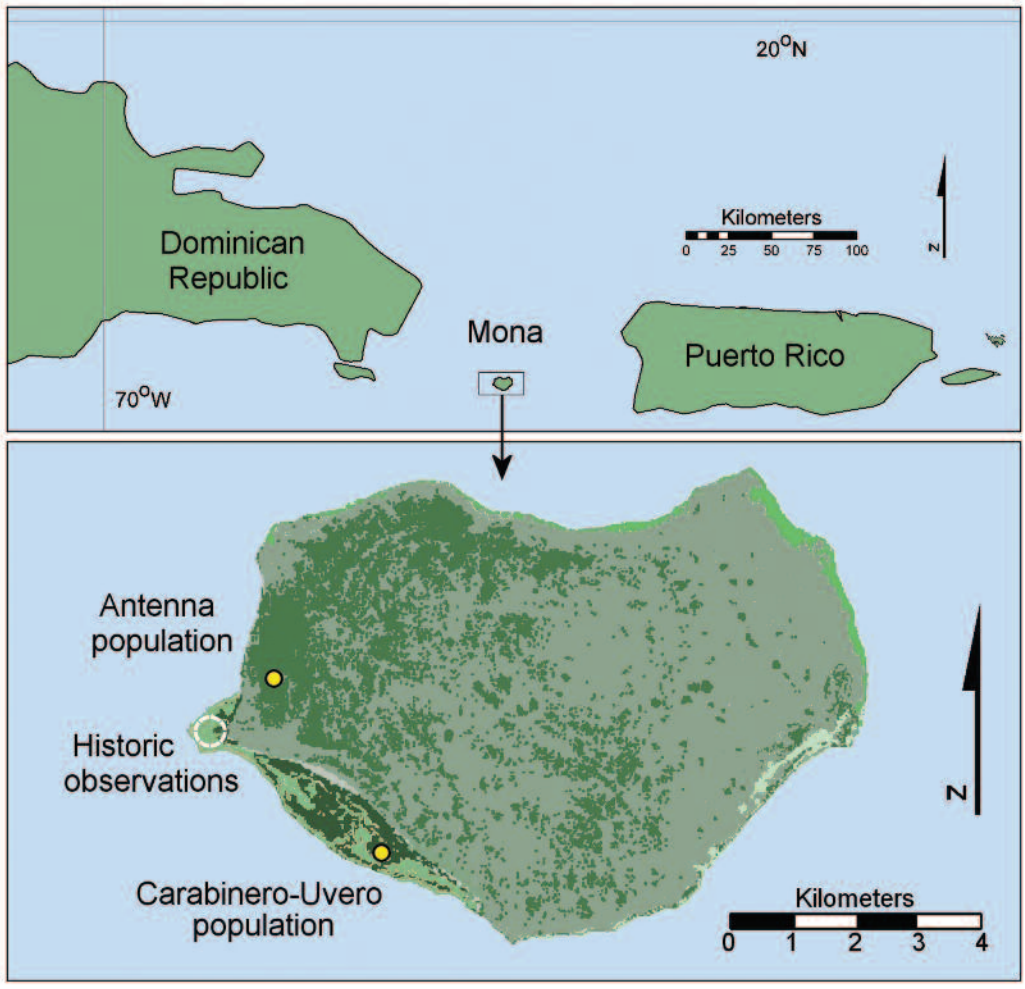
A limited, potentially imperiled and sparsely documented population of *Pseudophoenix sargentii* has been reported from Mona Island, between Puerto Rico and Hispaniola. Literature and specimen review produced a very scant record of this population but suggested decline over many decades. Recently, a second population was located on Mona. Here, we report results from a fieldwork project to survey, map and characterize these populations, to collect seeds for living botanic garden conservation collections and to collect leaflet samples for ongoing conservation genetic research. We are grateful to The International Palm Society for supporting this project.

Pseudophoenix is biogeographically intriguing. Endemic to the Caribbean Basin, the genus occurs mainly in the Greater Antilles, often in isolated populations (Zona 2002). The center of diversity for *Pseudophoenix* is southern Hispaniola, where all four species occur (Henderson et al. 1995, Zona 2002). Three of the four species show fairly narrow distribution. *Pseudophoenix ekmanii*, a strikingly beautiful, exceptionally ventricose palm, is restricted to the Barahona Peninsula and Isla Beata in the extreme southern Dominican Republic (Namoff et al. 2011). This amazing palm was a central highlight of the 2006 IPS Biennial, where IPS members saw the population firsthand in Parque Nacional Jaragua. *Pseudophoenix vinifera* occurs in both Dominican Republic and Haiti. In both countries, *P. vinifera* exists in small and scattered populations (Henderson et al. 1990, Zona 2002). *Pseudophoenix lediniana* is known from a single population in southern Haiti (Zona et al. 2007).

One species, *P. sargentii*, is also known from the Bahamas (Correll and Correll 1982), Turks and Caicos, Dominica (James 2003), extreme eastern Cuba, far northern Belize (Noblick 2009), Yucatán and Quintana Roo, Mexico (Duran & Franco 1992), Navassa Island, Isla Saona, and in the Florida Keys (Lippincott 1992). Thus, *P. sargentii* has the widest distribution of the genus. Perhaps due to this wide distribution with some significant disjunctions, many Caribbean island populations were described as separate species, subspecies, or varieties. The most recent revision of the genus placed a number of these

1. Location of *Pseudophoenix sargentii* populations on Mona Island. Historic observations at Sardinera come from Little et al. (1974) and Woodbury et al. (1977); the Carabinero-Uvero Population is documented by Hernandez (1994) and *Proctor 49505* (FTG); the new population (Antenna) is presented here. Basic vegetation types (see text) are adapted from Martinuzzi et al. (2008).



2. *Pseudophoenix sargentii* at the Antenna population. The flagging is used for census work. Compare to Figure 3. (photo: P. Griffith)

disjunct island *Pseudophoenix* populations into synonymy under *P. sargentii* (Zona 2002).

This project is focused on one such disjunction of *P. sargentii,* present on the island of Mona,

3. A group of adult *P. sargentii* at the Carabinero-Uvero population. Only one adult palm of 22 was in fruit in late January 2012. Compared to the palms in Figure 2, these appear taller (average of 4.5 m), much thinner (average of 16 cm diameter), and have a less robust crown of leaves, (average of 9 per plant). (photo: E. Santiago-Valentín)

between Puerto Rico and Hispaniola (Fig. 1). This location is of very limited size, of considerable conservation concern and of great phytogeographic interest. Only one other population of *P. sargentii* is located further southeast, on Dominica; the species is not known from other Lesser Antillean Islands and does not occur on the main island of Puerto Rico.

Conservation Concerns

Isolated populations of *Pseudophoenix* are often imperiled. For example, *P. lediniana* exists in a single population of fewer than 50 individuals, and seedling recruitment does not appear to be increasing this number (Zona et al. 2007). Two other species, *P. vinifera* and *P. ekmanii*, appear to have a reduced overall census, perhaps from prior destructive harvest of sap to produce an alcoholic beverage (Zona 2002, Namoff et al. 2011).

Pseudophoenix sargentii has recently been categorized as a species of Least Concern (Zona et al. 2007), as the species is relatively widespread. Many of the populations of *P. sargentii* are imperiled, however. Perhaps the best example is on Navassa Island, where a single wild individual remains (Zona 2002). One other well-known example concerns the individuals in Florida, which were once more widely distributed (Ledin et al. 1959) but were subsequently reduced to a single population on Elliot Key (Lippincott 1995). Careful, sustained work has succeeded in reestablishing some populations in Florida (Maschinski & Duquesnel 2006).

Pseudophoenix on Mona Island has also a very limited distribution, but conservation concerns in this case differ from other *Pseudophoenix* populations. Unlike many habitats, Mona Island benefits from a high level of protection and management as a Nature Reserve. Lack of permanent human settlement on Mona also greatly reduces the risk of human-mediated extirpation, although Acevedo-Rodríguez and Strong (2005) noted that seedlings of these palms have been sold in Puerto Rico and St. Croix. One possible threat to the Mona population is predation by feral goats and pigs (Cintrón 1991). Recent analysis of feral goat diets did not recover *P. sargentii* as goat forage (Melendez-Ackerman et al. 2008).

Past Records of *Pseudophoenix* on Mona

The earliest botanical exploration of Mona did not find *Pseudophoenix* (Britton 1915), and for

the next half century, the palms were not known to occur on the island (Little 1955, Little & Wadsworth 1964).

In 1969, this journal reported R.O. Woodbury's discovery, which appears to be the first printed record of the species on Mona (Read 1969). The earliest published census (Little et al. 1974) reported a single individual. Woodbury et al. (1977) stated that Little's (1974) observation was made before 1968. However, in 1968, Woodbury observed three palms but found these three palms dead in 1974 and suggested that this was by human actions (Woodbury et al. 1977). This observation prompted Little (1978) to pronounce the Mona population extirpated. Apparently no specimens were made but careful reading places these localities in the coastal lowland near Playa Sardinera (Fig. 1), on the western tip of the island.

In the 1980s, botanist José L. Vivaldi rediscovered this species on Mona by chance from the air during a routine Departamento de Recursos Naturales y Ambientales of Puerto Rico (DRNA) flight. The site of this population is near Playa Uvero, in a coastal lowland forest in southern Mona. Since that discovery, efforts

4. An example of a dead palm at the Carabinero-Uvero site. Over the years, notes on this site (Hernández 1994; Acevedo & Strong 2005) suggest a decline in the number of healthy adult palms. (photo: P. Griffith)

5. *Pseudophoenix sargentii* in fruit at the Antenna site. All four adults were in fruit in late January 2012. (photo: E. Santiago-Valentín)

have been made to document and manage this colony of palms for conservation. First, DRNA biologist José Rosario erected an exclosure (i.e., exclusion fence) to keep feral pigs and goats from the largest adult plants. In 1986 Gerardo Hernández (DRNA) counted 32 adult palms, 6 dead palms and a single juvenile (Hernandez 1994). That year, Hernández expanded the exclosure to protect more of the palms, and carried out selective removal of canopy branches that shade the base of adult palms. Hernández added measures to deter climbing and flying granivores in 1991 and 1992, which allowed him to collect and germinate many seed for establishment at selected lowland sites on Mona (Hernández 1994). Two herbarium specimens from this population collected in 1989 (*G.R. Proctor 45905*: FTG, SJ) documented 26 mature trees, all about 6 m tall.

The most recent account (Acevedo-Rodríguez & Strong 2005) also reported 26 mature trees of 6 m height, and thus appears to have followed the information from *Proctor 45905* (cited therein).

A New Discovery

In 2009, José Sustache and Eugenio Santiago were made aware of a potential new population of *Pseudophoenix* on Mona Island, on the plateau near Playa Sardinera, which was found by Miguel Bonet (a DRNA Ranger) while hiking off-trail. Mr. Sustache verified this observation, confirming these palms were *P. sargentii*, and performed the first census of the new population in April 2009, counting 4 adult and 8 juvenile palms. Scouting for *Pseudophoenix* and monitoring for phenology was then added to routine fieldwork on Mona. This is the first population of *Pseudophoenix* reported from the dogtooth limestone plateau of Mona Island.

Need and Objectives

As detailed above, very little information characterizing this unique island population of *P. sargentii* is currently available. Given the inconsistent depth and variation in these reports, the need for an up-to-date census is evident: were the early reports incomplete? Did, perhaps, the population go through a bottleneck in the 20th century, with the remaining palms descended from few survivors? And, are the most recent reports still accurate?

Pseudophoenix can benefit from *ex situ* conservation through botanic garden collections, an important part of re-establishment efforts. As slow-to-germinate, slow-growing palms, *Pseudophoenix* species are not highly suited for the conventional nursery

trade, although it is difficult to find a more visually striking genus. Indeed, near extirpation of *P. sargentii* in Florida is largely due to past demand for the prized ornamentals. Cultivating *P. sargentii* from seed has been successfully performed by botanic garden conservation workers, but these efforts require a long-term view and significant commitment of resources (Maschinski & Duquesnel 2006). Developing *P. sargentii* populations from Mona Island will advance the conservation of this distinct population, and will help fill a phytogeographic gap in botanic garden collections where they can be of great utility to the research community and to the visiting public. Finally, ongoing conservation genetic research on *Pseudophoenix* (Namoff et al. 2010, 2011) would benefit greatly by the sampling of the Mona Island population.

Thus, in support of botanic garden living collections, conservation genetic research and basic phytogeographic and conservation assessment of *Pseudophoenix sargentii*, fieldwork on Mona Island was planned. The objectives were to:

Collect herbarium specimens of *Pseudophoenix sargentii* for FTG and UPR

Collect seed of *P. sargentii* for living collections at MBC, UPR and FTBG.

Collect leaflet samples of *P. sargentii* for conservation genetic research, from each individual in the population.

Map, census, assess and characterize the population, for age, size and recruitment.

The Current Fieldwork

Based on *Pseudophoenix sargentii* herbarium (JBSD, FTG and UPR) and living collections (MBC and FTBG), we expected flowering late in the calendar year and mature fruit in January or February. No flowering was observed in 2009 and 2010, perhaps due to unusually cold conditions or reduced rainfall. Finally, in 2011, inflorescences were observed, and in December 2011, a few mature fruit and abundant developing fruit were observed. With conditions thus lined up for a fruitful project, we travelled to Mona Island on January 20–23, 2012.

Here, we document the two native populations of *Pseudophoenix sargentii* on Mona, one occurring between Playa Carabinero and Playa Uvero ("Carabinero-Uvero") and one located near the DRNA radio communication antenna on the Mona Plateau (Fig. 2). These populations are growing in different vegetation associations, show different gross morphology and also appear to have differential reproductive success. Additionally, we report on the progress of initial *inter situ* (i.e., reintroduction to historical sites and other suitable locations) work in the 1990s (Hernandez 1994)

The Carabinero-Uvero Population.

As observed in the late 1980s, the Carabinero-Uvero population had 32 living adult palms in 1986 (Hernandez 1994) and 26 in 1989 (*Proctor 49505*: FTG). Survey by Mr. Sustache in April 2009 counted 20 living adult palms and 15 dead palms. One of these palms has been toppled and the growing tip has reverted upward, perhaps within the last 5 years. No flowers, fruits or seedlings were observed in 2009.

Survey in January 2012 counted 22 adult palms (Fig. 3), with quite a few dead palms also noted (Fig. 4). A single adult palm here was in fruit, and seeds were collected from this individual. Two seedlings were observed. Specimens (*Griffith 367*) are deposited at UPR and FTG.

The Antenna Population.

The nearest landmark to this newly found population is the DRNA radio communication antenna, thus we refer to this group of palms as the "Antenna Population." Survey in both 2009 and 2012 found 4 adult plants; none of these were in flower in 2009, but all 4 had fruit in 2012 (Figure 5). Eight juvenile plants (i.e., individuals with trunks, distichous leaf arrangement and not reproductively mature) were located along with a number of seedlings. No evidence of any dead palms has been observed. Five separate accessions of seeds for living collections were made, one from each adult palm, and a mixed collection from ripe fruits collected under the group of adults. Specimens (*Griffith 365*) are also deposited at UPR and FTG.

Propagated offspring.

Two offspring from *inter situ* efforts were observed at Sardinera at two exact sites recommended by Hernandez (1994). These plants, offspring from the Carabinero-Uvero population, are now juveniles with around 20 cm of clear trunk and leaves 2.5 m long after nearly 20 years of growth (Fig. 6). About an additional dozen plants have been planted

6. One of the propagated *P. sargentii* planted near the DRNA Facilities at Sardinera. The first records of *P. sargentii* on Mona (Little et al. 1974) come from this general area, but were at one time extirpated. Reestablishment efforts on Mona began in 1992 using seed from the Carabinero-Uvero site (Hernandez 1994). Note the characteristic distichous leaf arrangement for juvenile *P. sargentii*. (photo: P. Griffith).

throughout the sandy coastal vegetation along Playa Mujeres, near Sardinera. These are also offspring of the Carabinero-Uvero population.

Comparing the Populations

Habit is noticeably different between the two groups and consistent within each. The Carabinero-Uvero palms are an average of 25% taller, much thinner, hold fewer leaves and produce fewer inflorescences than the Antenna palms. The Antenna palms are strikingly ventricose (Fig. 7), with shorter, stouter trunks – double the diameter of the Caravinero-Uvero population – topped with more leaves and more inflorescences. Comparison of Figures 2 and 3 shows these differences and their consistency within each population.

The two sites also have some obvious habitat differences. The Carabinero-Uvero site is located near sea level (ca. 5 m) on the Sardinera Plain, with sandy carbonate soil (Gonzales et al. 1997), while the Antenna site is on the Mona Plateau (48 m elevation), on dogtooth limestone. Associated vegetation differed between the sites. The Antenna site (on the plateau) is in semideciduous dry limestone

7. *Pseudophoenix sargentii* from the Antenna population, showing the pronounced ventricose trunk character presented in all four adult plants in the population. The palm pictured has a diameter of 41 cm at the widest point. From left to right are Francisco-Ortega, Griffith and Sustache. (photo: E. Santiago-Valentín)

woodland, with moderate canopy cover, while the Carabinero-Uvero site is in a mature semideciduous forest with mostly closed canopy (Marinuzzi et al. 2008).

The strongly swollen trunks of the Antenna population are notable and are the largest yet reported for *P. sargentii* (Read 1968, 1969; Zona 2002). Prior workers described other taxa which included this character (*P. insignis* for example; Cook 1923). Read's (1968, 1969) keys do not make use of trunk characters, but the arching inflorescences seen in all Mona Island *Pseudophoenix* place the plants within Read's concept of *P. sargentii* ssp. *saonae*. Zona's (2002) revision of the genus presents the significant problems with recognizing segregate taxa of *P. sargentii*, and his treatment brings a number of these island taxa into synonymy. Thus, both populations of the Mona Island palms fit the modern concept of *P. sargentii*, given the petioled leaves and divaricating inflorescence rachillae. However, the prominent trunk swelling places the Antenna population significantly outside the range of trunk characters presented by Zona (2002), who reports cylindrical stems up to 25 cm dbh. Furthermore, the trunks of the Antenna population differ greatly from Read's (1968) report that *P. sargentii* trunks are "always enlarged at the base, then narrowed above."

One difference noted from the census data appears to be differential survivorship of the two populations. Available notes from the Carabinero-Uvero population (1986 through present) suggest an ongoing decline of mature adults, limited flowering and very limited recruitment of seedlings, whereas the information from the Antenna site suggests a very healthy population (albeit with few individuals), with good evidence of recruitment in the long and short term. If these trends continue, we may expect expansion of the Antenna population and further decline of the Carabinero-Uvero palms, perhaps to extirpation.

A thorough study of the palms on Dominica was also reported in this journal (James 2003), and that report showed some interesting parallels with the Mona populations. Firstly, a number of the *P. sargentii* palms on Dominica were also reported to have swollen trunks (James 2003), the largest one reaching 31 cm in diameter. Furthermore, the subpopulation with most reproductive output was also the population with most ventricose trunks, as also found in Mona.

With a native population of *P. sargentii* on adjacent Isla Saona, one possibility is that differences in the two populations seen on Mona are the result of two separate, but relatively recent introductions from Saona. Past introductions with few founders, population expansions, declines and perhaps extirpations may have occurred on Mona, and the differences seen between the groups on Mona may also be influenced by the circumstances in founding each population.

Although the demographic records are limited, taken together they suggest that some ecological change in the coastal lowlands has created less favorable conditions for the Carabinero-Uvero population, which appears to have fallen by nearly half over the last four decades. The nature of that change is outside the scope of this paper, but we offer recommendations to improve conditions for the Carabinero-Uvero palms below. In contrast, the apparent long term success of the Antenna population indicates that conditions have been very favorable to its health over the same period.

Moving Forward: Conservation and Research Recommendations

This project has produced a number of outcomes thus far. First, here we summarize what is now known about the census, health and distribution of *Pseudophoenix* on Mona Island, including the discovery of a new population of morphologically distinct palms. Also, documentation has been formalized through museum collections which include census information. Additionally, leaflet samples of each adult and subadult observed have been collected and prepared for population genetic analysis. And, a significant number of seeds has been accessioned for living collections at the Jardín Botánico at UPR, MBC and FTBG (Fig. 8). These outcomes correspond to the initial goals of the project.

Pseudophoenix sargentii on Mona occurs in two very limited populations – the Antenna population is morphologically distinct and limited to four reproductive adults, while the Carabinero-Uvero population appears to be in long-term decline. Thus, continued investigation and management of these palms is essential. Here, we present our recommendations for continued work to advance the understanding and conservation of the palms on Mona.

Continue current management.

Mona Island enjoys a very high level of protection, monitoring and management as a Reserve under the purview of the DRNA. Also, unlike many protected sites, Mona is also isolated as an island with no permanent residents and very limited human impact. This situation is ideal for the native *Pseudophoenix* populations, given the history of anthropogenic removal elsewhere (Zona 2002). Careful management of feral animal populations (especially pigs) underway by the DRNA is essential to the health of the *Pseudophoenix*, as well as other native plants on Mona (Cintrón 1991). We highlight the success of these current management conditions in keeping these palms in good health when many other *Pseudophoenix* populations are imperiled by human use and non-native herbivores.

Maintain exclosure at the Carabinero-Uvero site.

This action, initiated by Mr. Rosario and continued by Mr. Hernández in the 1980s, has helped limit predation by nonnative herbivores, and also to help produce abundant seed in past years. The current exclosure fence requires repair. Also, expansion of the exclosure may be undertaken to include all of the adult palms at Carabinero-Uvero. Measures to exclude granivores (introduced rats) have been previously successful in increasing seed production (Hernández 1994), and continuing this as possible will be helpful.

Selectively thin canopy at Carabinero-Uvero site.

The exclosure fence, as well as an additional exclosure surrounding the area of the Carabinero-Uvero site, has succeeded in limiting herbivory, and thus some of the Carabinero-Uvero palms are currently in dense canopy shade. Selectively removing canopy branches that shade the base of adult palms may encourage seedling recruitment.

Further develop and distribute living collections.

Maintaining living conservation collections of palms is essential to an integrated conservation strategy. Seed produced from both sites appears to be sufficient for distribution to other living collections beyond those mentioned here. Several botanic gardens in the Caribbean (for example, Jardin Botánico Rafael Moscoso, Dominican Republic), as well as other conservation entities, have ideal conditions to support these unique palms. As seeds germinate and living collections are established at MBC, FTBG and UPR, surplus palms can be distributed to other plant collections. Maintaining these palms at multiple gardens can ensure long-term preservation of this important material.

Perform targeted aerial survey for additional populations.

Despite its conspicuous, unique charisma, *Pseudophoenix* went undetected on Mona for over 50 years – on an island area of less than 60 km^2. This highlights the difficult logistics of fieldwork on the island – limited trails, difficult scrub vegetation, high temperatures, lack of surface water and limited shade complicate access to the interior of the Mona Plateau. Given that both populations currently known were discovered well away from access trails, we recommend targeted aerial survey for further individuals and populations. The vegetation association in which the Antenna population occurs is dominant on the western half of the Mona Plateau (Martinuzzi et al. 2008), and perhaps deliberate flights over this area would spot further populations. Surveys scheduled in January and February, when fruits are turning red, may be most productive.

Continue and expand inter situ outplantings on Mona.

As recommended previously (Hernandez 1994), propagating and establishing plantings of *Pseudophoenix* from both sites would be helpful for conservation management. We further recommend carefully managing the provenance data from these outplantings, given that two populations are now known, and also known to have different characteristics. Establishing plants derived from Antenna and Carabinero-Uvero in separate locations on Mona will help preserve the distinctiveness of these groups. Given that the DRNA has recently constructed a small greenhouse to develop research and conservation on the plants of Mona Island, this is an ideal opportunity to continue an active *inter situ* conservation program.

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8. Fruits and seeds of *P. sargentii* from the Antenna population. The fruits can contain one, two, or three seeds, and mature from green through orange to red. (photo: E. Santiago-Valentín)

for managing the seed accessions; Larry Noblick for providing guidance on palm characters; Ericka Witcher for assistance with maps; and the DRNA Cuerpo de Vigilantes for hospitality and support in the field. This project was partially funded by a CREST Grant (NSF- HRD 0734826) to Univ. of Puerto Rico. This is contribution number 224 from the Tropical Biology Program of Florida International University and number 5 of the Herbarium of the University of Puerto Rico Botanical Garden. We especially thank and dedicate this paper to the biologists, managers, and DRNA staff involved in the protection of Mona Island, especially to Gerardo Hernández, Miguel A. Nieves, Gaspar Pons, José Rivera, and José Rosario for their work to manage and conserve these palms. The palms they planted on Mona in the 1990s are healthy, but demonstrate the slow growth of this species – which prompts the old saying: *The best time to plant a tree was twenty years ago. The second best time is today.*

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