Palms

Journal of the International Palm Society Vol. 63(2) Jun. 2019

THE INTERNATIONAL PALM SOCIETY, INC.

The International Palm Society

Founder: Dent Smith

The International Palm Society is a nonprofit corporation engaged in the study of palms. The society is international in scope with worldwide membership, and the formation of regional or local chapters affiliated with the international society is encouraged. Please address all inquiries regarding membership or information about the society to The International Palm Society Inc., The International Palm Society Inc., 56 Autumn Oaks Drive, The Hills, Texas 78738 USA, or by e-mail to info@palms.org, fax 512-607-6468.

OFFICERS:

President: Ray Hernandez, 4315 W. San Juan Street, Tampa, Florida 33629 USA, e-mail rayhernandez77@gmail.com, tel. 1-813-832-3561.

Vice-Presidents: Jeff Brusseau, 1030 Heather Dr., Vista, California 92084 USA, e-mail Jbrusseau@newportnational.biz, tel. 1-760-271-8003. Julie Cleaver Malzoni, Av. Paulista 66. Apto. 71, Bela Vista, São Paulo, SP, 01310-100, Brazil, e-mail cleaver.julie@gmail.com, tel. 55-11-99-601-1677.

Corresponding Secretary: Toby Spanner, Tizianstrasse 44, D-80638 München, Germany, e-mail toby@palmsociety.org, tel. 49-172-630-7778.

Administrative Secretary: Larry Noblick, Montgomery Botanical Center, 11901 Old Cutler Road, Miami, Florida 33156 USA, e-mail lnob@montgomerybotanical.org, tel. 1-305-667-3800 ex 104.

Treasurer: Tom Jackson, P.O. Box 1102, Ross, California 94957 USA, e-mail jacksongrantgallery@outlook.com, tel. 1-415-923-3299.

Directors: 2016–2020: Robert Blenker, Florida; Jeff Brusseau, California; Gregg Hamann*, California; Haresh*, India; Susan Hubbell, Florida; Tom Jackson*, California; Leland Lai*, California; Michael Merritt, Hawaii; Romeo Montalvo, Texas; Larry Noblick, Florida; Lazaro Priegues, Florida; Michael Smukall, Florida; Grant Stephenson, Texas; Michael Valentine, Colorado; Scott Zona, Florida. **2018–2022**: Cindy Adair, Puerto Rico; Norm Bezona, Hawaii; Faith Bishock, Florida; Julie Cleaver Malzoni, Brazil; John Dransfield, United Kingdom; Len Geiger, California; Ray Hernandez, Florida; Horace Hobbs, Texas; Andrew Hurwitz, California; Chad Husby, Florida; Francisco (Paco) Martí Navarro, Spain; Don Martin, California; Jill Menzel*, Brazil; Fernando Roca, Peru; Tobias W. Spanner, Germany; Andrew Street, Florida; David Tanswell, Australia.

* IPS Benefactor

Bookstore: www.palms.org

Chapters: See www.palms.org

Website: www.palms.org

Palms (formerly PRINCIPES)

Journal of The International Palm Society

An illustrated, peer-reviewed quarterly devoted to information about palms and published in March, June, September and December by The International Palm Society Inc., 56 Autumn Oaks Drive, The Hills, Texas 78738 USA.

Editors: John Dransfield, Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE United Kingdom, e-mail j.dransfield@kew.org.
Scott Zona, 1807 Seminole Dr., Hillsborough, North Carolina 27278 USA, e-mail scott.zona@yahoo.com.

Associate Editor: William J. Baker, Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE United Kingdom, e-mail w.baker@kew.org.

Guidelines for authors are available on request from the Editors, or on-line at: www.palms.org/palms_author_guidelines.cfm

Annual membership dues are US$55.00 for Individuals (or US$150 for three years) and include a subscription to the Journal. Donor memberships are US$500 per year. Individual Lifetime memberships are available for a one-time fee of US$1000. Benefactor memberships require a one-time payment of US$2500. Subscription price is US$55.00 per year for libraries and institutions. Dues include mailing of the Journal by airlift service to addresses outside the USA. Dues may be paid on-line at www.palms.org.

Change of Address: Send change of address, phone number or e-mail to The International Palm Society Inc., The International Palm Society Inc., 56 Autumn Oaks Drive, The Hills, Texas 78738 USA., or by e-mail to info@palms.org.

Claims for Missing Issues: Claims for issues not received in the USA should be made within three months of the mailing date; claims for issues outside the USA should be made within six months of the mailing date.

Periodical postage paid at Austin, TX, USA and additional mailing offices. Postmaster: Send address changes to The International Palm Society Inc., The International Palm Society Inc., 56 Autumn Oaks Drive, The Hills, Texas 78738 USA.

PALMS (ISSN 1523-4495)

Mailed at Lawrence, Kansas 14 Jun. 2019

The full text of PALMS is available on EBSCO Publishing's database.

This publication is printed on acid-free paper.

CONTENTS

57 **Sabalpalm (*Sabal antillensis*) Recovery Over 40 Years: Lessons for Successful Palm Conservation**
J. de Freitas, J. Camilleri, S. van Eijk, V. Posno, I. Valdes, Q. Coolen, J.van Blerk & M.P. Griffith

69 **The Ivory Palm *Phytelephas aequatorialis* in Western Ecuador**
S. Escobar, T.L.P. Couvreur, R. Montúfar & H. Balslev

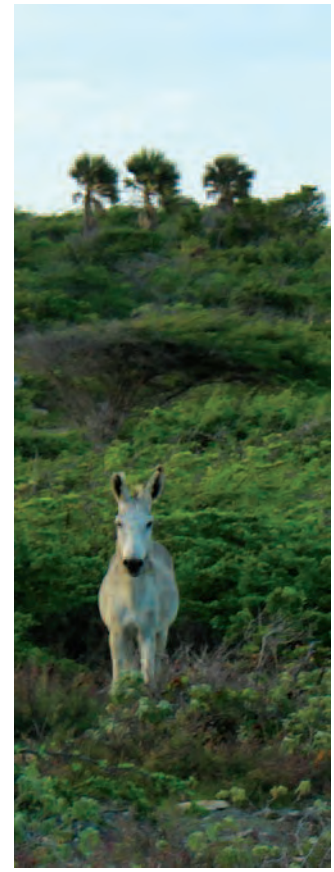
81 **Palms and Art in the Jardín Botánico Culiacán**
E. Pagaza Calderón, F. Colin, C. Cortés, C. Equihua Z., V. Codina & S. Zona

89 **Evidence of Suckering in *Hemithrinax ekmaniana***
A. Street

93 **Launching the Palmetum as Botanical Garden: A Report from Tenerife, 2010–2018**
C. Morici

Features

Palm News	56
Photo Feature	80
Patrons of the IPS	103



Feral donkey (*Equinus asinus*) causing trouble in Sabalpalm (*Sabal antillensis*) habitat, Bonaire. See article by de Freitas et al., p. 57. Photo by M.P. Griffith

FRONT COVER

Sabal antillensis (Sabalpalm) on Seru Bientu, Curaçao. See article by de Freitas et al., p. 57. Photo by M.P. Griffith.

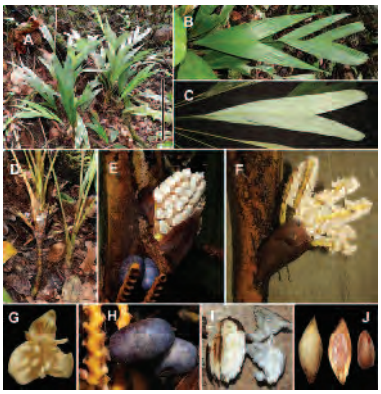
BACK COVER

Bismarckia nobilis and bell sculpture from the series *Return the World* (2014) by Adrián Villar Rojas, one of the sculptures at Jardín Botánico Culiacán. See article by Pagaza Calderón et al., p. 81. Photo by C. Equihua Z.

PALM NEWS

Shrikes (*Larius* spp.) are infamous for their habit of impaling their prey on spines, thorns or even barbed-wire fences. They do so to preserve food for later consumption, and depending on the shrike species and habitat, their "larder" may include lizards, small mammals, insects and even dates (*Phoenix dactylifera*), although shrikes rarely seem to eat the impaled fruits. A report by M. Fajardo and colleagues (Redia 101: 193–196. 2018. http://dx.doi.org/10.19263/REDIA-101.18.26) is the first to document **red palm weevils (*Rhynchophorus ferrugineus*) impaled by shrikes** in Spain and Saudi Arabia (their photo reproduced at right). We felt a kind of Schadenfreude in seeing the *Phoenix*-killing weevils impaled on *Phoenix* spines. This observation adds shrikes to a short list of birds that prey upon the invasive red palm weevils.

We are saddened to learn that **poet and palm-lover W.S. Merwin passed away** on March 15, 2019, at his home on Maui, Hawaii, surrounded by the hundreds of palms he planted in his garden (see article in PALMS 59: 194–202). Merwin's enthusiasm for palms resulted, over the years, in a lush garden, which is now maintained by the Merwin Trust.



A new species of *Pinanga*, *P. schwanerensis*, was described and illustrated (reproduced at left; photos by A. Randi) in an article in Phytotaxa by Agusti Randi, Agus Hikmat and Charlie D. Heatubun (https://doi.org/10.11646/phytotaxa.402.2.6). This beautiful, short-stemmed species is restricted to the Schwaner Mountains of central Indonesian Borneo (Kalimantan). It is the first new *Pinanga* to be described from Kalimantan in over a century. This is the first of several new discoveries made by Randi during the course of his MSc research that will be published in forthcoming papers. Jiro Adorador, who contributed a fascinating article on the palms of Samar Island, Philippines (PALMS 61: 161–195. 2017), published **a new species of *Heterospathe*, *H. fernandoi*, from ultramafic soils on Samar and adjacent islands**. The article appeared in Phytotaxa 401 (2): 117–126 (https://doi.org/10.11646/phytotaxa.401.2.3).

Ancient coins tell new stories. An analysis of the images of *Phoenix* palms stamped on ancient coins revealed ten palm-image types (based on form, style and realism) associated with three areas and episodes of favorable climate. The coins offer valuable insights into the characteristics of ancient date palms and their cultivation practices. The study, by Diego Rivera et al., is "Date-palm (*Phoenix*, Arecaceae) iconography in coins from the Mediterranean and West Asia (485 BC–1189 AD)" Journal of Cultural Heritage 37: 199–214. 2019 (https://doi.org/10.1016/j.culher.2018.10.010).

D. Rivera

Sabalpalm (*Sabal antillensis*) Recovery Over 40 Years: Lessons for Successful Palm Conservation

John de Freitas[1]
Jonah Camilleri[1,2]
Steven van Eijk[1,2]
Vera Posno[1,2]
Imeña Valdes[3,4]
Quirijn Coolen[5]
Johan van Blerk[6]
and
M. Patrick Griffith[3]

[1]*CARMABI, Willemstad, Curaçao, Dutch Caribbean.*
[2]*Aeres Hogeschool, Almere, Netherlands.*
[3]*Montgomery Botanical Center, Coral Gables, Florida 33156 USA.*
patrick@montgomerybotanical.org
[4]*Department of Biological Sciences, Florida International University, Miami, Florida, 33199 USA.*
[5]*BonBèrdè, Rincon, Bonaire.*
[6]*Echo Conservation Centre, Dos Pos, Bonaire.*

Sabal antillensis **is endemic to the Dutch Caribbean islands of Curaçao and Bonaire. Both island populations were thoroughly assessed in 1979, and subsequent management of both sites differed over the last forty years. Resurvey of these palms in 2018 clearly shows the value of exotic herbivore management for palm conservation: exclusion and management of introduced herbivores coincides with a vast increase in palms on Curaçao. We recommend a similar program for the much smaller and much more vulnerable population on Bonaire, as well as continued propagation of seeds for outplanting.**

The floras of Curaçao and Bonaire include only one native palm species, locally called Sabalpalm or Kabana. There had been much debate about the identity of this palm. Winkelman (1979) thought that the species on Curaçao and Bonaire was endemic only to these islands, yet De Freitas (1996) proposed the possibility that it was *Sabal palmetto*, common in Florida and the Caribbean, while Van Proosdij (2012) mentioned it as *Sabal* cf. *causiarum*. The distinct taxonomic status of Sabalpalm was only recently determined, and it is now described as *Sabal antillensis* (Griffith et al. 2017). Remarkable also for the species is its very localized occurrence on both islands (Winkelman 1979, Griffith et al. 2017). On Curaçao, it is only found on the higher Knip hills (Knip geological formation), mostly within and partly outside the southern part of the Christoffelpark. On Bonaire it is restricted to the Lima area, on a limestone terrace near sea level, west of Lac Bay and north of the solar salt works. It is not clear what causes the limited distribution on both islands. In both locations Sabalpalm is a prominent, iconic and emergent feature of the native flora (Figs. 1 & 2).

Christoffelpark, a nature conservation area in the western part of Curaçao, is the most biodiverse region on the island (de Freitas 2010). This park has been managed by Carmabi Foundation (www.carmabi.org) since 1978, the year in which the park was opened. Development and planning for Christoffelpark included a survey for rare trees (Voskens 1972) and detailed census and mapping of Sabalpalm (Winkelman 1979). Both studies were designed to obtain insight into the relative rareness and distribution of important tree species present in Christoffelpark. Winkelman's single-species emphasis also led her to travel to Bonaire and apply the same census methodology. Her work established a critical early record of the abundance and distribution of these rare palms, and also documented their ethnobotanical uses. According to Winkelman (1979), the total population on both islands in 1979 consisted of 1062 individuals, of which 354 were mature palms – with only 31 of these larger palms on Bonaire. Winkelman (1979) found no dead specimens on Curaçao, and three palms which were burnt and felled on Bonaire.

Winkelman (1979) suspected that goats were the main threat to the palm seedlings on both islands. In Christoffelpark goat and donkey populations have been actively managed since

Opposite page:

2. Sabalpalm (*Sabal antillensis*) on limestone terrace in southern Bonaire. Photo by Q. Coolen.

1. Sabalpalm (*Sabal antillensis*) on Seru Bientu, Curaçao. Photo by Carel de Haseth, used by permission.

the mid-1980s via exclusion and removal. The goat population around Christoffelpark is estimated to be 1 individual per 10 hectares, greatly reduced from a much higher past density (van Buurt & Debrot 2012, Verbeek 2016). Bonaire's donkeys (*Equinus asinus*) are abundant within and near the Sabalpalm population and have demonstrated a reductive effect on local vegetation (Roberts et al. 2018). Management of these introduced herbivores has prompted public controversy (DeSalvo & DeSalvo 2013, DeSalvo 2014).

Both before and since 1979 not much was known about the population status of the endemic palm, and whether populations were increasing, declining or stable – essential information for conservation assessment (IUCN Standards and Petitions Committee 2014). Nevertheless, it can be concluded that there are threats to the palm and there have been occasional sightings of dead palms (Winkelman 1979). Nature management authorities on both islands have a vested interest in preserving this iconic endemic due to its vulnerability, limited distribution on both islands, as well as the presence of the invasive red palm weevil (*Rhynchophorus ferrugineus*) on Curaçao (J. de Freitas, pers. comm.).

These gaps in knowledge motivate the current study, designed to determine the population status of the endemic palm species and compare this with the records from 1979. We seek to register all *Sabal antillensis* palms of Bonaire and Curaçao and compare this information with the prior record. Thus, the main question of the present research is: how has the population of the native *Sabal antillensis* palm changed over 40 years? This main question prompts the following sub-questions: Do the palms occur in the same locations Winkelman found them, or have these ranges changed? What does this information suggest for palm conservation? How can we further improve the conservation status of Sabalpalm?

Methods

Census: A survey was conducted on Curaçao from May 2 through June 25, 2018, and a survey was conducted on Bonaire between November 20 and December 4, 2018. Travel by car was used to get as close as possible to each survey site. Often a lookout point was used to spot the palms and plan how to carry out the survey in that specific area. Mature palms are often emergent plants in the vegetation and because of their unique habit are easily spotted in the landscape (Figs. 1 & 2). The basis for the present survey was the locations where Winkelman (1979) found specimens of the Sabalpalm, as well as other locations reported to us by a group of amateur and professional archaeologists and naturalists.

Demographic categories: In order to categorize the demographics of the population, Winkelman used a classification that combined size and phenology, assessing reproductive phases of the palms by the visual presentation of the plants (see Table 1). The same classes used in Winkelman (1979) were employed in the present study (Figs. 3–5) with modification; two overlapping classes of young plants were combined into one class (Table 1), and the phenological subclasses were not parsed. In the field, trunk lengths were estimated by comparing the tree height with our known body heights.

Data collection and record: Every palm was registered as a waypoint in a GPS receiver and noted on a field form. In order to speed up the data collection due to the limited time available, the decision was made that in case there were more than one specimen in an area of 10 square meters, the group was registered as one waypoint, and noted in the record. These palm locations were archived in GIS maps, along with measurement data from field survey. The complete field data (locations, measurements, classes) were filed and archived at Carmabi and Openbaar Lichaam Bonaire, and is also available from the authors by request.

Geographic range: GPS data was used to map the locations of the palms for comparison with the 1979 maps provided by Winkelman (1979). These data were used to create minimum convex polygons (Sergio et al. 2007) to estimate and compare the extent of occurrence on each island.

Evaluating change over time: Based on the discrete boundaries of the islands and habitats, the person-hours invested in the 1978 and 2018 field surveys, the emergent habit of Sabalpalm within its vegetation types, and the knowledge of land managers and citizens solicited, we are confident that these data represent two complete censuses of the palm species (i.e. not two samples of larger populations), especially with regard to the Adult class, separated by 40 years. Thus, comparison between these complete censuses does not require evaluation of sampling error

Table 1: Demographic classification. For the current study, we emphasize and report size/maturity (numbered classes), and do not report phenological observations (lettered subclasses per Winkelman 1979). We also combined Winkelman's (1979) classes "Jong Exemplaar" and "Zeer Jong Exemplaar" into class 3, Juveniles.

Class	Type	Description
1 Adult		
1a	Adult palm with new inflorescences and/or fruits	All Adult palms: Trunk Length ≥ 70cm with clearly visible tree trunk.
1b	Adult palm with Seedlings in the direct area	Trunk completely or partly uncovered by leaves (1 or more sides)
1c	Adult palm based on length and/or presence of old inflorescence	Seedling within a 15-m radius
2 Semi-adult	Clear trunk not visible	Trunk length 40–70cm, or total leaf length > 1m. Trunk completely covered by leaves. No fruits or flowers.
3 Juvenile		≥ 15–40cm. No clear tree trunk Some leaves present
4 Seedling		1–4 very small grass-like leaves ≤ 15cm. Most often appears as 2 grass-like leaves sticking out of the ground.

(e.g. p-values). We therefore directly compare the two complete censuses to evaluate if populations and population categories are decreasing, stable, or increasing. We also use these comparisons to infer the success of Seedling recruitment into subsequent classes. Geographic data was also compared between 1979 and 2018 to ascertain trends in the range of the species.

Results

Changes in Census: Tables 2 and 3 present the census results by class, summarizing the 1979 and 2018 data. Considering the Adult class (reproductive palms), the population in Curaçao increased to 318% of its original size over forty years, while the population on Bonaire decreased by 19%. Considering all classes together shows great increases on both islands, but this is largely due to large increase in Seedlings in both locations. Excluding Seedlings, total population on Curaçao increased nearly fourfold (383%), and decreased by 8% on Bonaire.

Changes in range: Fig. 6 compares the range of *Sabal antillensis* between 1979 and 2018. These maps show a reduction in the geographic range of this species on Bonaire, as well as an increase of the occupied habitat on Curaçao.

How has the census of *Sabal antillensis* changed over 40 years? Obvious recovery and recruitment of palms is seen on Curaçao but not on Bonaire. Considering only reproductive (Adult class) palms, Bonaire shows an alarming loss, especially considering the already small numbers of palms present. Curaçao palms have seen expansion and recovery, greatly improving their conservation status since 1979.

3 (top). Seedlings of Sabalpalm, Christoffelpark, Curaçao. 4 (bottom). Example of the Juvenile age class for Sabalpalm, Bonaire. Photos by M.P. Griffith.

The increase in Seedlings at both locations is notable but may be an artefact of phenology. On Curaçao it is likely that the increase in Seedlings between 1979 and 2018 correlates with increase in the number of reproductive Adults. On Bonaire, it is possible that more Seedlings were seen in December 2018 than in May 1979 because of the timing of the rainy season, with November being the wettest month. While there is some understanding of the timing of reproduction for Sabalpalm, the peak seed germination season is not well

5. Example of the Semi-adult age class Sabalpalm, Bonaire. Photo by Q. Coolen.

known. Seedlings are the most vulnerable life stage of most plants, and the number within a population can be quite variable year to year, compared to the number of reproductive perennial adults. Because of these highly variable aspects of seedling recruitment and mortality, we prefer to exclude the Seedling class in inferences about changes in population health between 1979 and 2018. As reported above, Tables 2 and 3 show clear differences in the Adult class on both Curaçao and Bonaire.

Nevertheless, seedlings are critical for long-term population health, as are each of the demographic classes in Table 1. The structure of age classes on Bonaire is consistent with herbivore pressure supressing Seedling recruitment into more mature age classes. Even perhaps with sufficient seeds germinating each year, not enough of these survived long enough to sustain the number of Adult palms over the forty-year period.

During the survey four dead Sabalpalms were found, one each on Seru Bientu, Seru Gracia, Seru Batata (all in Curaçao), and one at the southeast end of the range in Bonaire. The cause of death was not clear. There were no signs or symptoms of infestation by the red palm weevil, which is known as a pest of cultivated palms around Willemstad. While dead palms are a normal part of demographic turnover, the loss of any single mature palm on Bonaire significantly reduces the very small reproductive population, and as discussed below, can reduce the limited geographic range of these palms.

How has the range of this palm changed? On Bonaire, the decreasing number of palms coincides with a reduction in the extent of occurrence on the island (Figure 6). Over the 40-year timeframe, the range of these palms has been reduced from nearly 5 km^2 to less than 1 km^2. Even considering the limits of pre-GPS resolution of the 1979 maps, the 2018 survey demonstrates a reduction in occupied range, perhaps correlated with a reduction in suitable habitat (de Freitas et al. 2005). Most of the remaining Adult palms on Bonaire occur at the northwest end of the 2018 range shown in Figure 6. It is not known to what degree this has been caused by increased grazing pressure or increased human disturbance.

The opposite trend is noted on Curaçao; increased census values coincide with an increase in geographic range, from less than 5 km^2 in 1979 to over 8 km^2 in 2018. In both surveys, the vast majority of palms were

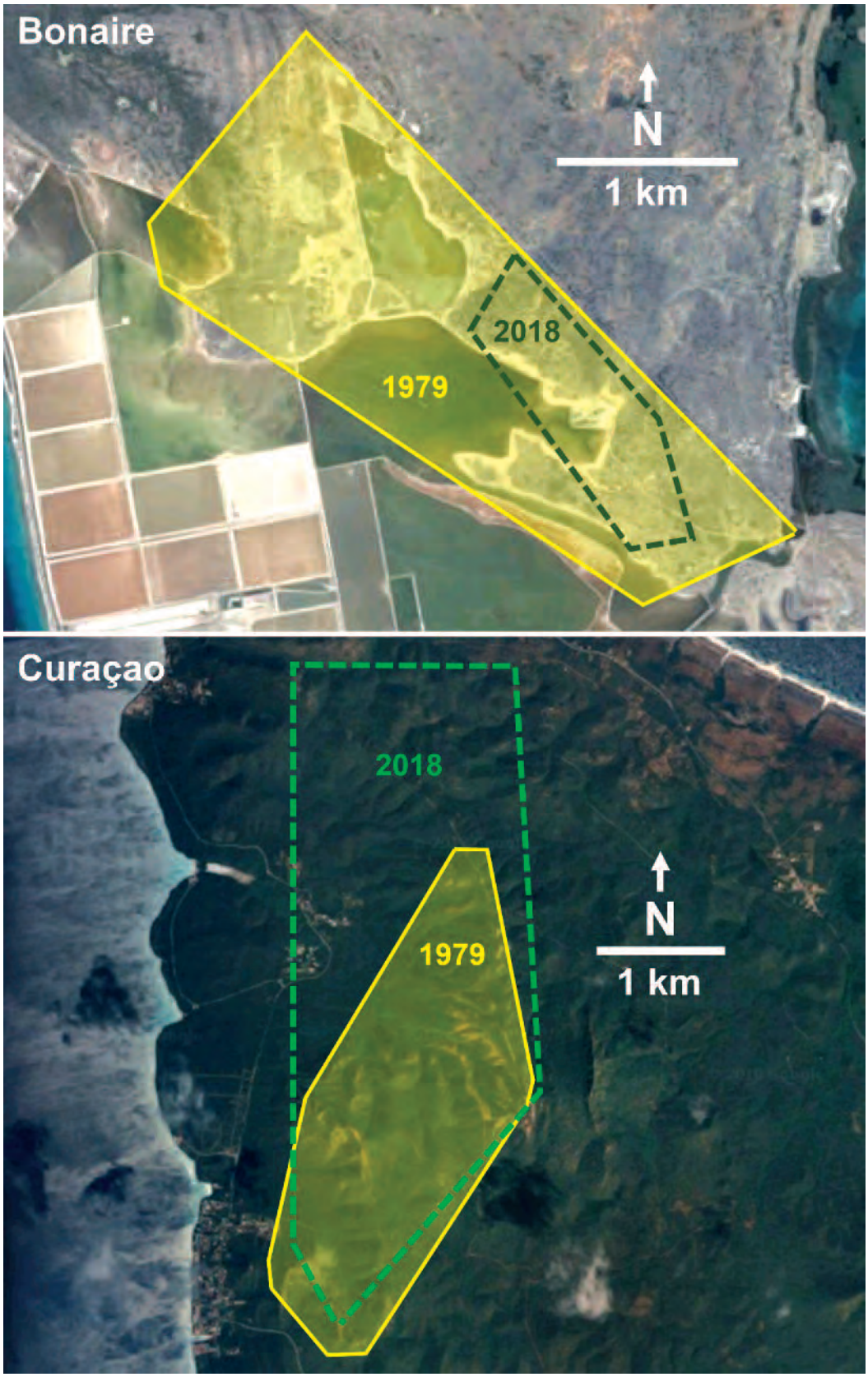

Bonaire
N
1 km
2018
1979
Curaçao
2018
1979
N
1 km

Table 2. *Sabal antillensis* census results from Curaçao.

Class	1979 Census	2018 Census
Adult	323	1030
Semi-adult	283	662
Juvenile	254	1604
Seedling	153	3144

Table 3. *Sabal antillensis* census results from Bonaire.

Class	1979 Census	2018 Census
Adult	31	25
Semi-adult	0	7
Juvenile	8	4
Seedling	10	53

centered around Seru Gracia, in the area around the antenna array west of Christoffelberg. Three hills without Sabalpalm in 1979 were colonized by 2018: Seru Male, Seru Un Blachi, and Seru Wau, with Seru Male located outside of Christoffelpark.

This range expansion prompts the question of how the palms could have dispersed to those hills. Two bird species (northern mockingbird [*Mimus polyglottos*] and white-crowned pigeon [*Columba leucocephala*]) mentioned as dispersers of *Sabal* by Zona & Henderson (1989), have related species on the island: tropical mockingbird (*Mimus gilvus*), bare-eyed pigeon (*Patagioenas corensis*) and scaly-naped pigeon (*P. squamosa*). White-tailed deer are known to eat fruit and flowers of palm species in the Florida Keys (Klimstra & Dooley 1990, Barrett 2004), and perhaps this species also does so in Christoffelpark. Other possible seed dispersal agents are rodents and the quite common green iguana (*Iguana iguana*). Rodents on Curaçao include house mouse (*Mus musculus*), *Baiomys hummelincki,* black rat (*Rattus rattus*) and Norway rat (*R. norvegicus*) (Husson 1960). Of these rodents the black rat is a more probable disperser due to its arboreal lifestyle. Rodents are known to remove ripe fruits and hide them far from the fruit-bearing plant as a future food source. These hidden fruits are not always retrieved and thus get the chance to germinate (Brewer 2001). However, rats have also been shown to be palm seed predators rather than dispersers in some island systems, including Lowe Howe Island (Auld et al. 2010).

Opposite page:

6. Comparison of ranges of Sabalpalm observed in 1979 (Winkelman 1979) and 2018 (current study). All ranges shown as minimum convex polygons that include all data points.

What does this study suggest for palm conservation? This study provides a clear demonstration of the positive effects of herbivore management: active exclusion of herbivores in Christoffelpark coincides with very successful recruitment, maturation, and range expansion of *Sabal antillensis*. By contrast, uncontrolled access by feral herbivores coincides with scarcer demographic depth to replace the few remaining palms on Bonaire. This scarcity manifests as a near 20% decline in Adult palms over forty years and a contracted range.

We conclude that the recovery of native Curaçao Sabalpalm was enabled by the removal of goats which began around the Christoffelpark area in the mid-1980s (J. de Freitas, pers. comm.; Meyboom 1994). Coblentz (1980) described the negative effects that the estimated 3000 goats had on the vegetation of the Christoffelpark before the removal program, including lack of herbaceous vegetation and erosion problems. Feral donkeys are also known to cause serious damage to vegetation by grazing and trampling (e.g. Department of the Interior 1979). Debrot and de Freitas (1993) showed that livestock access (exotic mammals) resulted in reduced vegetation and soil cover and dominance of annual species, while ungrazed rocks are characterized by the dominance of perennial species and higher vegetation cover in the Christoffelpark. Those negative effects are typical consequences of overgrazing (reviewed in Debrot & de Freitas 1993).

We also expect that the generally recovered vegetation cover in Christoffelpark has increased *Sabal* seed germination. Van der Hurk (2016) found lower *Sabal antillensis* seed germination for exposed seeds (seeds lying around in the open in the vicinity and under mature palms) in comparison to seeds from ripe fruits taken from the trees (30% vs. 73%). Orozco-Segovia et al. (2003) also found a limited germination period for seeds of the similar *Sabal causiarum*.

The effects of herbivory on plant communities can be variable (Russell et al. 2001), but

carrying capacity appears to be the common principle – especially in island habitats such as those examined here. Among palms, a similar challenge is noted in the Mascarene Islands, which have been under intense herbivore pressure (Maunder et al. 2002). Many positive examples of recovery are known, such as the re-emergence of island flora after feral sheep removal (Beltran et al. 2014) and goat removal (Hamman 1979). Specifically, for Bonaire, Coolen (2015) documented pronounced vegetation recovery after herbivore exclusion, especially with regard to tree seedlings and juvenile trees.

Despite well-established benefits to vegetation as well as to animal welfare (Hampton et al 2016), the largest challenge for feral herbivore management is securing broad social acceptance (Roberts et al. 2018). Of specific relevance for this controversy on Bonaire is the work of Freeland and Choquenot (1990): keeping a feral donkey population below capacity keeps those donkeys healthier!

How can we further improve the conservation status of Sabalpalm? To conserve the remaining Bonaire Sabalpalms, *herbivores must be managed*. Here we provide that recommendation, as well as other recommendations informed by our experience with similar challenges.

Recommendation 1: exclude feral herbivores from the Sabalpalm habitat. A fence of approximately 3.5 km around the northwest, northeast, and southeast of the Bonaire Sabalpalms would provide opportunity for natural recruitment of Seedlings into Juvenile and later age classes, augmenting and replacing the aging few Adults that remain. We respectfully propose that such a fence would not conflict with other land uses in that area and could also provide positive benefits to other native vegetation as well as local avifauna of concern (e.g. Flamingo). As the vegetation in the Lima area has high natural value for the island (de Freitas et al. 2005), perhaps this landscape enhancement can also improve the experience of visitors, which can be of essential value to a tourism-based economy.

Recommendation 2: monitor health and recruitment of Sabalpalm. Regular re-survey of the known Adults and any potential progeny can provide assurance that recruitment is being realized.

Recommendation 3: cultivate local Sabal antillensis *at other sites on Bonaire.* Conservation horticulture and restoration efforts by Echo Conservation Centre and others to plant *S. antillensis* at other suitable sites should be encouraged, continued and expanded. Having an offsite reserve of germplasm for restoration efforts is a vital part of an integrated plant conservation plan. Growing this native species more widely – both in Bonaire's cultivated landscapes as well as other managed natural areas – can help prevent irretrievable loss of genetic diversity and protect against extirpation (Assmussen-Lange et al. 2011).

Recommendation 4: continue and promote the very successful management program in Christoffelpark. Active exclusion and management of goats has allowed Sabalpalm to flourish in its natural habitat, providing a wonderful example of in situ conservation. This positive success should be raised up as an inspiration for the many similar conservation challenges faced by palms in the Caribbean and elsewhere.

Acknowledgments

We thank the agencies, officials, landowners and land managers who provided permission guidance, and access to sites and palms for this study, including Carmabi (Christoffelpark), Openbaar Lichaam Bonaire, CARGILL, and Frank van Slobbe (DROB). We thank the management and personnel of the Christoffelpark (managed by Carmabi Foundation) for their help during the fieldwork period. A special word of thanks goes to Carel de Haseth for providing the photo for Figure 1 and information on areas to search for new occurrences of the palm on Curaçao. Fieldwork costs were supported by the subsidy given to Carmabi by the Curaçao Government (Ministry of Public Health, Environment and Nature and Ministry of Education and Research), and Montgomery Botanical Center via Dr. Lin Lougheed, through the Plant Exploration Fund, as well as through the Peter R. and Stuart Y. Jennings Fund.

Literature Cited

Asmussen-Lange, C.B., M. Maunder and M.F. Fay. 2011. Conservation genetics of the critically endangered Round Island bottle palm, *Hyophorbe lagenicaulis* (Arecaceae): can cultivated stocks supplement a residual wild population? Botanical Journal of the Linnean Society 167: 301–310.

Auld, T.D., I. Hutton, M.K.J. Ooi and A.J. Denham. 2010. Disruption of recruitment in two endemic palms on Lord Howe Island by

invasive rats. Biological Invasions 12: 3351–3361.

Barrett, M.A. 2004. An analysis of key deer herbivory on forest communities in lower Florida Keys. PhD Dissertation Univ. of South Florida. 129 pp.

Beltran, R.S., N. Kreidler, D.H. Van Vuren, S.A. Morrison, E.S. Zavaleta, K. Newton, B.R. Tershy and D.A. Croll. 2014. Passive recovery of vegetation after herbivore eradication on Santa Cruz Island, California. Restoration Ecology 22: 790–797.

Brewer, S. W. 2001. Predation and dispersal of large and small seeds of a tropical palm: predation and dispersal of large and small seeds of a tropical palm. Oikos 92: 245–255.

Buurt van, G., and A.O. Debrot. 2012. Exotic and invasive terrestrial and freshwater animal species in the Dutch Caribbean. Wageningen: IMARES Wageningen UR.

Coblentz, B.E. 1980. Goat problems in the national parks of the Netherlands Antilles. 16 pp. The Netherlands Antilles National Parks Foundation.

Coolen, Q.T. 2015. The impact of feral goat herbivory on the vegetation of Bonaire: an experimental study in the Washington-Slagbaai National park. WUR, Stinapa, Imares & Carmabi report. 51 pp.

Debrot, A.O. and J.A. de Freitas. 1993. A comparison of ungrazed and livestock-grazed rock vegetations in Curaçao. Biotropica 15: 270–280.

Department of the Interior (U.S.A.). 1979. Proposed feral burro management and ecosystem restoration plan and draft environmental statement, Grand Canyon National Park, Arizona. Unpubl. report National Park Service. 51 pp.

DeSalvo, G. and L. DeSalvo. 2013. Flotsam & jetsam. The Bonaire Reporter 21(13): 2.

DeSalvo, G. 2014. Can Bonaire meet the donkey challenge? The Bonaire Reporter 21(8): 3.

Freeland, W. J. and D. Choquenot. 1990. Determinants of Herbivore Carrying Capacity: Plants, Nutrients, and *Equus asinus* in Northern Australia. Ecology 71: 589–597.

Freitas, J.A. de. 1996. De inheemse bomen van de Benedenwindse eilanden (Curaçao, Bonaire en Aruba). Stichting Carmabi (Curaçao). 95 pp.

Freitas, J.A. de. 2010. De natuurwaarden van de conserveringsgebieden van het E.O.P. Curaçao, hun status en bedreigende factoren. CARMABI Report for the Spatial Planning Department of Curaçao (DROV). 210 pp.

Freitas, J.A. de, B.S.J. Nijhof, A.C. Rojer and A.O. Debrot. 2005. Landscape ecological vegetation map of the island of Bonaire (Southern Caribbean). Royal Netherlands Academy of Arts and Sciences, Amsterdam, 64 pp. & 2 maps.

Griffith, M.P., J. de Freitas, M. Barros and L.R. Noblick. 2017. *Sabal antillensis* (Arecaceae): a new palmetto species from the Leeward Antilles. Phytotaxa 303: 56–64.

Hamann, O. 1979. Regeneration of vegetation on Santa Fé and Pinta islands, Galápagos, after the eradication of goats. Biological Conservation 15: 215-236.

Hampton, J.O., B. Jones, A.L. Perry, C.J. Miller and Q. Hart. 2016. Integrating animal welfare into wild herbivore management: lessons from the Australian Feral Camel Management Project. The Rangeland Journal 38: 163–171.

Husson, A.M. 1960. De zoogdieren van de Nederlandse Antillen/Mammals of the Netherlands Antilles. Uitg. Natuurwetenschappelijke Werkgroep Ned. Antillen Curaçao no. 12: 1–170.

Hurk, van den T. 2016. Germination trials with seeds from native trees of Curaçao. HAS Univ. of Applied Sciences & Carmabi. 49 pp.

IUCN Standards and Petitions Subcommittee. 2014. Guidelines for Using the IUCN Red List Categories and Criteria. Version 11. Prepared by the Standards and Petitions Subcommittee. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf.

Klimstra, W.D. and A.L. Dooley. 1990. Foods of the key deer. Florida Scientist 53: 264–273.

Maunder, M., W. Page, J. Mauremootoo, R. Payendee, Y. Mungroo, A. Maljkovic, C. Vericel and B. Lyte. 2002. The decline and conservation management of the threatened endemic palms of the Mascarene Islands. Oryx 36: 5–-65.

Meyboom, M. 1994. De invloed van geiten op de natuurlijke vegetatie van het Christoffelpark te Curaçao. Verslag Natuurbeheer nr. 3144. Landbouwuniveristeit Wageningen. 77 pp.

Orozco-Segovia, A., A.I. Batis, M. Rojas-Arechiga and A. Mendoza. 2003. Seed biology of palms: a review. Palms 47: 79–94.

Proosdij, A.S.J. van. 2012. Arnoldo's zakflora/ Wat in het wild groeit en bloeit op Aruba, Bonaire en Curaçao (4e editie). Walburg Pers (Zutphen). 318 pp.

Roberts, M., W. Cresswell and N. Hanley. 2018. Prioritising invasive species control actions: evaluating effectiveness, costs, willingness to pay and social acceptance. Ecological Economics 152: 1–8.

Russell, F.L., D.B. Zippin and N.L. Fowler. 2001. Effects of white-tailed deer (*Odocoileus virginianus*) on plants, plant populations and communities: a review. American Midland Naturalist 146: 1–26.

Sérgio, C., R. Figueira, D. Draper, R. Menezes and A.J. Sousa. 2007. Modelling bryophyte distribution based on ecological information for extent of occurrence assessment. Biological Conservation 135: 341–351.

Verbeek, B. 2016. "Goats or no goats" The influence of goats on soil erosion and vegetation in Arikok National Park, Aruba. Master's Thesis, Wageningen University. 45 pp.

Voskens, J. 1972. Het nationale park "De Christoffel", Inrichtingsplan. Afstudeerverslag 111 van de Landbouwhogeschool Wageningen. 92 pp.

Winkelman, J.E. 1979. Inventarisatie *Sabal* spec. (Cabana) (Fam. Palmae) op Curaçao en Bonaire (N.A.). Landbouwhogeschool Wageningen & Stinapa (Curaçao). Doctoraalverslag. 13 pp.

Zona, S. and A. Henderson. 1989. A review of animal-mediated seed dispersal of palms. Selbyana 11: 6–21.

The Ivory Palm *Phytelephas aequatorialis* in Western Ecuador

Sebastián Escobar
Department of Bioscience, Ecoinformatics and Biodiversity Group, Aarhus University, Aarhus, Denmark.
sescobar@bios.au.dk

Thomas L.P. Couvreur
Institut de Recherche pour le Dévelopemment IRD, DIADE, Université de Montpellier, Montpellier, France.
thomas.couvreur@ird.fr

Rommel Montúfar
Facultad de Ciencias Exactas y Naturales, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador PUCE, Quito, Ecuador.
rjmontufar@puce.edu.ec

AND

Henrik Balslev
Department of Bioscience, Ecoinformatics and Biodiversity Group, Aarhus University, Aarhus, Denmark.
henrik.balslev@bios.au.dk

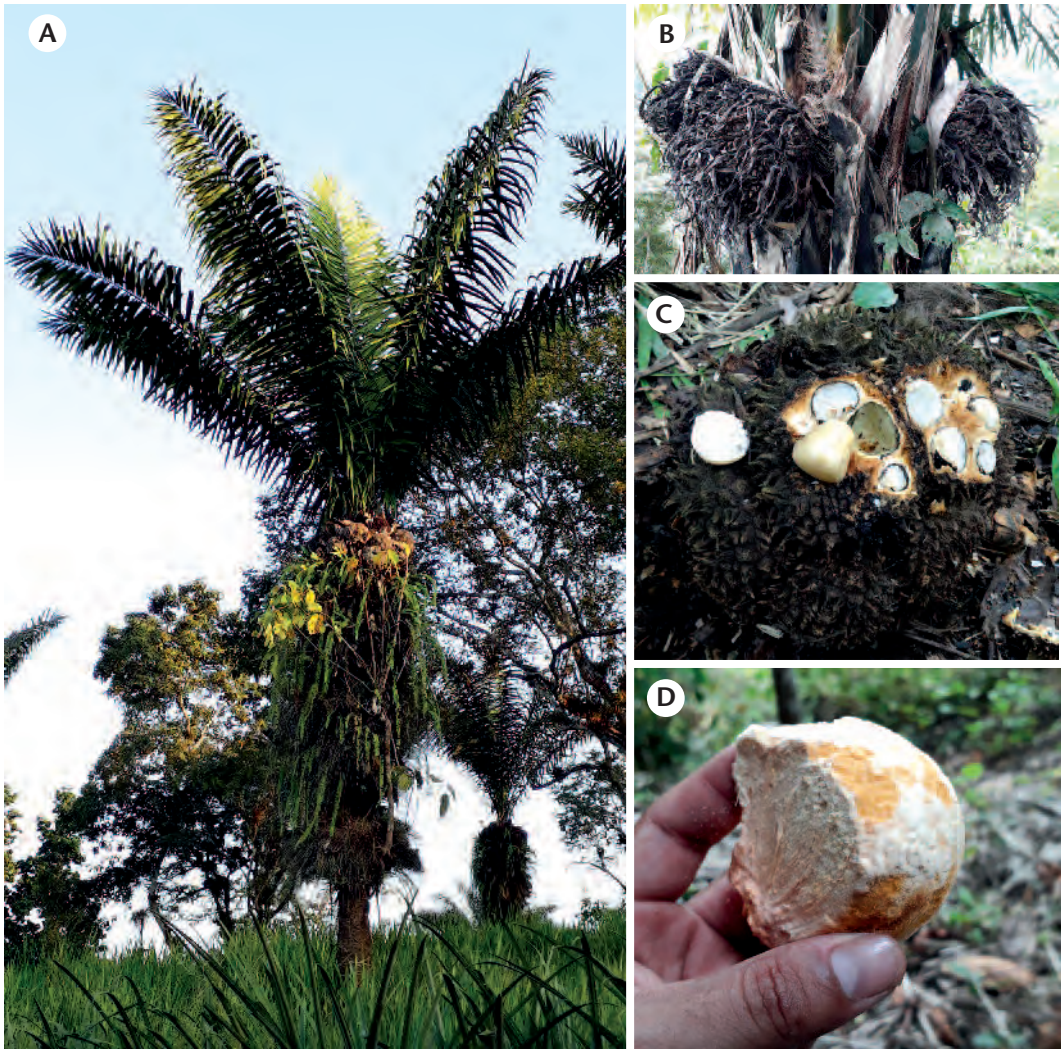
Phytelephas aequatorialis **is the commercially exploited ivory palm in western Ecuador, where less than 25% of the natural forest remains. To determine the conservation status of this palm, we visited 15 populations, growing under different degrees of human disturbance in both the lowlands and the lower Andean slopes. We collected leaf material for genetic analyses, which we hope will provide valuable information that can help the conservation and management of this important species. For a first view, populations growing outside forests in pastures appeared to be threatened because they did not reproduce naturally. The species *per se*, however, is not threatened because of its wide distribution and large populations. Conserving its populations could secure the species' genetic and phenotypic diversity, which, in turn, is the raw material for its domestication.**

The palm *Phytelephas aequatorialis* (Fig. 1), also known as *tagua* or ivory palm, is endemic to western Ecuador, which is a region highly affected by deforestation. *Tagua* grows from sea level up to 1500 m above sea level, in lowland rain forests and semi-deciduous forests along the Pacific coast, and it extends up the slopes in pre-montane and montane forests on the western Andean foothills (Borchsenius et al. 1998).

Its populations are fragmented because 77% of the coastal region of western Ecuador has been deforested (Sierra 2013), and forests in the highlands are also rapidly disappearing. *Tagua* grows well in agroforestry systems or pastures where it has been left standing (Borgtoft Pedersen & Skov 2001). Nevertheless, populations in pastures lack natural regeneration, which can be seen by the absence of sub-adult individuals (Velásquez-Runk 1998, Brokamp et al. 2014) and which endangers the populations future (Montúfar et al. 2013). The loss of populations due to deforestation may reduce the species' resilience capacity and economic potential.

Tagua is an important Non-Timber Forest Product (NTFP) commercialized in rural and urban areas of western Ecuador. Natural populations of this palm are mainly exploited for harvesting the hard, white endosperm of its seeds, also known as *tagua* or vegetable ivory. *Tagua* (the seed) is used as raw material in button and handicraft manufacturing, and its commerce has been a profitable industry in

1. *Phytelephas aequatorialis* near the town of Chone. A. Adult female individual growing in a pasture. B. Rounded infructescenses of *tagua*. C. Obconical fruits showing the hard endosperm of the seeds. D. Detail of an individual seed covered in fleshy mesocarp. Photos by S. Escobar.



2. Route followed during the field trip in western Ecuador.

western Ecuador since the 19th century until today (Barfod et al. 1990, Montúfar et al. 2013, Brokamp et al. 2014). The leaves of *tagua* palms, locally known as *cade*, are in turn harvested for thatching (Borchsenius & Moraes 2006). Despite the economic importance of *tagua*, there is no available information about its intraspecific diversity at the genetic level. This information is essential for improved conservation and management of this palm. With this in mind, we undertook a study in western Ecuador (Fig. 2) where we sampled populations of *tagua* as part of the more wide-ranging PhD research on *P. aequatorialis* by the first author.

Our field trip started on Tuesday July 10, 2018, early in the morning and lasted for eight days of hard work in the field. We left Quito, Ecuador's capital located in the middle of the Andes at 2800 m above sea level and descended the spectacular western flanks of the Andes towards the Pacific Ocean. We made a quick stop close to the town of Santo Domingo de los Colorados where we saw the first *tagua* individuals growing in pastures. These adult individuals were fairly old and tall, since farmers had left them standing for their fruits. In these pastures, we noted the absence of seedlings and juvenile individuals around the adult palms. We observed similar alterations in the population structure in other pastures visited during the trip. We continued driving all day arriving at dusk at the small touristic village of Puerto López, famous for its good whale sightseeing. After checking into our hotel, we noticed that the key-holders were made of, guess what? Yep, *tagua*.

This region of the lowlands towards the Pacific Ocean in Ecuador is spectacular. First, we are at the limit of the influence of the cold Humboldt Current, which creates dry conditions to the adjacent land. Second, there is a small mountain chain called Chongón-Colonche, which creates a smooth relief. This leads to an intricate mix of dry forests dominated by the kapok *Ceiba pentandra* (Malvaceae), with humid forests in which *tagua* palms are abundant. In these forests, populations of *tagua* are naturally fragmented which is one of the reasons for our visit.

Our next stop was the Agua Blanca community, famous for its *tagua* crafts and *cade* rooftops, located within a dry forest with shrubby vegetation. Upon arrival, we did not see any *tagua* individuals, which is normal given the climate. We quickly found a local guide who explained to us that the inhabitants in the area fetch *tagua* in the nearby humid Chongón-Colonche mountains. After a 3-hour, mainly uphill hike in the boiling hot sun, we arrived in a more humid area where the xeric vegetation had disappeared and instead, we found a humid rain forest. This forest represented a small rain forest pocket surrounded by drier vegetation, created thousands of years ago. But first things first, we had to take a rest and rehydrate ourselves because this walk had put our physical

3. Sebastián Escobar and Rommel Montúfar improvising a tool in the forest near Agua Blanca community for reaching young leaves of *Phytelephas aequatorialis*. Photo by T.L.P. Couvreur.

4. Production of *animelas*, the precursors of buttons, in the town of Manta. A. Drying of *tagua* seeds under the sun. B. Dried seeds. C. Selection of dried seeds according to their size. D. Slices resulting from the cut using a sawblade. E. Making of a hole in the slices. F. Resulting *animelas* sorted by size. G. Refined *animelas* conserving the pericarp of the *tagua* seeds. Photos by S. Escobar.

condition to the test. Interestingly, *tagua* was the only palm species occurring in this forest. Some individuals were very tall, and we estimated that they were over 100 years old. We then took our time to sample numerous individuals (Fig. 3) since we assumed that this population might harbor interesting genetic diversity, probably different from those located within the many forest fragments created by man's deforestation over the past half century.

After finishing our sampling, we headed north following the highway along the ocean. We arrived at Pacoche, which is a national reserve composed of separate patches of secondary forest and local farms. This reserve is comparable to an oasis since it is a humid ecosystem embedded within a semi-deciduous forest. Besides *tagua*, we saw several other palm species, and in particular the impressive and massive western Ecuador subendemic royal palm *Attalea colenda* (Borchsenius et al. 1998). This species is also threatened by the continuous deforestation in the region. Another common palm here was *Chamaedorea linearis*, which is easily recognized by its regularly ringed vividly green stem.

In Manta, we visited a factory that uses *tagua* seeds to produce *animelas*, the precursors of buttons. Most of the production is exported to Europe, generating around $14 million annual income to Ecuador (Brokamp et al. 2014). To enter the factory, you must walk on a "carpet" of drying *tagua* seeds (Fig. 4). The owner of the factory took us for a tour, explaining along the way how the dried seeds were selected and processed. Selected seeds are first cut into thin slices using a fast-rotating blade that is handled masterfully by the men. The women then

5. Variation in the distribution of leaf segments of *Phytelephas aequatorialis*. A. Leaf of a juvenile individual from the lowland rain forest at the Agua Blanca community, with segments aggregated in different planes. B. Leaf of an adult individual from the montane forest of Otongachi, with segments regularly inserted in one plane. Photos by S. Escobar.

make a hole in the slices of tagua with utmost precision. A last selection process sorts the resulting *animelas* into low- and high-quality products, ready for export.

At this point, we left the coastal Pacific plain and went deeper inland, where the natural forests have been transformed into agricultural land. First, we visited the region between Manta and Chone. Sometimes we drove for kilometers without seeing any *tagua*, or any palms for that matter apart from the coconut palm, *Cocos nucifera*, which is widely cultivated in this region. Nevertheless, we managed to find large populations of *tagua* growing in humid forests on hills. Then we moved eastwards, where the human influence on the forests was even greater. Along our way, we saw people selling small red vividly colored fruits of *Bactris gasipaes* var. *chichagui*, the wild variety of the peach palm, which occurs naturally in this part of South America (Couvreur et al. 2006). *Chontilla*, as it is locally known in Ecuador, is consumed in a thick soup called *borroque*. This region is dominated by monocultures of maize, oil palm, and several types of banana. We drove through tens of kilometers (literally!) of these plantations and could not stop wondering how beautiful the forests that once grew there must have been.

Luckily, we were able to find a couple of remnants of tropical rain forest at the natural reserves Pedro Franco Dávila-Jauneche and Río Palenque. These forests are the last remnants for kilometers around; and they are well worth the visit. There is no transition zone, no buffer, one goes from the fields to the rain forest in a few steps. It triggers an interesting sensation between sadness linked to all the destruction mixed with hope and joy because these patches of forest are still there. These forests are safe-havens for plants, palms in particular, as well as animals. For example, a small population of howler monkeys (*Alouatta palliata*) naturally inhabit Pedro Franco Dávila-Jauneche. Besides *tagua*, other palm species occurring there are *Attalea colenda* and *Astrocaryum standleyanum*. These patches could be likened to a forest museum, harboring the remains of a once incredible natural diversity.

For our next stop we visited a small village called Zapote. Here, we met Anelio Loor, an old friend, known for his everlasting smile and his passion for nature. Anelio is what we could call a real-life conservation hero. He was trained as a technician in biodiversity inventories in the large Forest Dynamics Plot project in Yasuni National Park in the Ecuadorian Amazon. Returning home after 16 years, Anelio decided to become active in biodiversity conservation. He acquired one of the last patches of western Ecuador lowland rain forest close to his house, using his own hard-earned savings and a few head of cattle. He wants his young children to play in the same environment he did many years ago and called his forest *Esperanza* meaning *hope* in Spanish. He does not exploit or manage Esperanza. He just leaves it alone. However, with the support of botanists he set up a 1-hectare forest plot in his free time, measuring and identifying the plants on a regular basis just as he learned to do in *Yasuní*. Anelio has one ambition, which is to acquire the last patch of forest adjacent to his own before it is subjected to the same fate as all the other forests in the region. We said goodbye, wishing Anelio the best with his conservation efforts.

By now, we started to have a fair number of *tagua* collections from the coastal plains and lowland forests of western Ecuador. However, tagua also occurs along the Andean slopes up to 1500 m above sea level. We thus set out for the second leg of our trip, and headed towards the privately-owned reserve of Otongachi, close to Santo Domingo de los Colorados. Otongachi is in an area of montane forest on the Andean foothills at about 850 m above sea level, in which *tagua* grows abundantly. We noted an interesting morphological characteristic of this population (Fig. 5). *Tagua* leaves are generally characterized by having their segments arranged in groups and spreading in different planes (Borchsenius et al. 1998). However, in Otongachi we observed *tagua* individuals with the segments regularly inserted along the midrib and spreading in a single plane. We also found individuals with mixed characteristics (i.e. individuals with segments regularly inserted in different planes and individuals with segments grouped in one plane). It is possible that this morphological variation is an adaptation to this more humid habitat compared to what we had seen along the coastal plain. In addition to *tagua*, we observed other palms such as *Oenocarpus bataua*, *Iriartea deltoidea*, *Prestoea acuminata*, and *Chamaedorea pinnatifrons*. Here, we met with researchers from our home institutions, the *Pontificia Universidad Católica del Ecuador* (PUCE) and the *Institut de Recherche pour le Dévelopemment* (IRD) who were studying the floral biology (Figs. 6 & 7) and thermogenesis of *tagua* (Fig. 8), a trait poorly understood in this dioecious palm (Pincebourde et al. 2016).

6. Recently opened pistillate (female) inflorescence of *Phytelephas aequatorialis* at the reserve of Otongachi. Photo by S. Escobar.

7. Recently opened staminate (male) inflorescence of *Phytelephas aequatorialis* at the reserve of Otongachi visited by possible pollinators. Photo by S. Escobar.

8. Heat production of a closed staminate (male) inflorescence captured by an infrared camera at the reserve of Otongachi by researchers from the PUCE and the IRD. Photo by T.L.P. Couvreur.

For our last journey we traveled near to San Francisco de Las Pampas, a village located on the Andean slopes at 1500 m above sea level. This harbors one of the highest known populations of *tagua*. The landscape is a mosaic of remnant forest patches with *tagua* and the Andean palms *Wettinia kalbreyeri* and *Ceroxylon echinulatum*, and pastures for cattle browsing in which *tagua* individuals are left standing. We met with the Tapia family who owns a portion of land and a small patch of natural forest where we sampled leaves of *tagua*. However, Mrs. Tapia warned us to take extra precaution when sampling *tagua* with mature fruits. Why? Because mature fruits attract rodents such as agoutis, squirrels, and mice, that in turn attract predators such as snakes! Luckily, we did not see any snakes during our field trip.

After eight days of fieldwork, we had sampled 15 different *tagua* populations and driven more than 1000 km. During our field trip we could note that *P. aequatorialis* is not under risk of extinction due to its wide distribution and large populations. However, many of its populations are highly threatened by deforestation, which could compromise the genetic diversity within the species. As for many palms in western Ecuador, they are generally the last trees standing in the pastures. Since *tagua* may be undergoing incipient domestication, it is essential to secure its genetic diversity through conservation (Borchsenius et al. 1998).

Acknowledgments

This field trip was financially supported by a grant of the International Palm Society to the first author, by SENESCYT and the PUCE (EcoTagua Project). The trip was performed under the framework of the International Mixed Laboratory Bio-Inca (IRD). We thank the Ministerio del Ambiente of Ecuador for providing the necessary sampling permit (MAE-DNB-CM-2018-0082), and to its Provincial Directions in Manabí, Santo Domingo de los Tsáchilas, and Los Ríos provinces for providing mobilization permits for the samples. We also thank Trafino S.A. company for providing practical infor-mation about *tagua* in Manabí. We are especially grateful to all those who helped us during our

fieldtrip by guiding us, allowing us to work on their properties, or providing information.

Literature Cited

Barfod, A.S., B. Bergmann and H. Borgtoft Pedersen. 1990. The vegetable ivory industry: Surviving and doing well in Ecuador. Economic Botany 44: 293–300.

Borchsenius, F., H. Borgtoft Pedersen and H. Balslev. 1998. Manual to the Palms of Ecuador. AAU Reports 37, Aarhus, Denmark.

Borchsenius, F. and M. Moraes. 2006. Diversidad y usos de palmeras andinas (Arecaceae). Pp. 412–433, in Moraes,M., B. Øllgaard, F. Bochsenius and H. Balslev (eds.). Botánica Económica de Los Andes Centrales, Universidad Mayor de San Andrés, La Paz, Bolivia.

Borgtoft Pedersen, H. and F. Skov. 2001. Mapping palm extractivism in Ecuador using pair-wise comparisons and bioclimatic modeling. Economic Botany 55: 63–71.

Brokamp, G., H. Borgtoft Pedersen, R. Montúfar, J. Jácome, M. Weigend and H. Balslev. 2014. Productivity and management of *Phytelephas aequatorialis* (Arecaceae) in Ecuador. Annals of Applied Biology 164: 257–269.

Couvreur, T.L.P., N. Billotte, A.M. Risterucci, C. Lara, Y. Vigouroux, B. Ludeña, J.L. Pham and J.-C Pintaud. 2006. Close genetic proximity between cultivated and wild *Bactris gasipaes* Kunth revealed by microsatellite markers in Western Ecuador. Genetic Resources and Crop Evolution 53: 1361–1373.

Montúfar, R., G. Brokamp and J. Jácome. 2013. Tagua: *Phytelephas aequatorialis*. Pp. 165–173. in Valencia, R., R. Montúfar, H. Navarrete and H. Balslev (eds.). Palmeras Ecuatorianas: Biología y uso sostenible. Herbario QCA de la Pontificia Universidad Católica del Ecuador, Quito, Ecuador.

Pincebourde, S., R. Montúfar, E. Páez and O. Dangles. 2016. Heat production by an Ecuadorian palm. Frontiers in Ecology and the Environment 14: 571–572.

Sierra, R. 2013. Patrones y factores de deforestación en el Ecuador continental, 1990–2010. Y un acercamiento a los próximos 10 años. Conservación Internacional Ecuador y Forest Trends. Quito, Ecuador.

Velásquez-Runk, J. 1998. Productivity and sustainability of a vegetable ivory palm (*Phytelephas aequatorialis*, Arecaceae) under three management regimes in northwestern Ecuador. Economic Botany 52: 168–182.

Photo Feature

Pigafetta filaris

A large stand of *Pigafetta filaris* growing on the north coast of the Bird's Head Peninsula in Indonesian New Guinea (close to Sorong). This spectacular tree palm is restricted to the north-west of New Guinea and the islands of Maluku but can be locally very common in both primary and disturbed vegetation.

William J. Baker
Royal Botanic Gardens, Kew

Palms and Art in the Jardín Botánico Culiacán

Erika Pagaza Calderón
Fernando Colin
and
Carmelo Cortés
Jardín Botánico Culiacán
Av. Las Américas 2131
Col. Burócrata, C.P. 80030
Culiacán, Sinaloa, México

Clementina Equihua Z.
Unidad de Divulgación y Difusión
Instituto de Ecología, UNAM
México D.F., México

Verana Codina
Colección Isabel y Augustín Coppel
Parque España 47 PB
Col. Condesa, C.P. 06140
Cuidad de México, México

and

Scott Zona
1807 Seminole Drive
Hillsborough, North Carolina 27278
USA

The Culiacán Botanical Garden is a gem of a garden in northwestern Mexico. The Garden is home to a burgeoning palm collection, as well as a world-class collection of contemporary sculpture. Both collections are a cultural resource for the residents of the city of Culiacán.

Culiacán is the capital of the state of Sinaloa, in northwestern Mexico, located on the Pacific Coast of mainland Mexico, at the mouth of the Gulf of California. It experiences a frost-free climate with hot summers and mild winters. Most of the region's 667 mm (27 inches) of rainfall occurs in the summer. Overall, the climate is semi-arid, which means that plants require irrigation. The city is well known for seafood, agricultural crops and, unfortunately, the violent Sinaloa drug cartel. In the heart of the city, however, is the Jardín Botánico Culiacán (JBC) or Culiacán Botanical Garden, an oasis of green and calm in an urban setting.

The nucleus of the Culiacán Botanical Garden was the plant collection of the founder, Carlos Murillo Depraect, a civil engineer with a passion for plants, especially palms. He donated his collection, and the state government gave over 10 ha (25 acres) of land. Since 1986, the garden has been open to the public. For many years, there was no entrance fee, but in recognition of the increasing value of the garden as a cultural space, the administration introduced a small, nominal entrance fee two years ago. The Culiacán Botanical Garden is popular with local residents, who visit the Garden for a variety of

1. A bonsai *Washingtonia filifera* that is 20 years old. Photo by S. Zona.

reasons. Exercise classes, quinceañera and wedding portraits, and drawing by art students from the nearby university are almost daily sights in the Garden.

The JBC is focused on the flora of Mexico, especially the state of Sinaloa, and palms. Much of Sinaloa is arid or semi-arid, and the native plants are perfectly adapted to low

2. Palms in the nursery. Left. A collection of *Chamaedorea metallica*. Right. The distinctively windowed leaf of *Reinhardtia gracilis* var. *gracilior*. Photos by S. Zona.

rainfall and high evapo-transpiration. The coastal areas of the state were once covered with a vast expanse of tropical deciduous forest, an ecosystem now threatened, as much of the land has been converted to agriculture and shrimp farms along the coast. The

3. *White Circle* (2003) by Kiyoto Ota. Photo by S. Zona.

4. *Encounter* (2007–2015) by James Turrell. The two photos were taken only 1 minute and 13 seconds apart at sunset and vividly illustrate the ever-changing colored lights that are projected on the canopy. Photos by S. Zona.

5. *Washingtonia robusta* and *Roystonea regia* tower over other palms in the Palmetum. Photo by S. Zona.

northern tip of the state, part of the Sonora Desert, boasts a fascinating flora of cacti, agaves and other succulents. The eastern portion of the state extends into the Sierra Madre Occidental, whose flanks support rich and diverse forests of pine and oak. Consequently, the Garden has a wealth of plants that it can display. The JBC also holds the National Collection of palms. The Garden is building a collection focusing first on Mexican species and then on palms from other parts of the world. Much of the Garden's palms

6. *Astrocaryum mexicanum*. Photo by S. Zona.

are grown in the Palmetum, but palms also occur throughout the garden as particular details that enhance the landscape.

The JBC's plant collections offer something for everyone. There is an impressive collection of cacti and other succulents, a water garden, a bamboo collection, an edible garden, a temperate plant collection and even a tropical bonsai collection. The later boasts a 20-year old bonsai of *Washingtonia filifera* (Fig. 1).

Plants, including palms, are acquired for the JBC through collecting expeditions, donations or exchanges with other institutions. Propagation takes place in an on-site nursery,

where seeds are germinated and grown until the palms are large enough to plant out in the garden. A small back-up collection of palms is maintained to replace palms that die in the garden (Fig. 2).

Since 2002, the Garden has taken on a new role, that of a contemporary sculpture garden and gallery without walls (Figs. 3 & 4). Artists from all over the world were commissioned to produce site-specific works that address the issues most relevant to the citizens of Culiacán, including regional identity, violence and changes in the natural world wrought by humans. The Garden now is home to a world-class collection of contemporary art, beautifully displayed among the lush, tropical foliage. A stand-out piece is *Encounter* (2007–2015) by Californian artist James Turrell (Fig. 4). This is one of Turrell's "skyspace" constructions, which are generally built as a specifically proportioned chamber with an aperture in the ceiling open to the sky. In *Encounter*, viewers sit in benches inside a room in a pyramid that has a white canopy with a central, elliptical opening. Each day, through a combination of colored lights that are shown on the ceiling, as well as light from the sky, a change of perception is created that transforms the viewers' experience of sunrise and sunset. The moment is enhanced with the sounds of crickets, birds and so forth. It is a sensorial close-encounter with nature.

The palm collection is diverse, comprising ca. 160 species. Large and imposing specimens of *Roystonea regia* and *Washingtonia robusta* are everywhere in the Garden (Fig. 5), along with specimens of *Phoenix canariensis*, *P. dactylifera*, *Wodyetia bifurcata*, *Saribus rotundifolius* and several species of *Sabal*. Understory palms include *Ptychosperma elegans* and *P. salomonense*, *Pinanga coronata*, *Rhapis excelsa* and *Astrocaryum mexicanum* (Fig. 6). The Garden has a rich collection of *Chamaedorea* species, representing a portion of the species that are native to the country. Some of the highlights include the rare and seldom-seen climbing *Chamaedorea elatior*, as well as the diminutive *Chamedorea geonomiformis*, *C. tuerckheimii* and *C. metallica*. Given the threats faced by many species of *Chamaedorea* in Mexico, this *ex situ* collection can play a role in future conservation research.

7. A young *Latania lontaroides*. The bell sculptures are from the series *Return the World* (2014) by Argentine artist Adrián Villar Rojas. Photo by S. Zona.

8. Aluminum signs are clear and easy to read. The red dot in the lower right corner of the sign symbolizes that this species is endangered in the wild. Photo by S. Zona.

As many of the Garden's most unusual palms are still young, the palm collection is destined to become more interesting with the passage of time. Of course, many of the palms, although not yet reproductively mature, are still beautiful. A young *Latania lontoroides* still shows the red coloration that gives this palm its common name, the red latan palm (Fig. 7).

Signage in botanical gardens is always difficult, as signs must be weather-resistant, permanent and legible but not too obtrusive. Signage for the palms in the JBC is exceptional. Large aluminum signs (Fig. 8) are located at the base of specimens, and each sign features an embossed illustration of the palm, scientific and common names, geographic range and a brief text highlighting such things as uses or conservation status.

The Garden has an on-site laboratory and seed bank and is conducting research into long-term storage of native plant seeds, including palms. Palms are notoriously difficult to store under the dry and cold conditions that are typical for seed banks, but the staff is experimenting with cold storage of *Chamaedorea* seeds. Seed bank storage is an important part of a multi-pronged approach to plant conservation.

A very important role of the Garden is its work in environmental education. The Garden receives up to 12,000 school children per year and hosts workshops for children of all ages to learn botany and art.

The JBC is an outstanding cultural centerpiece for the city of Culiacán and will probably, with time, become a must-see attraction for tourists from around the country and abroad. Both collections of palms and sculpture offer visitors the opportunity to appreciate form and space, to enjoy the interplay of color and texture, and to be transformed by the beauty around them.

Evidence of Suckering in *Hemithrinax ekmaniana*

Andrew Street
Montgomery Botanical Center
19001 Old Cutler Road
Miami, Florida 33156 USA
andrew@montgomerybotanical.org

1. The caespitose habit is hardly noticeable with only a casual glance.

To palm lovers, *Hemithrinax ekmaniana* needs no introduction. To others seeing it for the first time, there is an exotic allure to this Cuban endemic. *Hemithrinax ekmaniana*, with its lollipop shape, is a highly coveted, critically endangered palm.

2. A closer inspection shows another small shoot coming from the base of the main plant.

I have read about this palm many times, and although I have never seen it in Cuba, I am told that the setting where it grows is as breathtaking as the plant itself. Still, never had I seen any description of this plant possibly being a clustering palm. All literature states that it is a solitary species.

Given that *Hemithrinax ekmaniana* is known to be a solitary palm, you can imagine my shock at discovering two axillary shoots on one of my plants (Figs. 1–4). This finding naturally triggered a head-to-toe check-up of the palm: the emerging spear leaf was tight, and the palm's color was nothing out of the ordinary. In short, the plant was sturdy and healthy.

My next thought was that these shoots were perhaps seedlings from dormant seeds that had sprouted long after planting or from seeds

3. Moving aside the leaves reveals an established second stem.

of some nearby *Coccothrinax* germinating at the base of my palm. I quickly ruled this out after I gently excavated around the shoots and found that they were connected to the main plant. I began to consider the notion that *Hemithrinax ekmaniana* can, on occasion, exhibit a clustering habit.

In other genera, differences in stem number – solitary versus caespitose – are not sufficient evidence of separate species. A relative of *Hemithrinax ekmaniana*, *Coccothrinax argentata*, is known to sucker occasionally at the base of the trunk. If the main stem grows to robust adulthood, the small suckers will cease to grow

4. On the other side is a third stem with fully palmate leaves and elongated petioles.

and eventually die. This is most likely also the case with *Hemithrinax ekmaniana*. When you consider the heavy petticoat of dead leaves carried by this species, it is no wonder the small sprouts have never been noticed. Under natural conditions, if these sprouts ever occur, they would surely be overtaken by the healthy growth of the primary stem.

Since making my initial observation, I have found another example of a suckering plant in my collection, and I have heard anecdotal evidence of another observation of suckering of this critically endangered palm. It is all par for the course when you grow rare, little-known palms!

Launching the Palmetum as a Botanical Garden: A Report from Tenerife, 2010–2018

Carlo Morici
Palmetum de Santa Cruz de Tenerife, Avenida de la Constitución, 5, Islas Canarias, 38005 Spain
carlomorici@gmail.com

The Palmetum in Santa Cruz de Tenerife, the Canary Islands, was started in 1996 on a former landfill by the ocean. Since late 1999 it has continued for many years as an unfinished project (Caballero & Morici 1996, Morici 2001).

From 2010 onwards, steps have been taken to improve the design, scope and goals of the garden and its collection. It was opened to the public in 2014, and by then, I was contracted as its curator. The beautiful gardens now hold a valuable collection. We have been planting palms and trees for 22 years, taking IUCN priorities into account and safeguarding accession data. Today it is a functioning botanical garden in its fifth year of life, with several small ongoing projects.

2010–2012: Making a Park

The collection was started in 1996. From 1999, it grew through the years with minimum maintenance (Morici 2003, Morici 2005). Many rare and common palms in good and bad conditions were surrounded by pipes and rubble, with no paved roads and no signage. In early 2010, the hill had an unpleasant unfinished aspect (Fig. 1). The artificial waterfalls had not had any water for years. Wide empty spaces were everywhere, with too much sun and wind and a few dead palms here and there. The steel dome of the Octagon house was decaying, and the shade-house was falling down. Gardeners were not allowed to enter the shade-house, so climbing weeds entangled everything. Those bitter years before the opening had set the focus for the future.

In 2009, I made new plans for the Palmetum with the two agronomists who fought for this project from the very beginning: Dr. Manuel Caballero, who started the Palmetum in 1995 and kept on pushing the project among politicians, and Maria Flores, head of Parks and Gardens of our city, who saved the maintenance during the bad years, introduced

1. This aerial view of late 2010 shows the major construction works finished in 2011. Source: Palmetum archives.

the use of mulch and eliminated pesticides and herbicides. They asked our politicians to apply for public funding in order to finish and open the Palmetum. I worked with them to increase the botanical value of the project. A commitment for island floras and endangered species took me to remodel the master plan and to dedicate 95% of the area to island plants. We all agreed that we needed hard landscape and infrastructure, but the style of the garden had to be natural and, with few exceptions, would include no permanent art, no captive animals, no pesticides, no infill plants for mere beauty and no horticultural selections or hybrids.

In spring 2010, the economic crisis enveloped the islands (and the whole country) with peak unemployment, but with great luck major building work began in the Palmetum, funded by the Spanish government "Plan-E," for about €4 million. The goal was to open the gate to visitors in less than two years. The whole hill became a building yard, and paths, squares and viewpoints were asphalted or paved with stones. Contractors built a two-storey entrance building with a tower and a panoramic bridge that takes the visitor to the upper slopes, as well as toilets and a greenhouse for the nursery and maintenance sheds. Labelling, signage, lighting, railings, benches and bins were placed. The old dome of the Octagon was dismantled and replaced. By summer 2011 the transformation was complete: the Palmetum had become a park and no longer looked like an ongoing experiment.

2. While the largest builiding works were finished in 2011, landscaping was far from completed, and the margins of this river were exposed and unfinished. Source: Palmetum archives.

3. *Livistona lanuginosa* and *L. fulva* in 2014. Palms from drier habitats grew well through the years of irregular maintenance. The just-opened Palmetum still had abundant empty space and little mulch and plants covering the soil. Source: Palmetum archives.

I was involved during this building phase to take care of the botanical aspects, and I could also impose some landscape design, being helped by Paco Álvarez, a young landscape designer and palm collector from SE Spain. We opened the six viewpoints on the Southern slope, giving ocean views to the sections of Africa, Asia and the Pacific islands. We also designed the first aluminum information signs, most of them bilingual, in Spanish and English. Paco also designed the official logo, for which we chose a leaf of the Cuban endemic *Coccothrinax borhidiana*, representing our commitment to critically endangered island species.

The International Palm Society's midterm meeting for 2011 was hosted in Tenerife, and the visit to the still closed Palmetum was the centerpiece of the trip. All was new. Some corners were more than spectacular, but about half of the surface still had no vegetation at all. The group of directors was joined by a group of members of the Spanish palm society ABEPYC, and the mayor of the city came to greet all these palm VIPs. Everybody loved the visit and felt the potential of our freshly finished park. IPS president Bo-Göran Lundkvist planted a *Pritchardia minor*, which is still thriving. Those months were important, because our politicians still had no plan for the garden's opening and management, and they were still open to positive influences. Just one year earlier, Colin Wilson, a very active IPS member from Australia, came to Tenerife to help the palmetum. He wanted to help with seeds, but he also was determined to meet our politicians, to shake their hands and tell them how important our project was as seen from the other side of the world. So it happened, and Colin received a shield of the city as a gift.

2013–2014: Opening the gate

The city hall took the first steps to open the "unknown Palmetum" in 2013. The garden was too raw to be inaugurated (Fig 2.), but it was time to let the citizenship visit it. This time the City had a plan: they felt that the key was guided tours, which I had been giving to various people. There was a need to introduce the Palmetum positively to the island and to the world, so they worked extensively in marketing. I was on the go again, but for the first time I was working with

4. The Octagon was refurbished in 2015. Left to right: old *Caryota* planted in 1996 that were blooming and declining, two stunted *Pelagodoxa* were starting to recover, and two very young *Caryota zebrina* that would soon became trees. Source: Palmetum Archives.

the public: for three months, starting in early September, I guided two tours per weekend. It was unusual, tiring but pleasant work, and group by group about 2500 residents discovered the hill. Four times a week I would give and improve the botanical tour and would tell better "facts and jokes." We felt that 90 minutes was the right duration of human attention, and so I developed my route on a circuit of about 1600 m to fit that time. Different technicians from the city hall watched the effect of all this on the visitors, and we used those months to learn more. Soon the experience would be applied to tune-up the whole Palmetum for guided tours; we understood the value of the native wild fauna: moorhens, hoopoes, egrets, endemic plain swifts and many more bird species are often seen by the paths. They are a joy for visitors. At the same time, we set a permanent exhibit of palm objects in the hall by the entrance, as the building for the palm museum was still unfinished. We had a number of objects, from fossils to car plates, and lots of pictures of the very start, when the hill was still a hell and the buried rubbish in the landfill was "steamy." Most objects had been purchased by the well-known palm specialist Dennis Johnson in 1996, who was contracted at the start of the Palmetum for this purpose.

In early January 2014, we learned that the Royal Family of Spain would come at the end of the month for the official inauguration. I would give them my well-tuned guided tour, just shortened to 50 minutes. We had just two weeks to set up everything!

Suddenly the Palmetum had the full attention of the city. The running budget was about €100,000 for two weeks, but the princes had not been on the island for quite a few years, and everybody was working as if it was much more! Almost all the teams of gardeners of Santa Cruz were working in the Palmetum and around it. The sudden change of appearance was surprising: All the garden surfaces were being refinished for the first time with mulch, cinder, sand and rocks (Fig. 3). I planted as if there was no tomorrow along the paths, both rare palms and a few common shrubs such as crotons and coleus, to be removed one or a few years later. A small truck of "perennials" came from the Jardín Botánico de Aclimatación de La Orotava, with lots of bromeliads and aroids to fill up our shade-house. We have never had more than a few herbaceous plants and now the understory of the Octagon was crowded with lush green foliage. It was deep winter with clouds and drizzle, and we had hectic days, doing all at once with stress and satisfaction: fixing the shade-cloth of the Octagon (Fig. 4), adding some 300 more signs, preparing text and images for the entrance hall, painting benches, replacing rocks in the walls, rockeries and waterfalls. María Flores was coordinating landscape contractors from the city. She had a brilliant idea and decided to start our "sustainable corner" by the road near the main entrance: an excavator opened a crack on the side of the hill to reveal a slice of the disgusting underground. That would become a permanent exhibit for visits to the Palmetum: in that "corner" we show how we "recycled a landfill," how we use mulch and bring in the treated wastewater from the city, in order to grow all our plants with no pesticides.

Drizzle and work lasted until the evening before, while the inauguration day came

5. Members of Spain's Royal Family planted a young *Roystonea princeps* at the Palmetum's official inauguration. The palm is now thriving. Photo by the Royal Family House.

blessed by the sun. I spent almost one hour walking around with the princes in the mid-morning, until His Majesty Felipe delivered a delightful inauguration speech in the Caribbean circle. The princes together planted a young *Roystonea princeps* by the Caribbean waterfall (Fig. 5). The visit had an enormous positive impact in the news and on the city, and we also garnered coverage by the national press. Two days later, the Palmetum was finally open to the public. During the first two months, only guided groups would be allowed, because people needed to be guided to the nicer, more finished parts of the collection.

2015–2017: Setting up the real scenario

At the end of 2014, I was contracted as the curator. The Palmetum was finally open, and I had an office and a place to work. I met new people who worked closely with me, and they played a major role in many new developments. We enjoyed synergy with the rest of the new staff and with all those who worked externally on the educational projects. My tasks had changed, and I had to do much more than filling up the huge park and keeping a name locally and internationally. I had to give life to an institution, a new official municipal botanical garden, with all the basic activities of education, conservation and research. There were no more free guided tours, so the most urgent work was to transform "my" popular guided route of the Palmetum into a printed self-guided tour with map and app. Agar Lorenzo designed the brochure that transformed the Palmetum into a museum with 18 points of interest.

New plantings in the open gardens

Despite all that we planted in the years before, by early 2015, it still had too many empty spaces (Fig. 7). There were still pipes and dead stumps scattered around, and the two roads that go up to the main gardens were especially empty and sad-looking. So, after the "urgent" plantings of 2014 to fill up the garden for the inauguration and the earliest months (Scholz 2015), I kept on planting more and more in the following years, also starting new areas, moving large rocks and "fixing" the landscape in many ways. Hundreds of species went from pots to the ground in these following years, and about 1000 more aluminum signs have been added. About half of the new plantings have been non-palms, as the Palmetum needed lots of trees and low vegetation. We planted New Caledonian conifers, Caribbean endemic shrubs, Canarian flora representatives, uncommon fruit trees, especially some unusual cultivars of bananas, including the poorly known *fe'i* bananas. I kept almost all the best visual spots for palms, while I tried to use the right deciduous trees to screen afternoon sun in summer and the evergreen ones for wind breaking. Besides the new species, another task was filling up existing groups of ageing palms with one or few younger specimens.

2015 was also a year of felling undesired plants. We progressively removed an enormous number of trees and palms weakened by the droughts. In order to make room for the endangered species, we removed lots of common species, garden hybrids, plants growing in the wrong place, especially those stealing light or nutrients from some botanical gems. By late 2015, the gardens were much cleaner but also emptier than some months before. When I visited the area where we stored the cut trunks I was surprised by the huge mounds of logs. Those hard decisions were good decisions: the most valuable accessions were now standing out and growing in better conditions. All the attention of the team was for them; all the Palmetum was for them.

Not only new plantings but whole new areas were started in these years: the Canarian section was nearly empty and had little more than a lot of *Phoenix canariensis*. I decided to narrow the scope of the collection down to the plant species growing wild in the Anaga UNESCO Biosphere Reserve, our neighboring mountain range, which is a holy land for botanists of the whole world. Now we grow about one hundred species native to Anaga, including some narrow endemics. This section is an obligatory step at the entrance of the Palmetum and the message is that if you want to see the exotic gardens up on the hill, you will first have to be reminded about local endemics and their enormous value.

The zigzag ramp going up from the bridge to the upper gardens was empty too, as it had not been landscaped since it was built in 2011. The bridge now has five yellow crown-shafted *Chambeyronia macrocarpa* growing below. The lower part of the path is now "miscellanea," with some *Trachycarpus*, *Jubaea* and *Parajubaea*, then the upper part is within the Caribbean section, with young, thriving groups of *Coccothrinax boschiana*, *Coccothrinax hioramii*, one *Copernicia fallaensis* and some interesting Caribbean endemics from other plant families.

In 2015, we built our 19-m long "Ekmanian rockery," with the shape of a half moon, 8 m

6. *Roystonea regia* by the large Caribbean Circle. They have been imported from Cuba and Florida as juvenile trunking specimens in 1996–1997. Source: Palmetum archives.

large in its widest part, with seven *Hemithrinax ekmaniana* and seven *Pseudophoenix ekmanii*. In the Pacific section, we made new ponds of mud for *Metroxylon vitiense* of Fiji and the aquatic conifer *Retrophyllum minus* of New Caledonia. We added more boulders and rockeries in Madagascar, by the group of *Ravenea xerophila*, and in the Caribbean section, under the existing groups of *Coccothrinax gracilis* (Fig. 7) and *C. boschiana*.

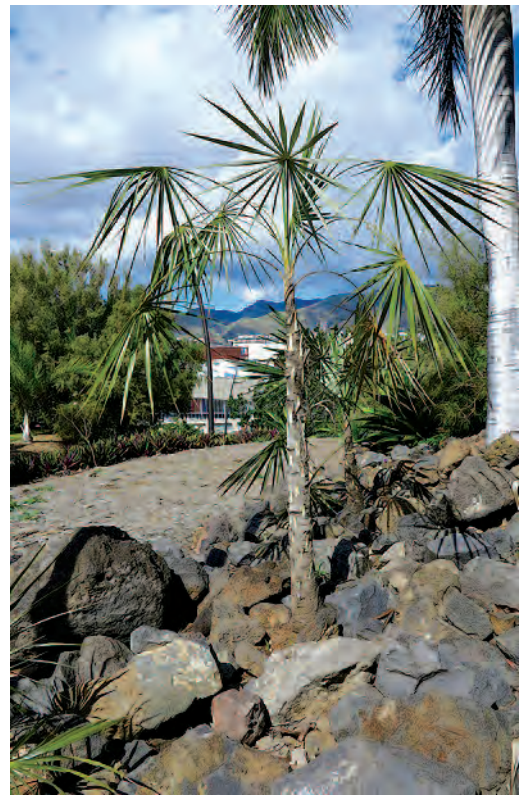
Visitors

During these first years, visitors steadily increased, from 31,674 in 2014, to 52,298 in 2018, of which 30% are Canarian residents and 70% come from elsewhere. By country, we see an abundance of Germans, British, Italians and French, but also non-European travelers are frequent. Schools come with different types of guided tours, and children are 1.5% of the visitors. The peak season is in the cooler months, because of the schools and the cruise-ship season. Most people leave very satisfied, and the Palmetum has become a highlight of tourist prestige for the city. Our best marks come from Tripadvisor, always rating us as the second or third "best thing to do in Santa Cruz de Tenerife." European tourists who come in winter enter in a state of ecstasy when they see the neat exotic landscape and the ocean shimmering nearby. For people who come from a cruise-ship it is often the only contact with nature during a short stop in Tenerife. Among these thousands of visitors, we received all types of botanical VIPs, such as part of the teams of leading botanic gardens related to palms, like the Palmengarten and Fairchild Tropical Botanic Garden, the Parc Forestier in New Caledonia, as well as professors of different universities, experts in museums, zoologists, agronomists and phytopathologists, often interested in collaborating somehow.

Education, Conservation and Research

Education matters, and we work hard with guided tours for schools and other groups of citizens. I personally spend some days per year training the people who would give the tours in the following months. School visits are not only focused on palms, but we give an enormous amount of information about other plants, animals, ecology, ethnobotany and garden maintenance. In early 2017, we also published a digital "didactic booklet," so schools have their own material.

We started seed exchanges with different botanical institutions interested in palms, and I also worked on the connections with the other botanical gardens of the archipelago. The Jardín Botánico de Aclimatación de La Orotava, in North Tenerife, is specialized in American flora, and we received from them some interesting West Indian endemics to enrich our Caribbean section, while we helped their American palm collection that now counts about 250 species.



7. *Coccothrinax gracilis* has a unique silohuette. They took about 18 years from seed to become adults. Rocks and mulch are widespread in the palmetum. Photo by Kyle Wicomb, 2019.

The Palmetum serves as a solid base for research projects by keeping valuable documented collections. So far, we have taken some steps to cooperate with the University of Hawaii and of the Balearic Islands. The University of La Laguna, in Tenerife, keeps ongoing surveys of ants and mosquitoes. In 2016, I attended some conferences to represent the Palmetum, such as the Spanish and Portuguese society of botanical gardens (Asociación Iberomacaronésica de Jardines Botánicos), in Fuerteventura, EUNOPS, European Network of Palm Specialists, in Gran Canaria and the meeting of the commission for the evaluation of New Caledonian palms for the IUCN, in New Caledonia (Warimavute 2017). In December 2017 the Palmetum organised the "1st Meeting of Botanic Gardens of the Canary Islands."

Current status of the collection

In 2017, I updated our database and studied the collection. It includes at least 2300 plant taxa, 38.6% has some data about their wild origin, 420 taxa are in the IUCN red list: 73 are

8. Two *Hemithrinax compacta* were started from seed in 1998. This is the larger of the two, pictured in 2019; it produced its first inflorescences the year before. Photo by Carlo Morici.

critically endangered and two are extinct in the wild. The palm collection has 573 taxa, of which 163 are represented by at least one adult. Some 192 palm taxa are in the IUCN red list, and 38 of them are critically endangered; 42 IUCN-listed palms have reached the adult stage. Of the IUCN-listed palms, 11 are adult accessions with data of wild origin. The collection of *Coccothrinax* has an exceptional value, and while many specimens have been lost during the early years, it is still one the most complete in the world. Over the years, many collectors contributed with seeds of precise geographical origin (Morici & Verdecia. 2004, Morici 2013). It is the largest outside of the Caribbean basin, rich in critically endangered species and still improving (Jestrow et al. 2017).

Growing conditions get each year better, as palms and trees grow up breaking the wind and the scorching sun of the early years. Plants from very different climates do well here, such as *Parajubaea* and *Pelagodoxa*, and we can also grow as "marginals" species that usually do not do well in the warm subtropics, like *Rhopalostylis baueri* and *Cyrtostachys renda*. The gardens are filling up with exotic genera of palms and we still have some empty spaces. Tender palms like *Metroxylon vitiense* thrive outdoors with no protection and the lower level of the Octagon is planted with the most delicate Oceanian genera, such as *Brassiophoenix*, *Ponapea* and *Clinostigma*. While the new plants added in the past few years grow up, many of the earliest plantings have reached maturity. As a remarkable example, one of our exceedingly rare and slow *Hemithrinax compacta* (Fig. 8), collected in the wild and sown in 1998 (Morici 1999, 2000), flowered for the first time in late 2016, with a leaf height of 210 cm and still no visible trunk. All this is maintained by a small and efficient team of seven gardeners, who have been steadily improving their skills.

As the plant collection grows, the number of bird species observed in the Palmetum is still increasing. The initial hill of rubbish had no significant bird fauna, and only 12 bird species were sighted until 1995, while in 2017 a total of 58 species has been sighted in the Palmetum (SEO-Birdlife Tenerife, pers. com. 2017) The most recent "first sightings" are *Chloris chloris* in January 2017 and *Merops apiaster* in April 2017 (Garcia del-Rey, pers. comm.).

9. Aerial view in Spring 2018. Photo by Paco Sotelo.

2018 and Today

We have learned a lot: our oceanic climate is fabulous, and the volcanic soil is usually very good, while the quality of water is possibly what really limits the diversity. We use a recycled waste-water rich in nutrients and good for most palms, but its quality changes throughout the year. Many wet-forest palms seldom adapt, such as most species of *Licuala*, *Calyptrogyne* and *Pinanga*. There is still some gas released by the decaying rubbish, but it is decreasing and is removed by an extensive system of pipelines. Nevertheless, some known spots of the Palmetum still have excessive bottom heat. Sometimes the heat is beneficial, and we get some incredible growth rates of neighboring palms. One of our two *Mauritiella armata* grew three times the size of the other in ten years, and the by far the largest of our three *Tahina spectabilis* was the last to be planted. The *Mauritiella* was eventually killed by a higher temperature in Spring 2017, and we fear the same might one day happen to the largest *Tahina*. Each year, we still uproot one or a few damaged palms because of a sudden increase in soil temperature.

The gardens on the hilltop are filling up (Fig. 9), but there is still room for more, since some large common trees are still scattered on the mountain and they can be removed in the next few years as soon as we have more interesting species available. There are also some large unopened areas that are waiting for development. For this purpose, a master-plan for the future of the Palmetum was developed in 2015 by Jose Timón, an agronomist who participated in the engineering of the Palmetum since 1995. Future developments include a new section for Papua New Guinea with a pond, three hides for bird-watching and a museum-shadehouse-picnic area. Much more room for plants is available on the slopes, which are still mostly empty. They are roughly six hectares, with few large trees. During the last few years, pests of *Phoenix canariensis* have been killing almost half the native palms that had been planted in 1995–1996 on the N and E slopes, and more are dying these days, chiefly due to the weevil *Diocalandra* and *Fusarium* fungal attacks. In summer 2017 we planted uncommon flowering trees on the northern slope and the rest will soon be landscaped with plants as diverse as Pacific dry forest, Canarian coastal scrub, and species of *Coccothrinax*. In 2018 we enhanced the collection of useful species in order to prepare another self-guided tour with map and app, focused on the usefulness of palms and other plants. This ethnobotanical tour is being launched in Spring 2019.

While the growth of plants and visitors steadily goes on, maintenance has increased too. Each year our staff feel a bit more overwhelmed and now it needs more employees to meet all this success. We hope the City will soon understand this and push the project further. Manuel Caballero joined us in late 2018 as a retired volunteer and is now helping the technical agenda.

A path to follow

The Palmetum is a meaningful example of how a degraded space can become a cultural center with environmental value. It was not started by a similar scientific institution or built and bought in a few years by a powerful investor: a true botanical garden can be created from thin air and patience, with a group of passionate people who keep their goals for twenty years and the support of a city hall, seeking for different public funds. The focus set on uncommon species and the scarcity of popular ornamental plants is fundamental to give room and attention to the most valuable living germplasm. Uniqueness also comes from the creativity of a low-tech garden design based on the needs of each species. The collection is organized as an exhibition project, and our two main themes of palms and islands are very attractive to the general public, who also loves the great location, between the city and the ocean.

The project goes on, along the way of its master-plan, pursuing the "natural goals" of botanical gardens. New palms are growing up in the nursery, and new projects are born every day. Regarding the collection I shall start looking for *Lodoicea*, of which we just have a dry seed on display, and devote the next years to the quest for saving the endangered island species that need places like this to be conserved and propagated, such as *Ravenea musicalis*, *Saribus jeanneneyi* and *Hyophorbe amaricaulis*.

Acknowledgments

I wish to acknowledge the International Palm Society as a whole, because the society by itself was the ultimate source of inspiration for dreaming up the Palmetum. Manuel Caballero used to read Principes since the 80s. I joined the IPS in 1991. In 1994 María Flores sent a flier about the incoming project from the City Hall of Santa Cruz to all the IPS members in the roster. Since then, more than 300 IPS members have somehow actively helped the Palmetum to get to this point and many still do so. In my day-to-day work I receive technical advice from many of my colleagues, and I am especially grateful to Agar Lorenzo, Osmani Matos and Rubén Perez, who helped me from the start with their skills, persistence and creativity. I am grateful to Javier Francisco-Ortega for reviewing this manuscript and paying so much interest in our project.

Literature Cited

Caballero M. and C. Morici. 1996. Proposal for a Palmetum in Santa Cruz de Tenerife. Mooreana 6: 51–52.

Jestrow, B., B. Peguero, F. Jiménez, R. Verdecia, L. González-Oliva, C. Moya, C. and J. Francisco-Ortega. 2017. A conservation framework for the Critically Endangered endemic species of the Caribbean palm *Coccothrinax*. Oryx 52: 452–463.

Morici, C. 1999. Notes on the Cuban endemic species of the genus *Thrinax*: A preliminary contribution to the knowledge of its status. Acta Horticulturae 486: 93–98.

Morici, C. 2000. *Thrinax* in Cuba. Palms 44: 63–68

Morici, C. 2001. The Palmetum of Santa Cruz de Tenerife. Palms 45: 161–167.

Morici, C. 2003. El Palmetum, un sueño paralizado. Espádice 4: 2–6.

Morici, C. 2005. El Palmetum de Santa Cruz: Estado actual y potencial. Makaronesia 7: 120–129.

Morici, C. 2013. Report on the growing *Coccothrinax* collection at the Palmetum in Tenerife. The Palm Journal 203: 22–25.

Morici, C. and R. Verdecia. 2004. Diario de viaje: recolectas por el sur de Cuba, entre *Copernicia* y *Coccothrinax*. Espádice 6: 9–13.

Scholz S. 2015. Das palmetum von santa cruz de tenerife. Der Palmengarten: 78: 142–148.

Warimavute, G. 2017. Red List Assessment of New-Caledonian Palms (Arecaceae) and Recommendations for their Conservation. MSc. thesis. Université de la Nouvelle-Caledonie.

The IPS is grateful for the support of the following patrons

2018

Platinum ($5000 and up)

Mr. Gregg Hamman, California, USA, in support of the Endowment Fund.

Ms. Glenn Franklin, North Carolina, USA, in support of the Endowment Fund.

Gold ($1000 to $4999)

Ms. Sally Sneed Betts & Ms. Sarah Morlang, USA, in memory of their parents, Melvyn & Phyllis Sneed.

Silver ($500 to $999)

Bronze

Ms. Elizabeth (Libby) Locke Besse, Florida, USA.

Mr. Michael Merritt, Hawaii, USA, in support of the Endowment Fund.

Network for Good

2019

Platinum ($5000 and up)

Gold ($1000 to $4999)

Mr. Leland Lai, California, USA, in support of the production of PALMS.

Silver ($500 to $999)

Bronze

If you would like to make a gift, however large or small, please contact IPS President Ray Hernandez, rayhernandez77@gmail.com or any IPS Board member. To give on-line, visit www.palms.org.