Palms

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The fruits of *Pinanga insignis* are arranged dichotomously and ripen from red to purplish black. See article by D.R. Hodel, p. 5. Photo by D.R. Hodel.

IPS INTERNATIONAL Palm Society

FRONT COVER

A mighty *Metroxylon amicarum*, heavily laden with fruits and festooned with epiphytic ferns, mosses, algae and other plants, emerges from the low-hanging clouds near Nankurupwung in Nett, Pohnpei. See article by D.R. Hodel, p. 5. Photo by D.R. Hodel.

BACK COVER

Hydriastele palauensis is a tall, slender palm with a whitish crownshaft supporting the distinctive canopy. See article by D.R. Hodel, p. 5. Photo by D.R. Hodel.

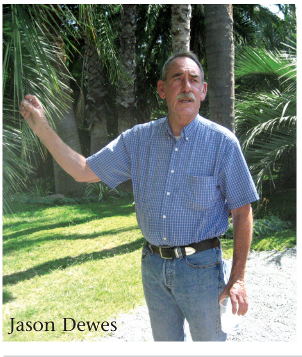
PALM NEWS

CA Dept. Food & Agric.

Last year, the **South American Palm Weevil (*Rhynchophorus palmarum*) was found during a survey of the Lower Rio Grande Valley, Texas**. This palm-killing weevil has caused extensive damage in other parts of the world, according to Dr. Raul Villanueva, an entomologist at the Texas A&M AgriLife Research and Extension Center at Weslaco. The weevil's larvae bore into palm trunks and crowns, causing direct damage to palms, but the weevil is also the vector of the red ring nematode (*Bursaphelenchus cocophilus*), which is the causative agent of red ring disease of coconut. The weevil also occurs in California, Mexico, Central and South America and the Caribbean. How it arrived in Texas, whether on its own accord or hitchhiking on transported plant material, is not known.

A new study of the morphology, pollination and cultivation of the double coconut (*Lodoicea maldivica*) was published by S. Blackmore et al. in the open access Journal of Botany. Field observations suggested a number of potential biotic pollinators including bees, flies, slugs and geckos, but trigonid bees were identified as the most likely potential natural pollinator, which is a finding that contrasts with the conclusions of a study published in PALMS (47: 135–138. 2003.) in which dolichopodid flies were implicated as the most likely pollinator. In addressing cultivation, they stressed the importance of temperature, humidity and light levels as well as maintaining an undisturbed environment during germination and establishment. Download the article at http://www.hindawi.com/journals/jb/2012/687832/abs/.


Arthur Chapman


Jason Dewes

We were saddened to hear the news late last year that former IPS President **Richard "Dick" Douglas passed away** on 22 November 2012. Richard, a retired pilot, created a beautiful garden in Walnut Creek, California, where he often welcomed fellow IPS members and members of the Northern California Palm Society of which he was a past president. An expert grower of palms, he generously shared his knowledge and love for palms, be it on PalmTalk, where he was known as "PalmGuyWC," or in person with other local palm enthusiasts and visitors to his garden. Richard will be greatly missed by his friends in the IPS and by the many people whose lives he touched.

A **new taxonomic treatment of *Licuala* in Borneo** was published by Dr. Leng Guan Saw in the Kew Bulletin (67: 577–654. 2012.). An astounding 26 new species and two new varieties were described. Of particular interest is the identity of *Licuala* 'Mapu,' which was shown to be the mottled form of *L. mattanensis* var. *paucisecta*. A new variety that will be on everyone's wish-list is *L. cordata* var. *ashtonii*, which has naturally occurring slits or "windows" in the large, undivided, orbicular leaves.

Island Hopping for Palms in Micronesia

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Ever since I was smitten with palms over 40 years ago, one place and its palms that fascinated me to no end was Micronesia. The combination of palms and idyllic tropical islands is always extraordinarily appealing. Indeed, the first day I arrived in Honolulu in 1974 for graduate studies at the University of Hawaii I headed straight to Foster Garden. The first palm I saw after entering the garden was a striking *Clinostigma ponapense*, easily the most handsome and regal plant I had ever seen. It was the quintessential palm, a spreading crown of long-pinnate leaves with elegantly pendulous pinnae held by a lime-green, cylindrical crownshaft topping a straight, clean, neat, chalky white, ringed trunk, all supported by a short cone of large, conspicuous, black roots. The label indicated its origin was Pohnpei, Micronesia, and I knew right then that I must visit that place someday. Well, someday took nearly 40 years but in November, 2011 I finally got my wish and I visited Micronesia to photograph and document its palms as part of a larger, multi-year project I am heading up that covers palms on all the Pacific Islands.

I departed Los Angeles on October 30 and spent several days in Honolulu visiting friends and photographing palms and trees. In Honolulu I focused on two species of *Ponapea*, solitary, moderate, pinnate-leaved palms with truncated, toothed pinnae tips related to *Ptychosperma* and occurring in Micronesia and Melanesia. These were *P. hosinoi* and *P. ledermanniana*, which were in the collections of Lyon Arboretum of the University of Hawaii and Hoomaluhia of the Honolulu Botanical Gardens system. Although I hoped to see these two species in habitat in a few days, it was reassuring to have detailed photographs of flowers, fruits and other diagnostic features already in hand in case I was unsuccessful in finding them in Micronesia.

My flight from Honolulu to Micronesia was scheduled to depart very early in the morning (5 a.m.) on November 3. My son Robert, who was accompanying me to Micronesia, arrived in Honolulu late on the night of November 2. We settled into our airport hotel for a few hours sleep, were up at 3 a.m., did last minute packing and headed to the airport for our Continental Airlines flight. There are two ways to travel to Micronesia. One heads west from

Honolulu, island hopping to Majuro, Kwajalein, Kosrae, Pohnpei, Chuuk and then to Guam and Palau. The other way is to fly directly to Guam from Honolulu and then island hop in the reverse order. We chose the first method so that upon our return we would have only two, non-stop flights to arrive in Los Angeles: Guam to Honolulu and Honolulu to Los Angeles.

Micronesia comprises thousands of small, often quintessentially idyllic, tropical islands spread over a vast area of the western and northern Pacific Ocean southeast of Hawaii, north of New Guinea and the Solomon Islands in Melanesia, and east of the Philippines. Several island groups comprise Micronesia, including the Marshalls, Carolines and Marianas archipelagos. Micronesia was the site of fierce fighting during World War II, which in some places devastated the islands' fragile flora and fauna, including the palms. Today continued threats to the palms include loss and degradation of habitat due to farming, agroforestry and infrastructure development; invasive species such as the highly aggressive and invasive, large, rampant vine *Merremia peltata*, which blankets the native vegetation, effectively "smothering" it and suppressing or preventing reproduction; harvesting for food, medicine and materials; natural disasters such as storms and fire; and, in some cases, narrowly restricted ranges.

After World War II the U.S. administered Micronesia as a trust territory. Several of the islands and island groups gained independence in the 1980s and 1990s, including Chuuk, Kosrae and Pohnpei of the Federated States of Micronesia and the Republic of Palau, all part of the Caroline Islands Archipelago.

The islands are of volcanic origin, typically with barrier and/or fringing reefs, but some have been reduced to low, karst limestone rocks. The climate is warm and wet with little or no seasonal variation. Year-round temperatures range from about 24°C (75°F) to 32°C (90°F). Rainfall is high and ranges from 250 cm (100 inches) to 760 cm (300 inches)

1. The attractive fruits of *Metroxylon amicarum* are covered with glossy, brown scales.

annually. Our objectives, in the order we would visit them, were Kosrae, Pohnpei, Chuuk and Palau. Visiting these four islands would enable us to see all of Micronesia's indigenous palms. The palms we most wanted to see were *Ponapea ledermanniana* (Kosrae and Pohnpei), *P. hosinoi* (Pohnpei), *P. palauensis* (Palau), *Clinostigma ponapense* (Pohnpei) and *C. carolinense* (Chuuk). Other species we would see included *Heterospathe elata* and *Pinanga insignis* on Palau and *Metroxylon amicarum* and *Nypa fruticans* on all the islands.

Kosrae

After over 10 hours of elapsed time from Honolulu, crossing the International Date Line and making brief stops on Majuro and Kwajalein in the Marshall Islands, we finally arrived about midday on Saturday, November 5 at out first objective, Kosrae, in the Federated States of Micronesia.

Roughly triangular in shape, Kosrae rises to 634 m (2080 feet) elevation, and at 15 km (9 miles) across, dominates the lagoon in which it sits. Much off the beaten tourist track, Kosrae is an undiscovered jewel with relatively few visitors. However, it has much to offer those travelers who like lagoon activities, such as snorkeling and diving, or who like trekking in tropical rainforests to see plants, animals and local historic and cultural sites.

Greeted by a blast of hot, humid air as we exited the plane, we rented a 4-wheel drive vehicle and drove to our lodgings at the Pacific Treelodge Resort on the other side of the island. After unpacking and eating lunch at the hotel's superlative Bully's Restaurant, which sits on an inland lagoon at the end of an elevated boardwalk through an enchanting mangrove forest, we headed out to look at palms, mostly common species that occur on most of the islands.

As we did on all our island stops, I had made prior contact with non-profit, non-governmental organizations mostly involved with conservation efforts and environmental studies to provide us with guides to help us find the palms. On Kosrae the Kosrae Conservation and Safety Organization provided a guide, Jacob Sanno, who would accompany us in our exploration. Because we had a shortened first day, Jacob took us to the southern and southeastern part of Kosrae where we found *Metroxylon amicarum* at Malem, *Nypa fruticans* at the end of the paved road in Utwa, and the ever-present *Cocos nucifera* (coconut palm). On the way we could look up to the high ridges and see abundant *Ponapea ledermanniana*

2. *Nypa fruticans*, here at Utwa, Kosrae, forms vast stands in near mangrove tidal and estuarine areas of most islands in Micronesia.

3. In the forest understory along the trail to the Menka Ruins *Ponapea ledermanniana* has a rather open canopy of gracefully spreading pinnate leaves with the pinnae flat and in more or less one plane.

poking their canopies of distinctive, recurved, pinnate leaves above the forest and easily pick out the white inflorescences of the palms against the dark green forest vegetation, but they would have to wait for another day.

Metroxylon amicarum, a tall, solitary, pinnate-leaved palm with large, glossy and scaly fruits (Fig. 1), is unique in the genus in that it does not die after flowering and fruiting like its related species do. *Nypa fruticans*, the

4 (left). Inflorescences of *Ponapea ledermanniana* are white and immature fruits green. 5 (right). At this exposed site near Yesron in Utwa, Kosrae, *Ponapea ledermanniana* has a compact canopy of stiffly recurved leaves with the pinnae arising from the rachis to make a v-shaped blade.

mangrove palm, occurs all over the western Pacific and tropical Asia where it forms dense stands in brackish water estuarine areas. Long pinnate leaves arise directly from short, creeping and branching rhizomes, making a forest of upright leaves looking as if they are arising directly from the ground (Fig. 2). The curious inflorescences (flower stalks) and infructescences (fruit stalks) are club-like, especially the latter with the large fruits densely clustered and packed at the end of a short stalk. Fruits of *N. fruticans* often germinate on the palm before they drop to the ground or into the water to float away. The sun was setting as we hurried back to our lodgings and another fine meal at Bully's Restaurant.

Sundays in Micronesia are mostly strict days of rest so Jacob was unable to accompany us to look for *Ponapea ledermanniana* in the morning. However, after breakfast in Bully's Restaurant, Robert and I hired a local guide, Salik, who would take us to see some ancient Micronesian ruins up the Menka River in Utwa, about a two-hour walk along the river and up a valley through dense rain forest. We picked up Salik late on Sunday morning and drove to the trailhead for the Menka Ruins. As we began our walk we engaged Salik in talk about *kuter wet*, the indigenous name for *P. ledermanniana* on Kosrae and meaning "inedible nuts," perhaps in reference and contrast to the seeds of the betel nut palm, *Areca catechu*, which we would see in more abundance on Pohnpei, Chuuk and Palau. He replied that we would probably see some on our walk to the ruins, which was exciting news to say the least. We quickly entered the wet, heavily forested valley, following a muddy but well marked trail that meandered among the great rain forest trees with huge, spreading buttresses, some of which towered well over 30 m (100 feet) above us.

Much to our surprise and delight, we immediately began to see *Ponapea ledermanniana* scattered in dense shade on steep, well-drained slopes above the river or actually growing in somewhat swampy ground along the river. Here it was a solitary, slender, moderate to tall, understory forest palm with a brown, ringed trunk supporting a pinkish brown crownshaft and rather open canopy of

6. Because the rain forest vegetation had been cleared from this site near Yesron, Utwa, Kosrae, the natural nutrient recycling system was severely disrupted and many of the *Ponapea ledermanniana* displayed magnesium- and potassium-deficient older leaves.

gracefully spreading pinnate leaves with the pinnae flat and in more or less one plane (Fig. 3). The jaggedly toothed pinnae tips are a reminder of its close relatives *Balaka*, *Drymophloeus*, *Ptychosperma*, *Solfia*, *Veitchia* and *Wodyetia*. In the rather dense shade of the giant rain forest trees few of the palms were reproductive and the gracefully spreading leaves were in contrast to exposed specimens we would see later with a more compact canopy of strongly recurved leaves.

We spent much time sloshing through the mud and water and scaling steep slopes to examine and photograph the palms. Needless to say, we did not make it to the ruins, and as rain clouds threatened, we made our way back to the auto. After dropping Salik off we ate lunch and then met Jacob, who would take us to a site along Okat Road in Tafunsak on the northeast side of the island to see more *Ponapea ledermanniana*, this time on gently rounded ridges but still mostly as an understory palm with gracefully spreading leaves. Here more palms were in flower and the starkly white inflorescences were conspicuous if not showy against the dark green leaves. As I was taking photographs heavy rain began to fall and we tried huddling under some small trees in an unsuccessful attempt to stay dry. Finally Robert pulled out his umbrella and held it over me as I shot of a series of photos of the white inflorescences and infructescences heavily laden with full-size but not-yet-ripe green fruits (Fig. 4). Several of the palms here, especially those on sloping terrain, had trunks with a conspicuous cone of relatively short, brown stilt roots at the base.

We spent our last day, Monday, on Kosrae with Jacob visiting a site in Yesron in Utwa where *Ponapea ledermanniana* was growing on an unusually steep, exposed, weedy hillside that had been cleared to plant *Manihot esculenta* (tapioca, cassava, manioc). At this exposed site the palms looked entirely different from their understory counterparts that we had previously seen and had compact canopies of stiffly recurved leaves with the pinnae arising from the rachis to make a v-shaped blade (Fig. 5). Also, because the rain forest vegetation had been cleared from the site, the natural nutrient recycling system was severely disrupted and many of the palms displayed magnesium- and potassium-deficient older leaves (Fig. 6).

We felt that, due to its relative abundance, distribution on steep slopes and good regeneration, *Ponapea ledermanniana* is probably not endangered on Kosrae.

7. Near Liduduhnap Falls on the Nanpil River in Nett, Pohnpei, *Ponapea hosinoi* is a solitary, slender, moderate to tall forest palm with a brown, ringed trunk.

8. *Ponapea hosinoi* differs from *P. ledermanniana* in its grayish green crownshaft, conspicuously broader pinnae, and petioles and inflorescences with short, brownish hairs. 9. Rachilla and staminate flowers of *Ponapea ledermanniana* (bottom) are white while those of *P. hosinoi* (top) are brown to greenish.

Pohnpei

I was full of anticipation when we arrived Tuesday, November 8 about mid-day in Pohnpei. I was finally going to see *Clinostigma ponapense* in the wild, a nearly life-long dream. Pohnpei, circular in outline and the largest, highest and most populous island in the Federated States of Micronesia, is about 25 km (15 miles) across, rises to about 790 m (2600 feet) elevation and dominates the lagoon in which it sits. It is also one of the rainiest spots on earth, with some mountain locations receiving over 760 cm (300 inches) of rain annually. Dense rain forest covers the island and numerous rivers make their way from the interior out to the sea. After checking into our hotel and buying supplies, we headed to the offices of the Conservation Society of Pohnpei, which would provide us with guides and a vehicle in our search for the island's palms.

On Wednesday our guide Relio Lengsi drove us to see *Clinostigma ponapense* and *Ponapea hosinoi* near Liduduhnap Falls on the Nanpil River in Nett, long a classical collecting area for palms and other plant species on the north side of the island. Along the way to the falls, on the few occasions when the clouds briefly lifted and the mountainous interior was visible, it was easy to see the ridgelines with abundant *C. ponapense* poking their elegant canopies high above the surrounding vegetation.

Under threatening skies, Relio parked the auto near the falls and we entered the dense, wet rain forest, using a water-pooled, muddy, gently upward-sloping track, and nearly immediately encountered both species of palms. They were abundant, even gregarious, and we observed all life stages, from seedlings to reproductive adults. Here *Ponapea hosinoi* was an understory palm, only occasionally breaking through into the open in forest fringes or in disturbed sites. Like *P. ledermanniana*, it is a solitary, slender, moderate to tall forest palm with a brown, ringed trunk (Fig. 7). However, it differs from *P. ledermanniana* in its grayish green crownshaft, conspicuously broader pinnae, petioles and inflorescences with short, brownish hairs (Fig. 8), shorter fruits and floral details (Fig. 9).

Correspondence with Steve Perlman of the National Tropical Botanical Garden on Kauai in Hawaii and Carl Lewis of Fairchild Tropical Botanic Garden in Miami, Florida, who had visited Kosrae, Pohnpei and Palau a few years earlier to survey *Ponapea*, indicated that *Ponapea hosinoi* was mostly distributed on the northern side of Pohnpei while *P. ledermanniana* was mostly in the southern half. Thus, we were greatly surprised to find one individual of *P. ledermanniana* growing amongst a group of *P. hosinoi* on the northern side of Pohnpei. The two growing side-by-side enabled us to see easily the differences between them (Fig. 10).

The exceedingly handsome and plentiful *Clinostigma ponapense* is an emergent species,

10. Near Liduduhnap Falls on the Nanpil River in Nett, Pohnpei, differences between *Ponapea ledermanniana* (left) and *P. hosinoi* (right) are easy to see when they occur side by side.

11 (left). *Clinostigma ponapense* typically has inflorescences and infructescences in all stages of development, from in-bud flowers to mature fruit. 12 (right). What is most handsome about *Clinostigma ponapense* is its canopy of rich green, long-pinnate leaves with elegantly pendulous pinnae.

thrusting its regal canopy well above the surrounding vegetation. A dense cone of relatively short, brownish orange prop roots supported the ringed, chalky white trunk. Below the crownshaft were inflorescences and infructescences in all stages of development, from in-bud flowers to mature fruit (Fig. 11). What is most handsome about this palm, though, is its canopy of rich green, long-pinnate leaves with elegantly pendulous pinnae (Fig. 12).

As the clouds lowered and heavy rain began to fall, Relio suggested that we visit his family's farm near Meitik in Nett, not only to escape the rain but to eat lunch and view more *Clinostigma ponapense*. We needed no further encouragement as the rain became an ear-deafening downpour, flooding the road at several places on our way back down the mountain.

The rain let up as we finished our lunch at Relio's farm and we decided to explore some areas near the farm but at higher elevations. We left the paved road and continued up a rocky track until it petered out in a *kava* and betel nut plantation near Nankurupwung in Nett. Although the rain had stopped the clouds were hanging low to the mountain, mostly obscuring views of extensive, gregarious stands of *Clinostigma ponapense*. Suddenly the clouds lifted slightly and right in front of us, in a surreal setting, emerged an old, tall, venerable *Metroxylon amicarum* (Front Cover). As we headed back down the road to complete the day's activities we stopped to photograph betel nut palms (*Areca catechu*) and a local *kawa* farmer's house thatched with leaves of *M. amicarum* (Fig. 13).

The next day was also rainy and we spent it on the southern side of Pohnpei looking for more *Ponapea ledermanniana*. Relio again accompanied us and also along was Emos Epariam, another employee of the Conservation Society of Pohnpei who new the area well. The rain was heavy and unrelenting. Nearly every stream or small river was furiously lapping at the seemingly less-than-adequate bridges we crossed. During a break in the rain we ascended a muddy track near Pwok in Kitti where we encountered several specimens of *P. ledermanniana* heavily laden with white inflorescences and infructescences (Fig. 14). We tried to photograph more *Clinostigma ponapense* and only snapped off a few photographs of the curious aerial roots newly emerging some distance up the trunk before the rain quickly returned with a vengeance and drove us back to the shelter of our car. On our return to the hotel we stopped at Emos's house, met his family and indulged in authentic local Pohnpei food.

After seeing *Ponapea hosinoi* and *P. ledermanniana* on the island, we felt that both species are likely to be endangered on Pohnpei, while *Clinostigma ponapense* was abundant and regenerating and did not appear to be threatened.

On our last day on Pohnpei, which was bright and sunny, we were tourists in the true sense of the word, and with Relio we circled the entire island, stopping to take in several cultural sites, including the ancient and mysterious ruins at Nan Madol. Nevertheless, along the way, it was impossible not to look at palms, and we stopped several times to admire splendid specimens of *Areca catechu* and *Metroxylon amicarum* before returning to our hotel to pack for the next day's departure to Chuuk.

Chuuk

On Saturday, November 12, we caught our island-hopping flight from Pohnpei to Chuuk, formerly known as Truk. Chuuk comprises several mountainous islands rising to about 350 to 450 m (1150 to 1475 feet) elevation in an immense lagoon about 70 km (43 miles) across. The sight of one of WW II's important battles that left the lagoon floor littered with many Japanese ships, Chuuk is now primarily known as a diver's paradise for those who want to explore shipwrecks and tropical marine life. However, we were primarily interested in the enigmatic and little known palm, *Clinostigma carolinense* that, once named from Chuuk, had mostly disappeared from the annals of botany and horticulture. I was rather perplexed why such a large palm on relatively small islands had eluded botanists and horticulturists for over half a century while its close relative, *C. ponapense*, was not uncommonly cultivated in tropical locations in Hawaii, Australia and Southeast Asia. Had the ferocious air and sea battles in Chuuk, which decimated much of

13 (left). Near Nankurupwung in Nett, Pohnpei a local *kawa* farmer's house is thatched with leaves of *M. amicarum*. 14 (right). This *Ponapea ledermanniana* near Pwok in Kitti, Pohnpei was heavily laden with white inflorescences and infructescences.

15. Near Penia on Weno in Chuuk these *Clinostigma carolinense* were similar to *C. ponapense* but seemed larger and grew in highly disturbed, weedy forest remnants.

the islands' vegetation, resulted in the eventual extinction of *C. carolinense*?

As our plane taxied to a stop at the terminal on Weno, I glanced out the window and, much to my surprise and delight, I could easily see large stands of *Clinostigma carolinense*, known locally as *kiniau* or *tiniau*, with its characteristic spreading canopy of long-pinnate, gracefully arching leaves and elegantly pendulous pinnae, lining the low ridge top just behind and above the main town and airport. This reassuring sight made us think that seeing and photographing *C. carolinense* would be an easy task although, as usual, our optimism was tempered by past experiences that reminded us that when it comes to finding palms, all is not as it seems. Sure enough, after checking into our hotel, we pointed out the clearly visible and enticingly close palms to hotel staff and inquired about access to the ridge. An incredulous stare and the response, "There's no way to go there; no one goes there," crushed our optimism.

Nonetheless, we unpacked and headed to the hotel's restaurant to meet Clark Graham, a former U.S. Peace Corp volunteer who arrived in Chuuk in 1966, married a Chuukese woman, and settled down and raised a family. After his Peace Corps service, Clark operated diving and other businesses before founding a non-profit foundation and school to provide young children and adolescents with additional, after-school education and training in computers, math, English and athletics. Over lunch we shared with Clark our inquiry with the hotel staff about the palms on the nearby ridge. Clark explained that land ownership on Chuuk was intensely provincial, all land was privately owned, and even to pass over one's land required permission from a local chief and payment of a fee. Local lack of interest in the palms and restricted access meant that few if any people were aware of the palms and even fewer had visited them.

Clark reassured us, though, when he said that the next day he and a local villager would guide us to a stand of *Clinostigma carolinense* on his wife's property! We delighted by this news and over a few beers Clark regaled us with tales of his 45 years on Chuuk, which provided us with many laughs and surprises of the numerous characters and antics Clark had experienced over the years on this Pacific island.

The next morning dawned clear, sunny and hot as the hotel staff drove us out to Clark's school at Penia in a rickety and beat-up pick-up truck. After a tour of the school and loading up with water, Clark introduced us to the local villager who would accompany us to see the palms. He led us up a steep trail behind the school that wound through highly disturbed and weedy secondary forest composed primarily of coconut palms and breadfruit, bananas and mangoes. We were grateful for

16. On Weno the handsome canopy of *Clinostigma carolinense* pokes above mango and other trees in forest remnants with the immense Chuuk lagoon and barrier reef in the background.

17 (top). The light green inflorescences of *Ponapea palauensis* are held below the leaves. 18 (bottom). In the Rock Islands of Palau *Hydriastele palauensis*, with its characteristic canopy of strongly recurving, pinnate leaves, is typically conspicuous on the ridgelines

the shade these trees provided for it was exceedingly hot and humid. However, we soon had to traverse lengthy swaths of shadeless, chest-high grass that offered no protection from the oppressive sun and heat. Once we stopped and rested in the scant shade of a few coconut palms, and the villager effortlessly collected several green coconuts. With gleaming machete blades swirling in the sun, he quickly opened them and we drank heartily of the cool, refreshing liquid, a welcomed addition to our bottled water.

We continued through the tall grass, slowly making our way toward a remnant patch of weedy, disturbed forest where we could see several *Clinostigma carolinense* poking their magnificent canopies above *Merremia*-draped vegetation. Finally we arrived at the forest remnants and, although eager to observe and photograph the palms, we first huddled happily in the shade to drink voraciously of water and more coconut liquid.

Similar to and perhaps not distinct from its close relative *Clinostigma ponapense*, *C. carolinense* can be distinguished primarily by its smaller fruits. However, the few specimens we saw seemed also to be larger palms (Fig. 15), with a trunk near the base considerably huskier and of greater diameter than that of *C. ponapense*. We took photos (Fig. 16) and made notes, lingering among the palms and soaking up their ambience, certainly in no hurry to begin the long, hot trek back to the school. We did notice that there appeared to be little regeneration in the weedy, disturbed forest, a worrisome observation that lead us to believe that *C. carolinense* is likely to be endangered. Once back at the school, we consumed large quantities of water, desperately trying to rehydrate our parched bodies.

Exhausted from the long, hot trek to see *Clinostigma ponapense*, we spent the next and final day relaxing, exploring Weno, and visiting with Clark. In the afternoon, we joined some young Japanese who were in Chuuk performing service in the Japanese equivalent of the Peace Corps. We visited a cave near the base of the low ridge behind the village that contained a large artillery piece with which the Japanese had protected the entrance to Chuuk lagoon. The site provided a stunning view of the main town and not too far above us we could see several specimens of *Clinostigma carolinense*, so close yet inaccessible due to the thick, dense, weedy vegetation.

Palau

On Tuesday, November 15 we said our goodbyes to Clark and departed from Chuuk for the next and final leg of our island-hopping adventures, the Republic of Palau. After a short layover on Guam, we arrived in Palau in the evening, where Ann and Clarence Kitalong, with whom we would be staying and who would help us find the palms, warmly greeted us and took us to their house.

Like Chuuk, most of the islands comprising Palau sit in an immense lagoon about 100 kms (66 miles) long and 20 kms (13 miles) wide. Babeldaob, the largest island and home to the international airport, is comprised mostly of volcanic soils although pockets of limestone

19. When especially abundant on the smaller Rock Islands of Palau, *Hydriastele palauensis* were unusually impressive because they seemed to dominate the islet and its vegetation.

rocks dot the landscape here and there. The more southerly islands are mostly limestone and include the famous Rock Islands of Palau. The warm, wet climate means that dense rain forest covers most of the islands, and this forest makes the Rock Islands particularly striking and attractive because the thick vegetation occurs right down to the high tide mark. Access to the Rock Islands is by boat but many are difficult if not impossible to land on because wave action has undercut or sheared off the base of the islands, leaving no easy entry site.

Ann, who operates an environmental consulting service and has co-authored a book about the trees of Palau, is another Peace Corps volunteer and came to Palau in the late 1970s, married a Palauan, and settled down and raised a family. Her husband Clarence is a local chief who constantly kept us laughing with his rather dry sense of humor and vast knowledge of local culture and personages. More importantly, he is a true man of the sea and loves nothing more than to be spending the day on his boat, cruising the mostly uninhabited Rock Islands, snorkeling and fishing. Clarence's love of boats and the sea and his vast knowledge of the confusing and complex labyrinth of Palau Rock Islands were especially advantageous for us because two of the palms we wanted to see on Palau, *Hydriastele palauensis* and *Ponapea palauensis*, are restricted to these islands.

The next day, after buying water, drinks and food for lunch, we headed out with Clarence and Ann in Clarence's boat to look for *Ponapea palauensis* and *Hydriastele palauensis*. The former is a rare palm, known only from a few sites on two of the Rock Islands, while the latter is much more common. Anne guided us and Clarence expertly maneuvered his boat to a landing on one of the islands with *P. palauensis*. These islands are composed of karst limestone, a deeply eroded, pitted and fissured grayish rock with razor-sharp edges. A stumble or fall on this rock would easily result in serious injury or even worse. While Clarence wisely stayed in the boat and did some fishing, Ann and we carefully and deliberately made our way over the sharp rocks, taking extreme caution to step with accuracy and precision to avoid a nasty fall. Progress was slow but we finally arrived at a small population of the palms but not without incurring several cuts on our shins, ankles, arms and hands.

Unlike its close relatives on Kosrae and Pohnpei, which occur on volcanic soils, *Ponapea palauensis* inhabits solid limestone rock, its roots growing down into cracks and crevices and pockets of accumulated leaf litter and other organic matter, sometimes conspicuously arching and branching through the air in rather spectacular fashion. A tall, slender understory palm. *P. palauensis* has a brownish, ringed trunk supporting a short, grayish green crownshaft and spreading canopy of pinnate leaves with jaggedly toothed pinnae. The light green inflorescences are held below the leaves (Fig. 17) and carry the greenish white staminate flowers and later the fruits. On an earlier visit to this site Ann had noticed that the introduced sulfur-crested cockatoo (*Cacatua galerita*) had ravaged the newly emerging spear leaves of many of the palms, perhaps trying to get to the delicate and tasty apical meristem or palm heart. We noticed little of this damage now but nearly full size yet still immature fruits had been foraged for the endosperm, possibly by rats, prompting Ann to develop a plan to return to the palms and bag the infructescences to protect the fruits. Because of the threats posed by the exotic cockatoo and the palm's rarity and narrowly restricted distribution, we felt that *P. palauensis* must be critically endangered.

After visiting another, close-by site with more *Ponapea palauensis*, we headed for one of the few rock islands with a small beach where we could tie up the boat and eat lunch. After lunch and a brief bit of snorkeling in the crystal clear water, Ann and Clarence took us to see *Hydriastele palauensis*. This palm turned out to be quite common and conspicuous, thrusting its distinctive canopy of strongly and stiffly recurved, pinnate leaves well above the dense but relatively short forest of the Rock Islands (Fig. 18). Frequently these distinctive canopies were visible on the island ridgelines, even from a considerable distance. A tall, slender palm, it has a whitish crownshaft supporting the distinctive canopy (Back Cover) below which are held the sparsely branched, somewhat broom-like inflorescences. These palms, especially when abundant and on the smaller Rock Islands, were unusually impressive because they seemed to dominate the islet and its vegetation (Fig. 19). They sometimes occur on the sheer, vertical, limestone rock walls only a meter or two from above the water, seriously challenging one's understanding of the relationship among

20. Betel nut palms (*Areca catechu*) are widely cultivated in Micronesia for their seeds.

21. In the open on Babeldaob, Palau, *Heterospathe elata* is a tall, if not majestic palm.

plant, water and soil for successful growth. In a few bizarre cases, the trunks of these wall dwellers grew down before finally turning up.

Because of a prior commitment Ann was unable to accompany us the next day but we returned to the rock islands and again Clarence skillfully guided us among the labyrinth of islands and islets, mostly looking for more *Hydriastele palauensis*. On one of the Rock Islands upon which we were able to land we found *Heterospathe elata* and *Pinanga insignis*, species more common on volcanic soils and ones we would see in abundance the next day. We encountered more *H. palauensis* and its relative abundance impressed upon us its remarkable limestone rock island habitat.

We left the Rock Islands, heading to the southeast coast of Babeldaob, where Clarence wanted to show us a hill with a stunning view and limestone rock outcrops harboring gregarious stands of *Heterospathe elata*. Again, Clarence skillfully navigated his boat, this time through shallow, nearly overgrown, backwater channels thick with encroaching mangroves to arrive at our destination. After a quick lunch, we walked through plantations of betel nut palms (Fig. 20) and ascended the small but steep hill, passing through solid, dense stands of *H. elata*. At the rather precipitous top we admired the panoramic view of southern Babeldaob before descending and returning to the boat. We returned to the Rock Islands and finished off the day by visiting a sunken Japanese war plane, snorkeling and fishing, the latter providing us with a bountiful and tasty dinner.

Ann joined us for our last day in Palau and we headed north, not by boat but by auto, to explore Babeldaob for *Heterospathe elata* and *Pinanga insignis* growing on volcanic soils. The relative abundance of both species surprised us, the former occurring along road sides, in gullies, on slopes and ridges, in primary or weedy, disturbed forest, typically thrusting its handsome canopy of spreading pinnate leaves well above the surrounding vegetation (Fig. 21). The latter grew mostly in undisturbed primary forest and was equally abundant. An unusually attractive, colorful, and eye-catching understory palm, *P. insignis* is noted for its greenish to brown, ringed trunk, pinnate leaves with relatively broad, glossy, dark green pinnae, purplish brown crownshaft, and large, conspicuous, pendant infructescences heavily laden with red to purplish black, distichously arranged fruits.

We returned to Ann and Clarence's house, ate dinner, hastily packed, and then tried to catch a few hours of sleep before our very early morning departure to Guam and then onward to Los Angeles via Honolulu. We were happy and content and remembered with great affection the wonderful people, palms and places in Micronesia that we had seen.

Acknowledgments

Numerous people and institutions assisted us on our journey to see and document Micronesian palms, and all deserve our sincere thanks. They include David Lorence and Steve Perlman of the National Tropical Botanical Garden; Karen Shigamatsu, Mashuri Waite and Steve Connely of Lyon Arboretum of the University of Hawaii; Josh Sands and Alma Phocas of the Honolulu Botanical Gardens; Carl Lewis of Fairchild Tropical Botanic Garden; Andy George and Jacob Sanno of the Kosrae Conservation and Safety Organization; Patterson Shed, Relio Lengsi, Emos Epariam and Ryoko Kawakami of the Conservation Society of Pohnpei; Clark and Curtis Graham of the SHIPS/HOOPS Institution on Chuuk; and Ann and Clarence Kitalong of Palau. Audrey Keeler and the International Palm Society supported Don's travel in Micronesia.

Shedding Light on the *Pseudophoenix* Decline

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Pseudophoenix sargentii and _P. vinifera_ are popular ornamental palms in southern Florida and over the past five years growers have noticed a blackening of the leaf sheath, assumed to be caused by a fungus. In order to understand susceptibility, we created a ranking system to analyze possible susceptibility factors: age, location, provenance and species. All 100 _Pseudophoenix_ individuals at Fairchild Tropical Botanic Garden were ranked. The presence of the decline varied with plant age. Older individuals had increased susceptibility and individuals that were not reproductively mature were always asymptomatic. The decline was found in all species except _P. ekmanii_, plants of which were not reproductively mature. _Pseudophoenix sargentii_ was the most susceptible species. Neither provenance nor location in the landscape was a significant factor.

The Caribbean palm genus *Pseudophoenix* has species found in Florida, the Bahamas, Hispaniola, Dominica, Cuba, Belize, Mexico and Puerto Rico. Species in the genus are widely cultivated in tropical and subtropical climates (Dransfield et al. 2008, Riffle et al. 2012). All *Pseudophoenix* species are solitary palms known for their bottle-like trunks, tough, waxy leaves, narrow leaflets and beautiful green crownshafts of tubular leaf sheaths. The species thrive in porous limestone and sandy soils, such as the soils in southern Florida and at Fairchild Tropical Botanic Garden (FTBG) (Everett 1980).

Pseudophoenix species in southern Florida nurseries, landscapes and at FTBG have been observed to develop a black, moldy crownshaft that leads to a decline in plant health. The decline begins as brown areas on the crownshaft that develop into large, black, sunken cankers in the leaf sheath, resulting in premature senescence of the leaf. Eventually, the individual dies. Researchers have completed preliminary studies that indicate fungal infections are associated with the decline, although it is not known whether these are causal or opportunistic (M. Elliott pers. comm.). Palm growers in south Florida think that copper fungicides prevent the decline but cannot cure infected individuals. If this is substantiated, fungicide would have to be applied continuously in order to protect *Pseudophoenix* plants.

There are four species in the genus *Pseudophoenix* (*P. ekmanii*, *P. lediniana*, *P. sargentii* and *P. vinifera*) (Zona 2002), and all four are found at FTBG. *Pseudophoenix* plants at FTBG and in the horticultural trade come from two main seed sources. Given proper authorization, collectors can collect seed from

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Table 1. Distribution of decline by age among all species of *Pseudophoenix* at Fairchild Tropical Botanic Garden. Symptoms of each rank shown in Figures 1–4. There were 23 specimens ≤ 11 yrs, 56 specimens 12–24 yrs, and 21 specimens 25–75 yrs.

	Decline Rank			
Plant Age (yrs)	0	1	2	3
≤ 11	100%	0%	0%	0%
12–24	32%	30%	21%	21%
25–75	10%	10%	43%	38%

Pseudophoenix individuals in native habitats. The individuals that grow from these seeds are thus called wild-collected. Alternatively, growers can collect seeds from plants already in cultivation. The individuals that grow from these seeds are called nursery-sourced individuals.

Although decline has been observed in *P. sargentii* and *P. vinifera* in southern Florida, we do not know whether the other *Pseudophoenix* species are susceptible. We also do not know what factors, such as soil type or seed source, are associated with or might predict susceptibility to decline. The purpose of this study was to provide a standardized description of the progression of the disease and to analyze factors potentially associated with susceptibility to decline.

Materials and Methods

This study was conducted at Fairchild Tropical Botanic Garden, Miami, Florida, USA. *Pseudophoenix* individuals at FTBG are maintained in two main habitats, the uplands and the lowlands. The uplands are characterized by sandy, dry, limestone-based soils and regular irrigation. The lowlands habitat borders a natural mangrove hammock and has mucky, wet soils with no irrigation.

All 100 *Pseudophoenix* individuals in the FTBG collection were sampled on 27 January 2012, and were observed for the presence or absence of decline, degree of decline, age of the individual and origin. The sample comprised 17 *P. ekmanii*, 9 *P. lediniana*, 42 *P. sargentii* and 28 *P. vinifera*.

In order to standardize descriptions of the progress of the decline, we developed a system of ranked classes describing decline severity. Individuals with decline were separated into four ranked classes based on crownshaft discoloration, which increased with severity of decline. The zero rank class showed no signs of decline (Fig. 1), the first rank class showed slight discoloration on the crown shaft (Fig. 2), the second rank class had a brown crownshaft with lesions (Fig. 3), while the third rank class had large black wounds in the crownshaft (Fig. 4). We analyzed the impact of three factors (age, location – as a proxy for habitat and soil type – and whether plants were wild-collected as seeds or acquired as seedlings from nurseries) on the health of the *Pseudophoenix* collection. Analysis of these factors, unless otherwise stated, included only individuals ≥ 12 years old. The addition of this constraint created a sample of 77 Pseudophoenix individuals in total: 6 *P. ekmanii* and included 1 *P. lediniana*, 42 *P. sargentii* and 24 *P. vinifera*. Significance of factors was examined with contingency table analysis.

Age was determined for each individual using accession dates and ancillary information. Individuals acquired as seeds were designated as zero years old on accession date (N = 77); individuals acquired as seedlings were designated as one year old on date of acquisition (N = 17). For three older individuals of *P. sargentii*, accession dates were not available. For these plants, plant height was used as a proxy for age. It was estimated that a one hundred and fifty centimeter tall *P. sargentii* was approximately fifteen years old. Using this approximation, ages of these individuals were estimated. Accession records were used to determine whether plants were wild-collected or nursery-sourced.

Pseudophoenix individuals were mapped to their plot to locate potential hot spots in the garden for the decline. Plants were classified as growing in either upland or lowland areas from these maps.

Results

Decline was found in all of the *Pseudophoenix* species except *P. ekmanii* (Fig. 5). During the course of three months of observation after ranking, two *P. sargentii* individuals, initially ranked as 3, died.

1–4. Symptom ranks (0–3) for *Pseudophoenix* decline. 1 (upper left). Rank 0; individual showed no symptoms of the decline and had a green crown shaft. 2 (upper right). Rank 1; individual was just beginning to show signs of decline and showed slight symptoms of the decline with slight brown or grey tint on the crown shaft. 3 (lower left). Rank 2; individual showed moderate symptoms of the decline and had a brown crown shaft, possibly with a few black lines or spots. 4 9lower right). Rank 3; individual showed severe symptoms of the decline and had large black cankers and the formation of holes in the crown shaft.

Presence of decline symptoms varied with plant age (Table 1). Young plants (≤ 11 years) of *P. sargentii, P. lediniana and P. ekmanii* were asymptomatic. FTBG did not have plantings of *P. vinifera* younger than 12 years, but asymptomatic individuals were found in the younger individuals of this species, whereas older individuals all showed symptoms of decline. Similarly, the only older individual of *P. lediniana* (38 years old) had decline symptoms (Fig. 5). The youngest *P. sargentii* individual to show symptoms for the decline was 13 years old, while the youngest *P. vinifera* individual was 12.

When analyzing older plants (≥ 12 years old) of *P. sargentii* and *P. vinifera,* there was no difference in the presence of decline between upland and lowland plots at FTBG ($\chi^2 = 0.424$, $P > \chi^2 = 0.5152$). A similar lack of significant results was found when the two species were analyzed individually. There was also no difference in the presence of decline between FTBG plants from seeds that were wild-collected or nursery-produced seedlings for *P. sargentii* and *P. vinifera* ($\chi^2 = 0.795$, $P > \chi^2 = 0.3726$). This result for seed/seedling provenance was also non-significant when species were analyzed individually.

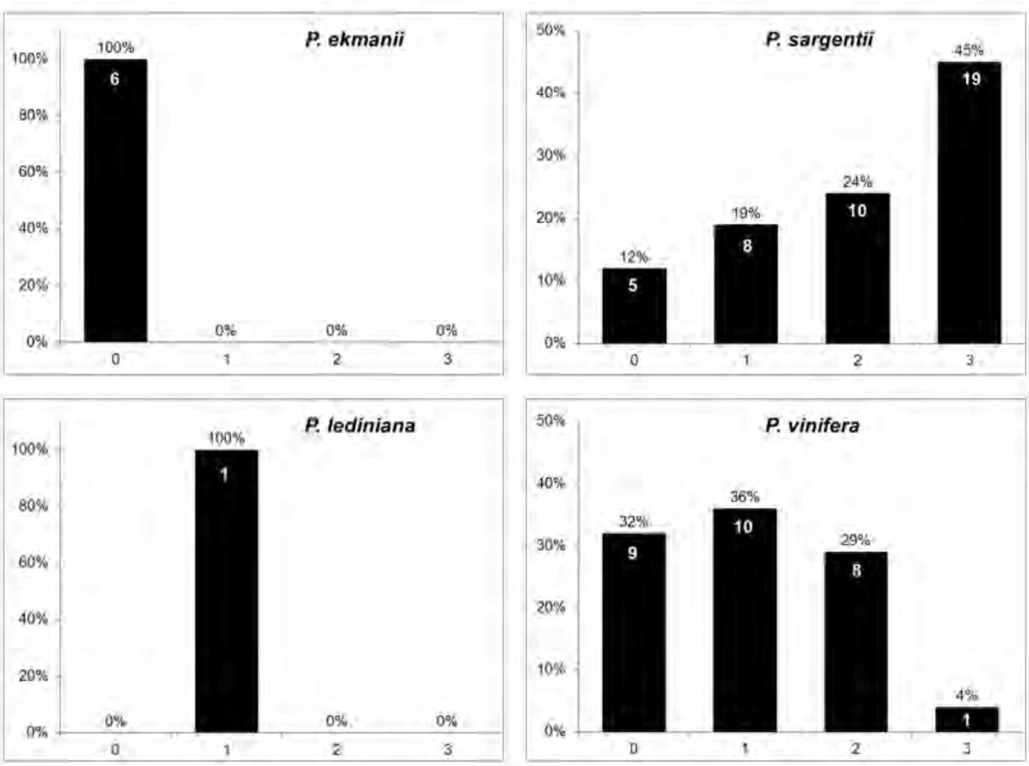
Mature individuals (≥ 12 years old) of *P. sargentii* and *P. vinifera* displayed all stages of decline (Fig. 5), but the two species differed in the severity of decline. The most common rank for *P. sargentii* was 3, while the most common rank for *P. vinifera* was 1 (Fig. 5).

The map of all *Pseudophoenix* individuals and their rank showed no hot spots in the garden for the decline.

Discussion

The decline severity ranking system presented here allowed us to analyze the decline's association with other factors and could be useful for documenting the progress of this disease over time. While this decline can lead to death, the decline is very slow to develop and time between initial symptom development and death appears to take years, not months. Many individuals with severe symptoms continue to produce viable seeds.

5. Distribution of decline ranks among individuals ≥ 12 years old for *P. ekmanii*, *P. vinifera*, *P. sargentii* and *P. vinifera* at FTBG. Data are percent of sample for each species at each rank, while white numbers within the bars are the number of individuals given each rank.



6. A picture from the Fairchild Tropical Botanical Garden archives taken in 1992 of a *Pseudophoenix sargentii individual with discoloration on the leaf sheaths.*

Decline was found in three of the four *Pseudophoenix* species. The two main factors found to be associated with progress of the decline were age and species of the individual. This study found no evidence that severity of decline was based on whether seeds were wild-collected vs. nursery-generated or on habitat and treatment after planting. Examination of older pictures of *Pseudophoenix* individuals found in the FTBG archives showed that the condition was present at least for the past 20 years and has only been recognized more recently, over the past 5 years (Fig. 6).

Pseudophoenix lediniana, *P. sargentii* and *P. vinifera* all showed symptoms once individuals were reproductively mature, and Table 1 suggests that with an increase in age, the symptoms increase in severity. No reproductively immature individual showed symptoms of decline. Although no *P. ekmanii* individuals showed decline, none of them was reproductively mature, consistent with the observation that juvenile palms are more resistant. Since the age of reproductive maturity differs for each of the species, however, age alone cannot predict susceptibility.

The trend for increased severity with age was exaggerated for *P. sargentii* individuals. Older individuals of this species may have been infected for a longer period than younger individuals by the agent(s) causing the decline. This increased exposure time could have resulted in the increased severity, although we do not know whether there is some factor associated with aging, such as a decline in vigor, a decreased growth rate or an increased allocation to reproductive effort that caused increased severity in older plants.

In southern Florida *P. sargentii* has been in cultivation for longer than the other three species and has the largest *ex situ* population. The heightened infection rate of *P. sargentii* could thus be a result of its historical popularity and use in southern Florida, which has produced both more and older individuals in the landscape. With increased popularity, cultivation, and exposure of *P. lediniana* and *P. vinifera*, the severity and number infected for these species will likely increase.

Since individuals decline slowly overtime, the use of preventive measures before the decline is observed are thought to be necessary in order to maintain healthy plants. Preventive measures common among palm horticulturists include but are not limited to hydrogen peroxide treatment poured directly in the bud or copper fungicide spray applied to the leaf bases. Neither of these techniques, however, have been tested or proven to be effective, so additional research for control measures is needed. Other suggestions to lessen decline in cultivated plants include increasing seed propagation only from asymptomatic individuals, possibly creating a stronger, less susceptible population.

More research needs to be completed in order determine the pathogen and to find treatments that are more effective and affordable. Two of the four species are considered to be critically endangered (IUCN 2012) and thus are of special concern. Evaluation of populations and the progress of the decline outside of FTBG and in other parts of the Caribbean will further increase our understanding of the threat posed by this decline throughout these species' native and cultivated ranges.

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An Anatomical Character to Support the Cohesive Unit of *Butia* Species

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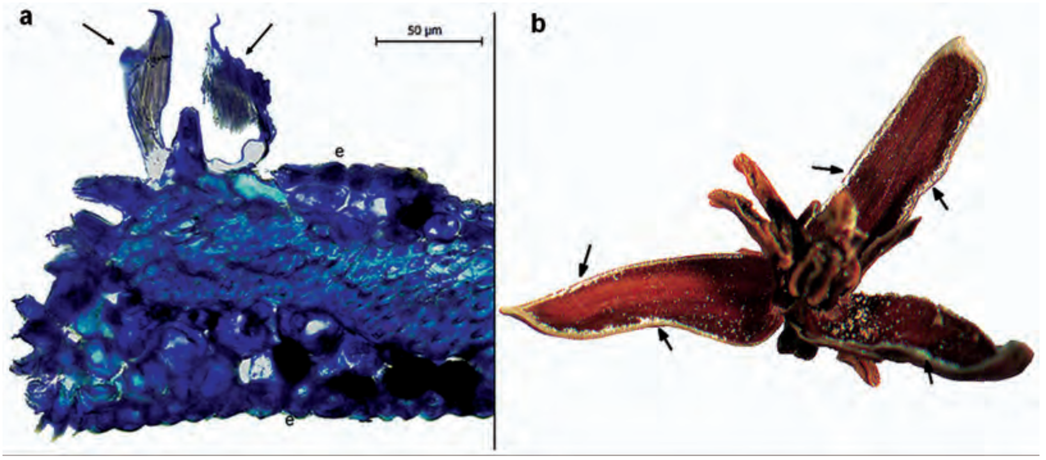
Raphides are common cell inclusions in vegetative and reproductive palm organs. However, epidermal raphide-containing idioblasts are quite unusual and have been recorded only a few times on flower petals in palms. Here we describe their presence in all *Butia* staminate flowers sampled, and we discuss their taxonomic and biological significance.

Raphides are widespread cell inclusions in angiosperms. They are linked to a wide range of functions in plants, including storage forms of calcium and oxalic acid (Arnott & Pautard 1970, Sunell & Healey, 1979), as simple depositories for metabolic wastes or promoting air space formation (Prychid & Rudall 1999), as defense device against herbivores (Sakai et al. 1972, Perera et al., 1990, Ward et al. 1997) or even as a reward for bee pollinators (D'Arcy et al. 1996). They have been described by Tomlinson et al. (2011) to be intrinsic to palm anatomy, commonly occurring in diverse organs (Uhl & Dransfield 1987, Tomlinson 1961, 1990, Tomlinson et al. 2011). In palm flowers, they have been recorded in almost all parts of the flower (Castaño et al. 2009). Thus, they have been reported in the base of the



1. Staminate flowers of *Butia*. A. Anatomical micrograph of *B. paraguayensis* (transversal view) showing epidermal raphide idioblasts. B. Dried staminate flower of *B. purpurascens* (at anthesis) 60x. Arrows indicate raphide bundles on petal margins. e, epidermis.

flower (Castaño et al. 2011), in the mesophyll of petals and sepals (Uhl 1972, Askgaard et al. 2008), on petals as trichome "sacs" (Robertson 1978), scattered throughout the pistil (Uhl & Moore 1971), in the mesophyll of the ovary (Uhl & Moore 1971, Barfod & Uhl 2001, Giddey et al. 2008), inside the pollen sacs (Henderson & Rodriguez 1999) and embedded in the inner tissue of the embryos (Zona 2004).

Butia (Becc.) Becc. is a medium size palm genus that includes 20 species (Govaerts et al. 2012, Noblick 2010). It is endemic to subtropical southern South America and occurs in Brazil, Paraguay, Uruguay and Argentina, growing in open dry areas, grasslands and *cerrado* formations (Henderson et al. 1995). *Butia* species form a highly diverse group due to the fact that they have probably undergone a rapid adaptive radiation (Pintaud et al. 2008).

During a recent survey on scent-producing organs in palm flowers, we identified characteristic structures on the corolla margins in staminate flowers of *B. paraguayensis* (Barb. Rodr.) L.H. Bailey (Fig 1a). Crystals on these areas were clearly identified by stereo-microscopy and this prompted us to undertake an in-depth study on their presence in other species within the genus. In this contribution we discuss the taxonomic and biological implications of these epidermal raphide-containing idioblasts in *Butia*.

Materials and methods

The study was carried out from February to June 2012 in the Montgomery Botanical Center (MBC) and the Fairchild Tropical Botanic Garden's Herbarium (FTG). We analyzed 13 out of 20 recognized *Butia* species. Fresh staminate flowers were sampled from live individuals at MBC: *B. marmorii* Noblick, *B. paraguayensis* (Barb. Rodr.) L.H. Bailey, *B. yatay* (Mart.) Becc., and *Butia* sp. Buds and open dried staminate flowers were sampled from specimens deposited at FTG: *B. archeri* (Glassman) Glassman, *B. capitata* (Mart.) Becc., *B. catarinensis* Noblick & Lorenzi, *B. eriospatha* (Mart. ex Drude) Becc., *B. exospadix* Noblick, *B. lallemantii* Deble & Marchiori, *B. marmorii* Noblick, *B. matogrossensis* Noblick & Lorenzi, *B. microspadix* Burret, *B. odorata* (Barb. Rodr.) Noblick, *B. paraguayensis* (Barb. Rodr.) L.H. Bailey, *B. purpurascens* Glassman, *B. yatay* (Mart.) Becc. Furthermore, we analyzed staminate flowers of related taxa, such as *Jubaea chilensis* (Molina) Baill. sampled from Los Angeles County (University of California) and Lotusland; *Syagrus coronata* (Mart.) Becc., *S. kellyana* Noblick & Lorenzi, *S. romanzoffiana* (Cham.) Glassman, all from MBC.

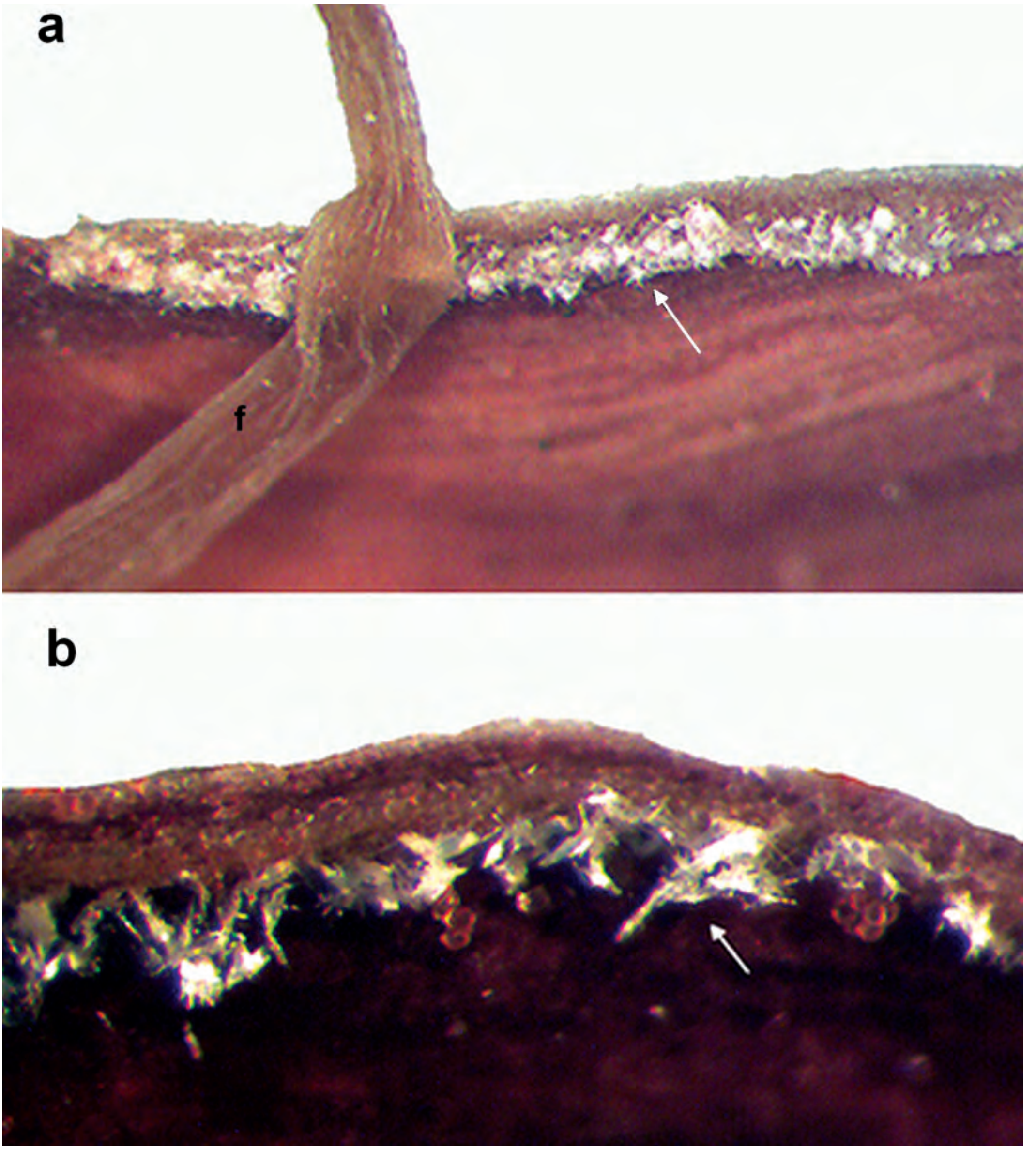
Flowers were studied under a light stereomicroscope searching for exposed raphide crystals and trichomes on the petal margins. Anatomical slides were prepared through free-hand sections or embedded in Technovit 7100 (2-hydro-xyethyl meth-acrylate). Serial sectioning was carried out using a rotary microtome (Sorvall Porter-Blum MT-1) at 5 µm. The sections were stained with toluidine blue. Observations were made using a Leica microscope (DM-500), micrographs were taken with a Leica ICC-50 and the images were edited using Leica Application System-LAS EZ (Leica Microsystems Framework).

Results and Discussion

Exposed raphide bundles on the corolla were identified in all *Butia* species sampled. They were easily recognizable under a stereo-microscope (Figs. 1b & 2). High densities of exposed raphide crystals were commonly observed in almost all taxa studied. They could not be easily identified in a few samples of *B. marmorii* flowers as they were remarkably smaller than in the other species studied; however, their presence was confirmed by optical microscopy. These idioblasts are globe-shaped and are dispersed in the epidermis of the petal (Fig. 1a). The raphide containing idioblasts, either of epidermal or subepidermal origin, are easily broken due the presence of thin cell walls. Therefore raphide crystals are commonly exposed in open staminate flowers (Fig. 1b). Raphide bundles and raphide containing idioblasts were not detected on the petal margins of the staminate flowers of the *Jubaea* and *Syagrus* species that were studied.

For many years, *Jubaeopsis caffra* has been reported as the only palm with raphide containing idioblasts ("sacs") on its corolla epidermis (Robertson 1978). However, similar

2. Raphide bundles on the inner zone of the petal margins of *Butia* species. A. Petal of *B. yatay* at 250x. B. Petal of *B. matogrossensis* at 250x. Arrows indicate the presence of raphides. f, stamen filament.



idioblasts have been recorded on the staminate flowers of *Aphandra natalia* (Barfod & Uhl 2001) and also on floral organs outside the palm family in the asparagoid family Tecophileaceae (Prychid & Rudall 1999). Furthermore, Cocucci (1964) probably referred to these kind of idioblasts when he recorded the presence of raphide containing idioblasts (described by him as hypertrophied cells) on the "tepals" of *B. paraguayensis* flowers; however, no further details were provided. Raphide containing idioblasts on the corolla could be present in other palm taxa, but a much wider research effort would be required to confirm this fact.

Past studies have suggested a close relationship between *Butia* and *Syagrus* (Henderson et al. 1995). Indeed, some currently recognized *Butia* species were actually placed for a long time in *Syagrus*, such as *B. campicola* (as *S. campicola*; Noblick 2004) and *B. leptospatha* (as *S. leptospatha*; Noblick 2006). However, cladistic analysis of morphological and anatomical characters (Noblick et al. in press) and DNA analysis based on PKR and seven WRKY gene markers showed that *Butia* is more closely related to *Jubaea* (Gunn 2004; Meerow et al. 2009). Both *Butia* and *Jubaea* share some morphological characteristics (Seubert 1998a & b, Dransfield et al. 2008, Noblick et al. 2012) and floral features, such as papillate petal margins. Our study shows that *Jubaea chilensis* does not present raphide-containing idioblasts on the petal margins. This supports *Jubaea* as a genus clearly distinct from *Butia*. Raphide-containing idioblasts could be proposed as a new synapomorphic character for *Butia*, further supporting its cohesive monophyly. Raphides have been used to support the establishment of the "*Chelyocarpus* alliance" (Moore 1972, Uhl 1972) and the relationships within other taxa such as Rubiaceae (Lersten 1974) and *Prunus* (Lersten & Horner 2000). Their absence represents a synapomorphic character in some Monocots (Prychid & Rudall 1999).

Raphide-containing idioblasts can be explained as a defensive device against florivory. In palms, they protect the flower against deleterious fauna (Uhl & Moore 1973) and form a physical barrier to keep insects away (Uhl & Moore 1977). High densities of raphide crystals could represent an efficient physical barrier to pollen-eating insects (Askgaard et al. 2008). Barfod et al. (1999) hypothesized that pollen-like raphide idioblasts are responsible for thwarting pollen-feeding insects such as *Derelomini* and *Mystrops* beetles in *Aphandra natalia*. The same authors indicate that the presence of raphide blisters could explain (among others) the absence of egg chambers in flowers of *Ammandra* species. Moreover, exposed raphide crystals could also be related to a pollination shift from predominately beetle-pollinated species, as observed for *Syagrus* spp., to bee-pollinated, as reported for *Butia* spp. (see Henderson 1986, Silberbauer-Gottsberger 1990, Gottsberger and Silberbauer-Gottsberger 2006 for pollination reports on *Butia* and *Syagrus*). Due to the fact that raphides do not damage the alimentary canals of bees (Roubik 1989), they could play an as yet underestimated role as a pollinator reward for bees (D'Arcy et al. 1996). Further studies are needed in order to understand the reproductive significance of raphide bundles in palms and, specifically, the significance of the raphide-containing idioblasts on the petals.

Acknowledgments

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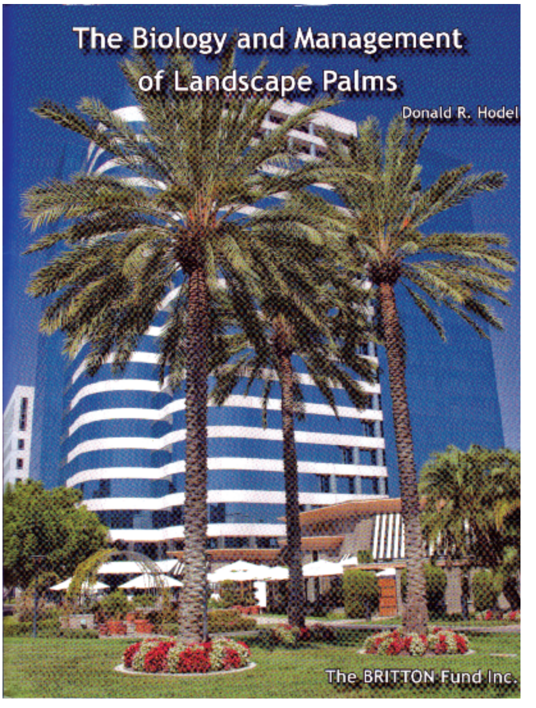
THE BIOLOGY AND MANAGEMENT OF LANDSCAPE PALMS – Donald R. Hodel. The Britton Fund, Porterville, CA. 2012. ISBN unknown. Price: US$35.00 Softcover. 176 pages, 429 color plates.



This book represents a compilation of eleven chapters, originally published over a period of 4 years, as articles in *Western Arborist*. It is well laid out and is copiously illustrated in full color with hundreds of high quality photographs by the author. However, in looking over the photographs it soon becomes apparent that there is a lot of redundancy in the illustration of various points. For example, the author provides four photographs of longitudinally split trunks, six of two-tiered canopies, seven of pencil-pointing and constricted trunks, five of trunk erosion, thirteen of trunk failure from unknown causes, etc. where one or two would have been sufficient. In some cases the same or similar photos were used more than once, even in the same chapter (e.g., Figs. 5 and 10 in Chapter 7 or Figs. 8, 9 and 10 in Chapter 8).

This book would more appropriately be titled "The Biology and Management of Landscape Palms in Southwestern United States." Although Hawaii is mentioned in several chapters, it is totally ignored in others. Management of landscape palms in Hawaii and other tropical areas is never given adequate coverage. Since the climate of Hawaii differs so greatly from that of California, its inclusion seems more like an afterthought than a serious attempt to address palm management issues under tropical environmental conditions. Only a couple of truly tropical palm species are described in Chapter 11, a compendium of palm species.

This book begins with an excellent chapter discussing the various aspects of basic palm biology that are relevant to landscape palm management. Included are a couple of side bars that discuss related topics such as "the role of palms in the urban forest" and "invasive species." In the latter, Hodel rightly contends that the term "native" should be based on "floristic and ecological, rather than geopolitical boundaries."

Because this book is a collection of previously published articles, there is little consistency in the scope and comprehensiveness of the various chapters. For example, Chapter 1 on palm biology is quite broad in scope but cites only three references. Chapter 10 on transplanting is only three pages long and discusses only studies published by the author on the subject. On the other hand, the chapters on palm nutrition and non-nutritional disorders provide much more comprehensive discussions of those subjects with extensive citations of research done in Florida and other parts of the world as well. The chapters on diseases and pests and the compendium of palm species are primarily limited in their scope to southwestern USA.

Chapter 8 presents 22 photographs of failed palm trunks that all look about the same and a not very useful table documenting 14 individual cases of palm failures, most of which had unknown causes. Because the various causes of trunk failure are discussed in other chapters, Chapter 8 could have been omitted with little loss of information.

Acknowledging that no book is perfect, there are errors in content within this book. For example, I noted fourteen incorrect statements and two mislabeled figures in the chapter on palm nutrition and fertilizers. For most chapters, however, the number of errors was typically only about two or three. I noted no

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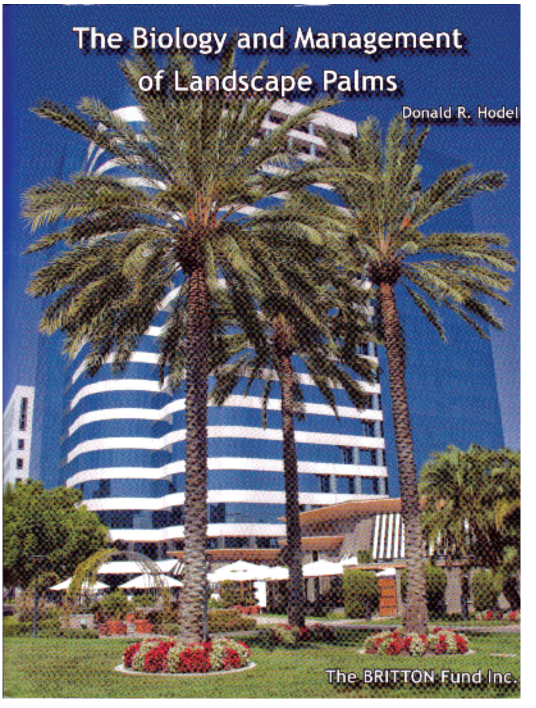

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Phoenix dactylifera and *P. sylvestris* in Northwestern India: A Glimpse of their Complex Relationships

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***Phoenix sylvestris* has often been regarded as the wild progenitor of the cultivated date palm *Phoenix dactylifera*. A genetic study recently discarded this hypothesis, suggesting however a possible occurrence of hybridization events during the expansion of date palm cultivation. A sampling campaign was carried out in Northwestern India as a first step towards understanding the complex relationships between these two species.**

Background

Phoenix sylvestris

Phoenix sylvestris Roxb., together with 13 other species, forms the genus *Phoenix* (Govaerts & Dransfield 2005). In a phylogenetic study combining morphological, anatomical and genetic data, it appears close to the date palm (*Phoenix dactylifera* L.) and to *Phoenix theophrasti* (Barrow 1998). The phylogeny of

1. Location of our study area within South Asia with present-day political divisions, indicating the approximate geographical extent of the Harappan civilization, also known as the Indus valley civilization (ca. 2600–1900 BC). Map by Laure Paradis.

the genus itself remains to be elucidated.

Phoenix sylvestris is widely distributed in South Asia, from Pakistan to Myanmar, across India, Nepal, Bhutan and Bangladesh (Barrow 1998, Henderson 2009) (Fig. 1). In present-day India, it is commonly found on low ground in the sub-Himalayan tract, along riverbanks on the Deccan Plateau (south-central India), in forests up to elevations of 1350 m in Himachal Pradesh, and especially on lower hill slopes in Haryana (northwestern India). It survives in disturbed areas, such as wastelands or seasonally inundated areas (Parmar & Kaushal 1982).

Apart from its distribution in a "wild" state, *P. sylvestris* is also cultivated in parts of South Asia, mostly in its eastern and southeastern parts according to the literature: West Bengal (including Kolkata), the Coromandel coast, Andhra Pradesh (southeastern India) and Chittagong (eastern Bangladesh) (Parmar & Kaushal 1982, Pattnayak & Misra 2004, Chowdhury et al. 2008), in Punjab and Sind provinces of Pakistan (Stewart 1972). It is cultivated mostly for its sap, which is boiled down to produce a sweet juice (jaggery, *gur, jaguri, bella*) and even sugar. The sweet juice can be drunk as such or may be made into wine (toddy, *tari*) (Griffith 1850, Parmar & Kaushal 1982, Chowdhury et al. 2008). This use does not appear to be restricted to the cultivated palms. In fact, the names used for the sweet juice derived from *P. sylvestris* sap are also given to the sweet juice extracted from other palms and from sugarcane (Pattnayak & Misra 2004).

2. Map of Northwestern India. Sampling areas are indicated. Map by Laure Paradis.

Whether wild or cultivated, this palm is used for other purposes as well. The fruit is sweet and edible, although the seed is large compared to the amount of flesh. It is used both as food and as fodder for domestic animals. The stem is widely used as building material – beams in houses and half-pipes to conduct water – and the leaves for matting and basketry. The palm is also planted as an ornamental along roadsides and in gardens. Additionally, many parts of the plant are used for their medicinal properties (Parmar & Kaushal 1982).

In English, it is called date-sugar palm, Indian wine palm, sugar palm or wild date palm. Its local names in South Asia are numerous, according to the different regions and languages spoken: *sendhi, kejur, khajur, khaji, salma, thalma, thakil* (Hindi-Urdu); *kajar, kejur* (Bengali, Bengal); *khejuri* (Oriya, Orissa, W. Bengal); *khajur* (Kolami, Andhra Pradesh, Maharashtra); *khijur* (Santali); *sindi* (Gondi); *khajur, khaji* (Punjabi); *seindi* (Berar); *inta kattinta* (Kerala); *sendi, khajura, khajuri* (Bambaiya, Mumbai, Mahashashtra); *boichand, sendri, shindi* (Marathi, Maharashtra); *kharak* (Gujarati, Gujarat); *sandole-ka-nar* (Dakhini, Deccan); *itchumpannay, periaitcham, itcham-nar, ichal, ithal pannay* (Tamil, Tamilnadu); *ita, pedda-ita, itanara, ishan-chedi* (Telugu, Andhra Pradesh); *ichal, kullu, ichalu mara* (Kannada, Karnataka); *andadayichali, sunindu* (Karnataka); *khurjjuri, kharjura, madhukshir* (Sanskrit) (after Blatter 1926, Parmar & Kaushal 1982).

Phoenix dactylifera in South Asia

The date palm is presently cultivated mostly in the Indus Valley, on the piedmont of Baluchistan and in the Punjab (Fig. 1). It is yet unclear how ancient this practice is; apart from very ancient isolated seeds found in southeastern Iran and the Baluchistan and which need direct radiocarbon dating (Tengberg & Newton in press, Costantini 1985), several sites belonging to the Harappan culture (also called Indus Valley civilization) have yielded archaeological seeds, including Harappa, Mohenjo-Daro and Nausharo; they date to the second half of the third millennium BC (Fig. 1) (Weber 1999, Marshall 1931, Costantini 1990). They probably belong to *P. dactylifera,* but the specific identity of some of them will be investigated.

Despite these ancient findings, the origin of date palm cultivation in the Indus Valley is locally attributed either to the army of Alexander the Great (4th Century BC), or more recently to Arab conquerors (7th Century AD) or to pilgrims returning from Mecca (Bonavia 1885, Chandra et al. 1992). British officials

3. Leaf grinding for cattle feed (Jarpara, Kutch) (Photo. Sarah Ivorra).

4. Date palms along the boundaries of cotton fields (Nagar Pol, near Anjar, Kutch) (Photo. Sarah Ivorra).

also tried to reintroduce date palm cultivation from the Persian Gulf in the late 19th and early 20th Centuries, with mixed results (Bonavia 1885, Milne 1918). The most recent endeavors have recently been focused on selecting potential local and introduced cultivars in Kutch, and on encouraging new plantations in newly irrigated areas of the Thar Desert in western Rajasthan (Chandra et al. 1992).

In present-day India, the main region where the date palm is cultivated is the fertile coastal belt of Kutch, the westernmost part of Gujarat bordering with Pakistan (Fig. 2). This southern part of Kutch was until the recent construction of bridges, isolated from the mainland by seasonally flooded salt marshes, the Little and Great Ranns of Kutch. This region has a tropical monsoon climate with hot summers and mild winters. It is very dry except during the monsoon season from July to September when rains can be torrential; in this climate, early maturing of the fruit is important because harvesting must take place before the onset of the rains.

The palm groves are located in three distinct areas – nearest the coast where little irrigation is necessary, and where most of the production occurs (near Mundra, Dhrab and Jarpara), away from the coast where the water table is low but accessible from wells for irrigation and where dates mature one week earlier than on the coast (near Anjar and Khedoi), and near small rivers and between hills where rainwater accumulates in a loamy sandy soil, where fruit maturity is reached even earlier (between Mundra and Bhuj; near Khedoi) (Chandra et al. 1992,Vashishtha 2003) (Fig. 2). It is thought that these groves have been more intensively exploited in the last 200 years, and even more so since the second half of the 20th Century, after the building of the bridges, which gave market value to the fruit by enabling their export from Kutch to mainland Gujarat. The origin of the groves is explained in a similar way as in the Indus Valley, with the additional option that Arab gardeners working in the palaces of former rulers of Kutch may have introduced the date palm.

The date palm population in Kutch was evaluated around 1.9 million in an area of 12,493 ha in 2005 (Date Palm Research Station of SDAU, Mundra, online document). This population is almost entirely composed of seedlings; the palms are not propagated by offshoots, but by seeds, and eliminating individuals after the first flowering event controls the male population. The quality of dates is therefore highly variable. Moreover, because of the early onset of monsoon rains, dates are harvested at *khalal* stage (here called *doka*) before complete maturation. Recent work at the Date Palm Research Station, now located in Mundra, has involved vegetative multiplication of selected local "elite" palms,

5. Modern date palm grove (Devpur, Kutch) (Photo. Sarah Ivorra).

but mostly the introduction and evaluation of foreign cultivars for their suitability in Kutch. Only two of these seem to be successful: 'Barhee' and 'Halawy,' from Iraq, the first being well known for the quality of its fruit at the *khalal* stage.

These characteristics of the Indian palm groves lead to low production and India therefore imports dates from Pakistan and Middle Eastern countries to meet consumer demand (300,000 tons in 2009 according to FAOSTAT).

The complex relationships between *P. sylvestris* and *P. dactylifera*

Morphologically, *P. sylvestris* is close to the date palm, but several characters allow their differentiation. *Phoenix sylvestris* is a strictly solitary palm, also distinguished by its dense

6. Fruits of *Phoenix dactylifera*.

7. *Phoenix* on field edges (ca. Jamnagar, Kathiawar Peninsula), identified as *P. dactylifera* using molecular analysis (Photo. Sarah Ivorra).

spherical crown composed of relatively short leaves with small leaf bases forming a characteristic dense and regular pattern of small diamond-shaped leaf scars on the trunk of old specimens. Leaf segments are grayish, not very rigid and sometimes twisted. Basal acanthophylls are long, deeply channelled adaxially, grouped by two and the transition with foliar segments is progressive. *Phoenix dactylifera* is considerably less homogeneous morphologically than *P. sylvestris*. It is usually clustering, although suckering tends to decrease with age and varies among varieties. In cultivation, the solitary habit may result from the removal of suckers. The crown of *P. dactylifera* is variously sized and shaped (spherical to hemispherical, dense to open, small to large), but the leaf bases always enlarge considerably producing a pattern of large leaf scars on the trunk. Leaf segments are variously colored, from dark green to bluish, and vary from thin and soft to thick and rigid. Acanthophylls are extremely variable in size, shape and grouping but they are generally much smaller than and sharply differentiated from foliar segments. Barrow (1998) distinguished *P. sylvestris* by having channelled acanthophylls, but this characteristic is also common in *P. dactylifera*. In both species, leaf segments are clustered and disposed on various planes. The fruits of *P. sylvestris* are smaller (15–25 × 12 mm) than those of the date palm (40–70 × 20–30 mm) (Barrow 1998).

Because of this morphological proximity, *P. sylvestris* has long been considered as the wild progenitor of the cultivated date palm. However, a genetic study challenged this hypothesis (Pintaud et al. 2010) and with the discovery of truly wild date palm (*Phoenix dactylifera*) populations (Gros-Balthazard et al., in preparation), it is now completely rejected. Nevertheless, the two species are inter-fertile, and their relationship remains to be investigated. Indeed, the two species are believed to occur in sympatry in Pakistan and northwestern India, and natural crossbreeding is possible. Furthermore, humans may wittingly use the pollen of *P. sylvestris* to fertilize date palms. This may be only anecdotal, for lack of *P. dactylifera* pollen for example, but also experimental and deliberate. Indeed, metaxenia, i.e. the influence of pollen on the size, shape and weight of fruits and also maturation time is well known (Al-Khalifah 2006, Swingle 1928). A potential beneficial effect of *P. sylvestris* pollen may encourage the farmer to use it instead of *P. dactylifera* pollen; a British officer with no prior knowledge in date palm cultivation related such an experiment in Lucknow (Uttar Pradesh) in the late 19th Century (Bonavia

1885). Sowing and germination of seeds from these crosses gives fully fertile hybrids. Subsequent selection of these individuals or their progeny with interesting features is possible and would lead to the creation of hybrid varieties. However, there is no confirmed record of that kind to date.

The sampling campaign

Northwestern India appears as the perfect place for the study of the relationships between these two species as they are believed to occur in sympatry. We visited Gujarat and Rajasthan (Fig. 2) during two weeks in June and July 2010 with the aim of prospecting and sampling *Phoenix sylvestris* and *Phoenix dactylifera*. We collected both seeds and leaflets, to be used in morphometric and genetic analyses, respectively. The result of this campaign is presented here as well as observations regarding the cultivation and uses of these two *Phoenix* species.

***Phoenix dactylifera* in the coastal plains of Kutch**

Several plantations were investigated in the three different cultivation zones defined by Chandra et al. (1992, see above): in Mundra, Dhrab and Jarpara, closest to the coast, near Anjar and Khedoi in the East of Kutch, some 20 km from the coast, and in Gadhsisa and Devpur, higher in the hills, about 30 km from the sea (Fig. 2). These stations are low in altitude, from a few meters above sea level for Mundra and surroundings to 150 m above sea level in Gadhsisa.

In Mundra, we visited the Date Palm Research Station of the Sardarkrushinagar Dantiwada Agricultural University. Its Dhrab extension holds a living collection of about 20 cultivars from collections located around the Persian Gulf, introduced since 1980, when the station was moved following a destructive flood. Within the reaches of Dhrab, we prospected two farms where date palm seedlings were found on the edges of fields but with a higher density than further inland. Overall, this area seems to be the main center of date palm production; apart from a higher density of palm trees and the research station, it also holds several nurseries that provide seedlings to growers in the whole of Kutch. The dates here are used mostly for human food, and the palm leaves are shredded and fed to cattle (Fig. 3). Soil salinity seemed to be an issue for one of the farms. Alongside the date palm, the major crops are pearl millet, sorghum, alfalfa and fruit trees such as sapote, papaya, guava, mango and coconut.

Near Anjar and Khedoi, we visited two farms where fields are larger and the date palms are also found at their boundaries (Fig. 4). In the suburbs of Anjar, the date palms are grown

8. *Phoenix sylvestris* along the Sasoy River, in the North of the Kathiawar Peninsula (Photo. Sarah Ivorra).

from seedlings originating from a nursery in Mundra and established as part of a government relief policy after the earthquake of 2001, which destroyed much of the agricultural infrastructure. On this farm, date cultivation is therefore only a decade old. The Khedoi farm, located 10 km away on the road to Mundra, also grows date palms from seedlings (about 150 individuals). However, in this case the seedlings are obtained locally, and date palm cultivation goes back to sometime during the 20th century. According to the farmer, the first individuals were introduced (in the form of seeds?) from Iraq and/or Iran. Manual pollination is practised, either with pollen from the three local male palms, or with pollen bought in Mundra when the timing of female flowering does not coincide with any of the males. Main crops in this area are pearl millet, sorghum, cotton, sugarcane and other fruit crops: coconut, papaya, pomegranate, grapefruit and mango. On both farms, channel irrigation is used, as the groundwater is too low and the climate too arid; outside irrigated fields, the vegetation is dominated by *Prosopis* xeric shrub-land. Dates are used for personal consumption, sold at the local market or used as cattle feed.

Around Ghadsisa, the landscape is hilly and the altitude higher, around 150 m above sea level. We first visited a large and modern farm focused on mango production and export. Several other fruit crops are grown – sapote, several types of citrus, bananas and pomegranate. Dates are not a major product of this farm, and the palms are planted (from seedlings) along the paths. A neighboring farm consisted of a new commercial monovarietal plantation of the 'Barhee' date cultivar established in 2008 through the import of offshoots from the Arabian Peninsula (U.A.E.), and where drip irrigation is in use. The third farm we visited in the area, within the village of Devpur, is also a modern date palm grove which displays several features of the previous plantation; the palms are planted following a grid pattern, drip irrigation is used, no other crops are grown between the palms, and the fruit on their stalks are protected from insect pests by plastic netting (Fig. 5). The only remaining traditional feature is that all the palms are grown from seeds.

Overall the picture of date palm cultivation in Kutch is diverse. Apart from very recent experiments with "industrial"-type cultivation, including the import of offshoots from abroad, in most cases, and in particular on what seemed to be the more traditional farms, the date palm is included in a diversified agricultural system very rich in fruit crops,

9. *Phoenix sylvestris* on Mount Abu (Rajasthan) (Photo. Sarah Ivorra).

similar to the Middle-eastern oasis *bustân*. The technique of hand pollination is well known, and the proportion of males is very low, as it is elsewhere. It is not unknown that pollen from Mount Abu *P. sylvestris* is used to pollinate date palms at the Date Palm Research Station and in Kutch, but there it is only an anecdotal practice.

A major difference with palm cultivation in the main date producing regions is the absence of vegetative propagation by the planting of offshoots; nearly all the date palms are grown from seeds. This leads to an absence of local cultivars and a large diversity of genotypes (Fig. 6). Several nurseries are working on the selection of female individuals for the edibility of their fruit at the earliest stage of maturation (*doka* in Gujarati, *khalal* in Arabic), when the flesh is still pale, juicy and crunchy like an apple. Nevertheless, these interesting genotypes are transplanted in palm groves but not cloned.

To conclude, we did not find any *P. sylvestris* on the coastal plains and hills of Kutch.

***Phoenix* in the Kathiawar Peninsula**

The Kathiawar Peninsula is located in Southwestern Gujarat and characterized by overall low relief, except in the south-central Gir hills. We collected *Phoenix* populations in two distinct areas – near the north coast on the Gulf of Kutch, close to the city of Jamnagar, and farther south near Girnar hill (part of the Gir hills), close to the city of Junagadh (Fig. 2).

In both regions and along our route between them, the palms were found growing both in ruderal form or in partly managed populations in hedges along fields, and in riparian populations, in riverbeds or on riverbanks.

In the agricultural landscape, the palms grow on field edges; individuals or clusters are occasionally present, sometimes close to the houses (Fig. 7). They form hedges, together with shrubs such as acacias, *Calotropis procera* and henna, and comprise male and female individuals in similar proportions. The distinction between *P. sylvestris* and *P. dactylifera* was not always clear and the specific assignation was performed in the lab using molecular markers. Near Jamnagar, one female individual bore a mixture of fertilized and parthenocarpic fruits, as in the case of natural pollination without human intervention, and another female was said not to produce fruits, at least not good ones, according to the farmers. This individual is categorized as "*jongli khajoori*," i.e. "wild khajoor," and had been tapped for sap. Genetic analysis identified it as *P. sylvestris*. Near Junagadh, we also saw little evidence of sap collection, with only one individual bearing incisions; it also belongs to *P. sylvestris*. A few meters away, several *P. dactylifera* were found in a hedge. Sap collection in the Kathiawar Peninsula is therefore not practiced intensively or commercially, in contrast with southeastern India or even Mount Abu. The palms are only casually used as part of a diversified agricultural economy, but this may not have been the case in the past. Whether the distribution of *Phoenix* in the region is of "natural" origin or linked to human activities is as yet unknown.

10. Scar left by the incision of the stem for sap tapping, on *Phoenix sylvestris* (Mount Abu, Rajasthan) (Photo. Sarah Ivorra).

Near Jamnagar we also collected material from a well-established riparian population along the Sasoy River, where the density is relatively high and comprises both male and female individuals, including very tall ones as well as

11. *Phoenix sylvestris* growing on the edges of (dry) fields (near Pali, Rajasthan) (Photo. Sarah Ivorra).

numerous young ones (Fig. 8). They are not visibly incised for sap collection; farmers pointed them out to us as wild date palms (*jongli khajoori*). Genetic analysis also identified them as *P. sylvestris*. In the Junagadh region, we encountered only very small and isolated riparian populations and collected material from one of them near the village of Mothra Kothra, where all individuals were identified as *P. sylvestris*. Again, there was no sign of management or exploitation of these palms.

Phoenix sylvestris in and around the Aravalli range

The Aravalli hills form a mountain range oriented southwest to northeast, separating the Thar Desert (Mârushthali) to the northwest from the rich Chambal valley to the southeast. It reaches 1722 m above sea level at the peak of Guru Shikha on Mount Abu.

We studied three populations – within the town of Mount Abu itself on the eponymous mount, on the northwest drier foothills near the town of Pali and on the southeast wetter hills about 15 km north of Udaipur.

The town of Mount Abu, located between 1100 and 1200 m above sea level, is an ancient settlement with architectural monuments attesting to its religious importance at least since the early 11th Century. It remains a religious center and a resort prized for its cool atmosphere in the summer. The landscape in and around Mount Abu almost up to the summit is man-made, where a variety of local and exotic species are cultivated on the terraced slopes. The town itself, quite loose in its structure, is strewn with *P. sylvestris* palms. Away from the town, the thick forest, which we did not investigate closely, does not seem rich in palms.

Overall, the population of *P. sylvestris* is quite large in a variety of settings – in town, in a cemetery, along riverbanks, on cultivated terraces and hills surrounding the town, and comprises many very tall specimens (Fig. 9). These palms are managed and visibly tapped for their sap (*tari*) for *gur* production; the scars consecutive to the incisions of the stem are large and deep (Fig. 10). Local farmers told us that the palms were not planted or sown, only

12. *Phoenix sylvestris* on the edges of cultivated fields between Delwara and Udaipur (Rajasthan) (Photo. Sarah Ivorra).

exploited for sap and fruit harvest. The fruits are used both for food and for animal fodder.

Along the road down from Mount Abu and northward following the Aravalli hills on their western side, we did not see any palm population. Only close to the town of Pali did we find *P. sylvestris* individuals growing in an agricultural, irrigated landscape. The palms are located on banks on the edges of cultivated fields or along canals (Fig. 11). They do not seem to be tapped for sap, as there are no visible cuts on the trunks. Local crops include castor-oil, citrus and aloe. Spontaneous ruderal species attest to the arid climate, with *Prosopis cinerea* and *Calotropis procera* dominating the scrub vegetation; these are the eastern reaches of the Thar Desert.

From Pali to Jodhpur then eastwards, palms are absent until some individuals near Bilara, again on the edges of cultivated fields. Driving south from Beawar toward Udaipur, following the Aravalli mountains on their eastern flank this time, we re-encountered palms, first scattered between fields near the town of Bhim, then frequently along dry riverbeds near Deogarh. In these small valleys, the mature palms look managed, as the leaves have been cut off along the stems.

Further south, between Delwara and Udaipur are hills on which quarrying and agricultural activities take place. The fields are mostly located in the narrow river valleys, on alluvial soil. The palms are again, like other fruit trees, located on the riverbanks or on the edges of cultivated fields, along dry stonewalls when there are any (Fig. 12). This population is similar to the one in Pali in terms of status or function of the palms, which do not seem to be tapped for sap either.

These three populations are intimately related to the agricultural landscape and cannot be considered as "wild." Although the palms are not vegetatively propagated, the seedlings where appropriate are certainly protected from grazing and encouraged, and mature palms are tended and exploited for a variety of purposes depending on the context. The Mount Abu population appears to be more intensively exploited and more central in the agricultural economy; the palms are not only relegated to field edges, they also form sparse but monospecific "orchards." Where *P. sylvestris* palms are present, they form an integral part of the domesticated landscape, mostly as solitary individuals and clusters between fields and along canals or riverbanks. Fruits of *P. sylvestris* appear smaller and less diversified in terms of size and shape than those of *P. dactylifera* (Fig. 13).

Discussion and Conclusions

Distribution

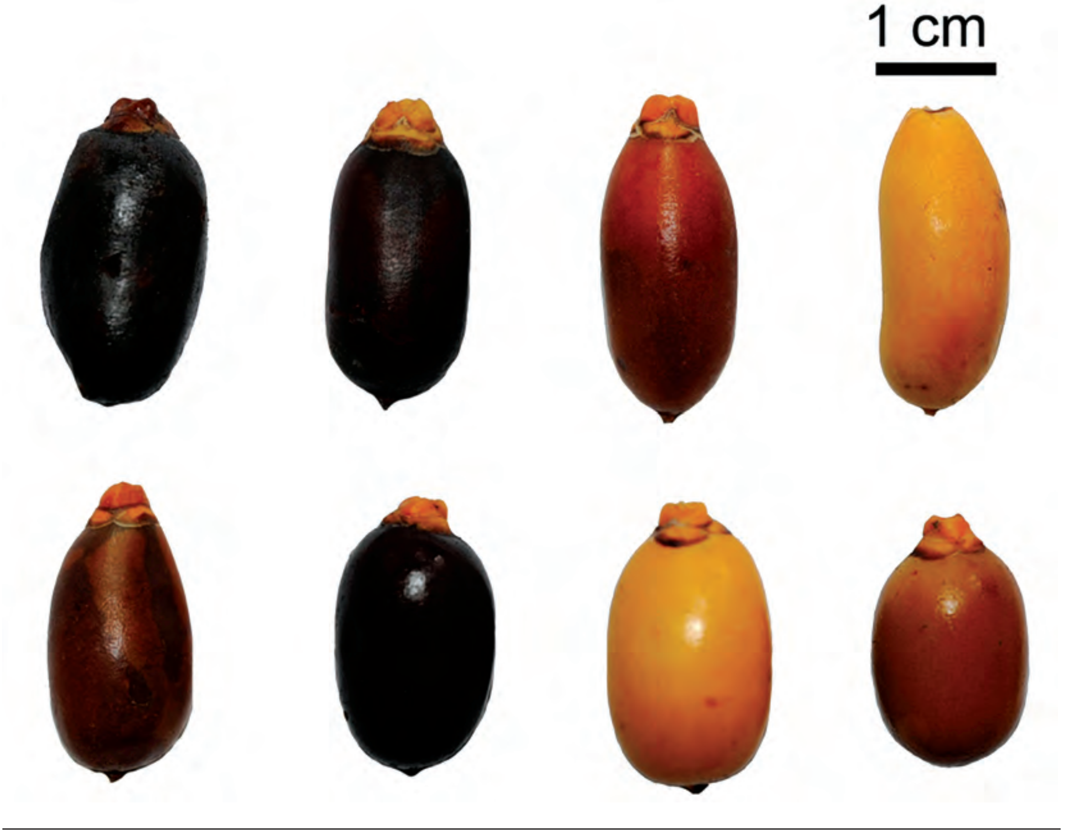
Regarding the question of distribution within our sampling area, *P. dactylifera* was found only in Kutch and on the northern coast of the Kathiawar Peninsula, along the Gulf of Kutch. In Kutch, *P. dactylifera* was the only *Phoenix* species found, and exclusively under cultivation; we did not observe the date palm in feral form. *Phoenix sylvestris* was identified in the Kathiawar peninsula, on Mount Abu and on the northwestern and southeastern foothills of the Aravalli, both in riparian vegetation and in agricultural settings, cultivated or at least managed and exploited.

Among our collection, it appears from genetic analyses that one station (on the outskirts of Jamnagar) consists in a mixture of *P. dactylifera* and *P. sylvestris* individuals. From our understanding of the farmers' point of view, they are considered in a similar way, indifferent to their specific status. This population is the only example of sympatry that we encountered at the microlocal level. It is located within the region anciently settled by the Harappan or Indus Valley civilization, which was centered, as the name suggests, in the Indus valley in present-day Pakistan, but also encompassed the whole of southern Gujarat, including the Ranns of Kutch and the Kathiawar Peninsula (Fig. 2). But how old is this situation of sympatry? Is it natural or related to human activities? Is it new due to a recent introduction of date palms, or is it more ancient, linked to past human impacts on the distribution of cultivated plants? Only historical and archaeobotanical approaches could help us here.

Cultivation, management and uses

Apart from rare (and new) exceptions, all populations from both species are composed of progeny only from seedlings. Male cultivated date palms are eliminated only after first flowering, and the selection of best fruit producers takes place on an individual basis but without vegetative propagation. *Phoenix sylvestris* populations do not seem to undergo any selection based on individual qualities. From a genetic point of view, the managed or cultivated *P. sylvestris* populations therefore should have the same structure as wild ones.

13. Fruits of *P. sylvestris*.



Regarding the uses of these palms, the fruit of both species are eaten or fed to animals, but we observed that only *P. sylvestris* was tapped for sap; in Kutch, there is no sign of this practice. However, not all palms of this species are tapped, only those included in the agricultural system and in certain regions – the Kathiawar Peninsula and Mount Abu. For instance, riparian populations in the Kathiawar Peninsula were left untouched, as were the individuals from the stations near Pali and Udaipur, even when growing on the edges of fields. Presumably, the latter were exploited for their fruit, leaves and stems. More detailed work on the status of these different sub-populations is needed to inform questions of choice: which palms are suitable for tapping, and which are not? In Mount Abu, the status of *P. sylvestris* palms is strikingly different; even the "orchards" look as if they were wild stands where all other trees had been eliminated in favour of the palms, a special kind of forest management or even agroforestry, a domestication of the territory.

The processes whereby palms are integrated into the agricultural system, for instance from riparian populations, have not been investigated. This "domestication" would best be tackled by joint ethnobotanical and biological approaches and could perhaps also be relevant to the first cultivation and domestication of the date palm. It would involve uses, cultivation practices, management and social representation of individuals and populations. The limited observations presented here already show the variety of situations occurring over a relatively small area.

Our first contribution based on this collection of both seeds and leaflets from populations of both species will be to investigate their morphological and genetic diversity as well as their potential hybridization in natural and anthropogenic environments. Morphological investigation of *Phoenix* seeds from local archaeological sites belonging to the Indus Valley civilization on both sides of the border, and even around the Persian Gulf not so far away, should also help us understand the long history of human exploitation of palm species in the area by identifying the species collected and possible cultivation practices.

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continued from p. 36

typographical errors, but incorrect word usage problems (e.g., grow vs growth) averaged about one per chapter. These are the types of problems that spell checkers usually don't catch.

At the end of this book is a useful glossary defining some of the botanical terms that would not be familiar to most landscapers. The "index" which follows is arranged by chapter and is more of a table of contents than a proper index. Topics are arranged by the order of occurrence in each chapter, rather than alphabetically, making it very difficult to find a topic. There is no cross-referencing of topics.

Despite the shortcomings mentioned above, this is still a useful reference. It is attractive, very well written, and brings together a lot of useful information about palms for landscapers in southwestern United States.

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