Palms

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FRONT COVER

The inflorescence of a palm long known as *Thrinax morrisii*. Learn the new name on p. 84. Photo by C.E. Lewis.

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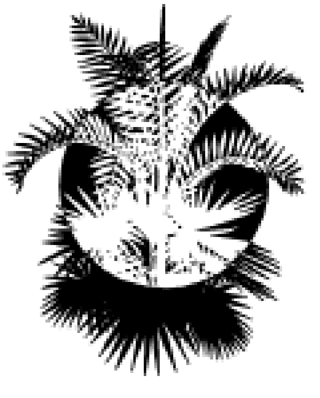
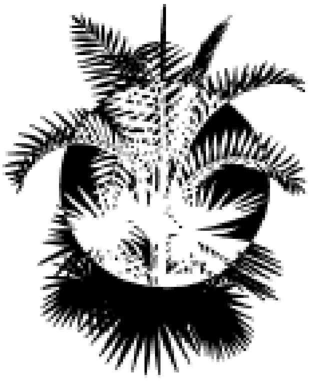


BACK COVER

Old *Ceroxylon echinulatum* trees and dead trunks left in a pasture. See article by J.-C. Pintaud and F. Anthelme, p. 96. Photo by J.-C. Pintaud.



NEWS FROM THE WORLD OF PALMS

As we reflect back on the Costa Rican Biennial, which ended less than two weeks ago, we call to mind many happy memories of the places we visited, the palms we saw and the friends we made. This Biennial was unusual in that it was not planned and hosted by a local chapter. Instead, IPS contracted with a local tour operator CRT to run the tours of parks and wilderness areas, provide transportation and guides and to keep track of 200-some palm-hungry IPS members. We think everyone of the attendees agrees, the Biennial was a huge success. The highlights were many and include gliding silently through the forest canopy in open gondolas, gazing down from a suspension bridge into the crown of an *Iriartea* and hiking through trails lined with *Bactris*, *Chamaedorea*, *Welfia* and *Calyptrogyne*. This was the first IPS Biennial held in Costa Rica, but many of us hope that it will not be the last.

The Biennial was preceded by the annual business meeting of the board of directors. The board discussed ways to improve the IPS website and the on-line shopping cart, the upcoming publication of the second edition of *Genera Palmarum* and the future of the IPS Bookstore, which is currently suspended. One of the pieces of business that the board decided upon at the meeting was the location for the 2010 Biennial: the palm-rich environs of Rio de Janeiro, Brazil. The meeting also installed newly elected and re-elected board members and officers of the IPS, including the new president, Bo-Göran Lundqvist of Hawaii. The board also disbursed over $22,000 in grants for research and education. Grant recipients will submit articles about their work for publication in the pages of this journal.

A taste of the Costa Rican adventure can be seen in the lively posts in the “IPS Biennial – Costa Rica 2008” forum on Palmtalk, the IPS’ interactive website, where users can discuss palms and share photos with one another 24/7. We often hear the complaint that the printed journal does not adequately address horticultural questions from specific palm-growing areas, but Palmtalk can do what the journal can not: the Palmtalk community can and does respond to every palm question imaginable. No question is too obscure or too simplistic. Whether you are a “newbie” to growing palms or a veteran, the Palmtalk community welcomes you. There is a link to Palmtalk in the upper right corner of the IPS home page at www.palms.org.

THE EDITORS

GROWING PALMS

Horticultural and practical advice for the enthusiast

Edited by Randal J. Moore

Contents

- When Lightning Strikes – *Scott Zona*
- Palms, Turf, Budgets and Priorities: Strategic Horticulture Management at Montgomery Botanical Center – *Lee Anderson & M. Patrick Griffith*

When Lightning Strikes

Lightning is one of nature's most spectacular phenomena, but as beautiful as it is to see, lightning is no friend of palms. Lightning strikes are as perilous to palms as they are to people. Tall palms are especially vulnerable to lightning strikes, and in some parts of the world, lighting is the leading natural cause of death for such palms. Large, stately palms are sometimes the tallest objects in the landscape, so it is only natural that they are struck by lightning. The loss of a big palm to lightning is not only tragic but costly, as a large, dead palm can be expensive to remove and replace.

1. *Roystonea regia* less than 24 hrs after a direct strike by lightning. The only visible damage is the longitudinal gash in the crownshaft. The palm died a slow death several weeks later.

Among the palm-growing regions of the US, the Tampa Bay (Florida) region receives the most lightning (over 16 flashes per km^2 per year). Central Florida and the coastal regions of North Carolina, South Carolina, Georgia, Louisiana, Mississippi and Alabama are next in line for lightning (8–16 flashes per km^2 per year). South Florida, the interiors of the southeastern states and southern Arizona are less prone to lightning (4–8 flashes


2. Two *Veitchia arecina* palms dying from a lightning strike that occurred about one week earlier. The collapse of the crown is a classic symptom of lightning strike. A small *Cryosophila* palm at the base of the center *Veitchia* was also killed.

per km^2 per year), but palms there are still at risk. Elsewhere in the world, Central America, the Amazon Basin, tropical west Africa, Madagascar, the Malaysian Peninsula and Darwin, Australia, have high rates of thunderstorms and associated lightning.

Some palms may be more vulnerable to lightning injury than others. Planters claim that coconuts (*Cocos nucifera*) are much more likely to be injured by lightning than African oil palms (*Elaeis guineensis*). Different factors may play a role in a species' vulnerability to strikes, including trunk diameter, height and water-holding capacity.

Plant injury is directly proportional to the duration and intensity of the strike. Direct strikes that cause visible damage (Fig. 1) are inevitably fatal. Even when no injury is apparent, internal damage can lead to decline and death. Moreover, lightning can "jump" from one palm to another, so that an entire zone around the strike target sustains injuries (Fig. 2). Minor strikes are survivable; however, even non-lethal wounds can lead to secondary problems, such as weevil infestation or fungal infections.

Strike damage manifests in several ways. The acoustic shock wave generated by the bolt can shatter stems and crowns outright. Moreover, water in the palm tissue may be vaporized by the intense heat of lightning, and the steam may explode tissues. If the strike occurs without accompanying rainfall, the lightning can ignite the palm, causing fire damage. Damage may be visible from the crown all the way down the stem to the ground. Longitudinal fissures and scorch marks are obvious signs of lighting strikes. The leaves yellow and droop, and the entire crown will eventually die, with its dead and dying leaves hanging like a skirt (Fig. 2). Trunk wounds exude a gummy discharge within a week or so. Usually the symptoms manifest quickly, within a few days, but in the case of a *Roystonea regia* adjacent to my house (Fig. 1), the leaves appeared green and healthy for many weeks. Eventually the developing spear leaf turned yellow, and the mature leaves discolored soon thereafter.

In a coconut plantation, the palms surrounding the strike will show a characteristic damage pattern. On the side facing the electrical discharge, leaves will break about a third of the way back from the tips. The broken tips hang and soon discolor. If broken leaves are the only sign of damage and no further leaf yellowing or dying occurs, the palm will likely recover.

There are no cures for palms struck by lightning. Once the health of the affected palm begins to decline, there is little a grower can do. As the palm begins to die and decay, it will emit the aroma of fermentation and attract palm weevils (*Rhynchophorus* spp.) and other pests. It may be best to remove the stricken palm as soon as the leaves begin to yellow, because once insects arrive, they may move to infect nearby, healthy palms.

Preventing lightning damage is possible using lightning rods, in much the same way they are used on buildings. A conductive rod is mounted in the crown of the palm and grounded via a copper cable of prescribed thickness attached to a metal stake driven in the ground approximately three meters away from the trunk. This is the standard adopted by the Tree Care Industry Association in the USA; standards may differ in other countries. As most large palms have only one main stem to protect, the systems are easier to deploy than similar systems for broadleaf trees. Nevertheless, they are expensive and should be installed only by an experienced arborist. The expense of a lightning protection system may only be justified for high-value palms on the grounds of hotels, monuments or other important sites.

If there is a bright side to palm deaths, it is that standing dead palm trunks are ideal nest sites for woodpeckers and other cavity-nesting birds. In many managed ecosystems, such as suburban gardens, dead trees are scarce resources. In suburban settings, the abundance of animals that depend on tree cavities has declined along with the availability of dead palms. At Fairchild Tropical Botanic Garden, large dead *Roystonea* palms are allowed to remain in the garden and are quickly colonized by woodpeckers. In turn, abandoned woodpecker cavities are used by parrots, owls, and other animals that cannot excavate their own nest cavities.

Lightning is a frequent and natural occurrence in many palm-growing regions of the world. We are helpless to prevent lighting strikes, but growers should be aware of the symptoms of damage and how to manage the risks of lightning. – *Scott Zona, Miami, Florida, USA*.

Palms, Turf, Budgets and Priorities: Strategic Horticulture Management at Montgomery Botanical Center

Just inside the front gates, at first glance the Montgomery Botanical Center (MBC) Palm Collection, carefully set in a canvas of seemingly lush, verdant lawn, appears extravagant for a living scientific collection. Admittedly, when one has seen diverse palms in habitat, or for that matter, in the drier environs of southern California, the MBC presentation may seem extravagant at first glance. Certainly majestic solitary palms such as the *Roystonea, Attalea* and even the relatively diminutive *Hyophorbe* are striking as they tower up from the surrounding turf.

At MBC, meeting high botanical and aesthetic targets with the greatest efficiency is our operational goal. This principle is woven through all aspects of horticulture management, starting with design strategies, and going all the way through to maintenance protocols. Behind the serene tropical scenes, balancing the mission priorities of scientific palm collections and beautiful landscaping is challenging and takes careful planning. Palms and greens are not necessarily competitors: identifying areas of overlap helps considerably.

Budgeting Priorities. An insightful article (Labbance, B. 2006. A century of minimal change: the benefits of low budgets. Superintendent 30: 30–38.) offers a clear example of how a specific long-term use coupled with conservative budget management act to preserve a classic landscape aesthetic. At MBC, the Olmsteadian aesthetic dovetails nicely with the priorities for a scientific collection – open vistas are vitally important, but homogenous lawns and manicured displays are not. Trends in MBC staffing demonstrate these priorities. Since 2004, staffing allocation for grounds maintenance has been reduced from 22% to 14%, while the allocation for collections care has been strengthened from 26% to 34%. (Administration remains flat at 8%). Living scientific collections are definitely top priority.

Site Selection Strategy. Meticulous site selection is essential to meet plant health and landscape aesthetic standards. Yearly review and planning by our landscape architect, Joe Hibbard, keeps our palm collections in visual harmony. This aesthetic expertise is brought together with the in-house horticulture experience to ensure the siting will allow the palms to thrive.

1. Turf and palm from Colonel Montgomery's Coconut Grove Palmetum. St. Augustine turf was reputedly established in this location for the Colonel prior to the 1932 holiday season. This *Sabal causarium* was also planted in 1932. Trunk diameter = 60 cm, height to crown = 17 m. Both palm and turf are in superior health.

Grounds Maintenance. Good turf does not have a negative effect on palm health. Arguably, healthy, sustainable turf management practices correlate with healthy palm collections. But briefly stated, turf is expensive. In recent years, we developed turf maintenance priority zones, ranking our maintenance intensity from grade 1 through grade 4. Only the area of the Colonel's Coconut Grove Palmetum requires irrigation and fertilizer (Fig. 1.); other open areas are progressively less intensively managed (Fig. 2.). Following the principle of the *Environmental Lawn* (Bormann et al. 1993. Redesigning the American Lawn: A Search for Environmental Harmony. Yale University Press; Shimonski, J. 2005. Parrot Jungle Island: A zoological theme park built upon IPM and plant health care practices: Featuring the ongoing development of an onsite mosquito larvicide program. Proceedings of the 2005 Association for Zoological Horticulture Conference Proceedings.), we maintain a heterogeneous, unfertilized assembly of grasses, perennial groundcovers, legumes and annual flowering plants is mowed to lawn height.

A large number of palms are solitary plantings which date to the 1930s, when the original caretakers favored the aesthetic of a single palm emerging directly from the lawn. Currently, we leave a collar of bare soil or mulch, which eases maintenance for both palms and turf.

Bedding also requires careful consideration. Massed plantings dictate co-bedding

2. The Environmental Lawn as expressed at MBC. Growing in shade here, this volunteer herbaceous cover contains broadleaved annuals, perennials, and grasses, mowed to turf height. These *Sabal domingensis* were grown from seed collected in the Dominican Republic by Dr. William Hahn in 1996.

and therefore turf removal. Smaller clumping species such as the *Chamaedorea* collections are also consigned to group planting in extensive mulched beds.

Irrigation Strategies. South Florida averages 152 cm (60 in.) of rain annually, and this rain is highly concentrated around the summer months. In the dry months of April and early May, South Florida can feel more like Palm Springs than Miami. Consequently, irrigation is essential for the palm collections. Deep extended irrigation immediately following granular fertilizer application assures that a good percentage of nutrients are flushed down into the deep feeder roots of the palms. The MBC Curators examined this carefully with tensiometer data to correlate irrigation zone run times with depth of water penetration. Their findings corroborated their thought process – longer run times equal deeper water penetration. Turf irrigation is not critical, so it has been reduced greatly in recent years. Unirrigated turf zones quickly spring back to verdancy in the summer.

Fertilizing Strategies. Except in our “grade 1” turf areas where vigorous growth is preferred, we avoid turf-specific fertilizers. The high nitrogen content of turf fertilizers is not in the best interests of palm health. A palm specific formulation (we prefer a 08-02-12 mix with a healthy dose of minor elements, especially manganese, potassium and boron) is broadcast over the entire root zone of a palm, which can extend out many feet in all directions. We use 25 tons of palm fertilizer per year (divided among three feedings), but only 1000 pounds of turf fertilizer.

It has been hypothesized that abundant turf may rob nutrients from some palms (Fig. 3). In theory, mulching blades installed on the mowers also allow for the rapid sequestration of whatever nutrients grass has taken up from the palm fertilizing regimen, since the clippings are left in place around the palm.


3. Coconut palm with nutrient deficiency, potentially caused by competition with abundant turf.

Endnote. Serious dedication to scientific palm collections is compatible with verdant vistas. Careful allocation of resources, harmonious landscape architecture and the unsurpassed natural beauty of palms can make conservation and research a surprisingly lush mission. – *Lee Anderson, Superintendent and M. Patrick Griffith, Executive Director, Montgomery Botanical Center, Miami, Florida, USA*

New Species of *Pinanga* (Palmae) from Vietnam

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1. *Pinanga cattienensis*, showing spreading rachillae and spirally arranged, red-pink fruits.

Five new species of *Pinanga* from Vietnam are described, and their relationships discussed.

Pinanga is a genus of 132 recognized species (Govaerts & Dransfield 2005), occurring from India through Indo-China, Malaysia and Indonesia to Papua New Guinea. There is no revision of the whole genus. The most recent taxonomic treatment of the Indochinese species was that of Gagnepain and Conrard (1937), based on previous works by Beccari (1910) and Magalon (1930). Gagnepain and Conrard recognized six species from Vietnam – excluding *Pinanga banaensis*, which is now placed in *Nenga*. Of these six species, we currently recognized three (*P. annamensis* Magalon, *P. baviensis* Becc. and *P. quadrijuga* Gagnep.).

Recent field work in Vietnam has revealed an additional five new species of *Pinanga*, which are described here, bringing the total number of species for the country to eight. Herbarium acronyms follow Holmgren et al. (1990), and the acronym VNM is used for the herbarium of the Institute of Tropical Biology in Ho Chi Min City.

Pinanga cattienensis Henderson, N.K. Ban & N.Q. Dung, **sp. nov**., a speciebus omnibus *Pinangae* Vietnamensibus cognitis vaginis foliorum persistentibus reclusis, inflorescentiis interfoliaribus et triadibus spiraliter dispositis differt. Typus. Vietnam. Dong Nai: Cat Tien National Park, road along Dong Nai river, 11°26′N, 107°26′E, 150 m, 27 May 2007, *A. Henderson, Bui Van Thanh, Vu Van Duy, Nguyen Ngoc Quynh, & Phan Van Phuc 3401* (Holotypus: HN! Isotypi: K! NY!). (Fig. 1)

Stems clustered, forming dense clumps of short stems to 0.5 m tall, sometimes to 1.5 m tall, 2 cm diam., green, covered with reddish-brown scales. Sheaths open, not forming crownshafts, 27–28 cm long, green with reddish-brown scales; ocreas present; petioles 87–116 cm long, green; rachis 90–95 cm long; pinnae 9–13 per side of rachis, linear, contracted at the bases, middle pinna 42 cm long, 2.5–3 cm wide at the middle, apical pinna 16.5 cm long, 5 cm wide at the middle, lobed; veins scarcely prominent adaxially. Inflorescences interfoliar, pushing through the persistent, disintegrating, subtending leaf sheaths, spreading; peduncles 0.5 cm long, 0.9 cm wide; prophylls 9–14 cm long, persistent and erect, splitting abaxially; rachis absent; rachillae 3–4, 9–13 cm long, rectangular in cross-section, glabrous; triads spirally arranged; staminate flowers 6 mm long; sepals forming a 3-lobed, flat, membranous calyx 1.5 mm long; petals 3, 6 mm long, triangular, fleshy, acute; stamens 20–22; pistillate flowers 2.5 mm long; calyx 2.5 mm long with 3, free, imbricate, scarcely ciliate, non-acuminate sepals; corolla similar to the calyx; ovary 2.5 mm long. Fruits 1.8–2 cm long, 0.5–0.6 cm diam., ellipsoid, red-pink; endosperm ruminate.

Local names and uses: None recorded.

Distribution and habitat: Endemic to Vietnam and known only from Dong Nai, growing in seasonally flooded lowland forest at low elevations.

Notes: *Pinanga cattienensis* differs from all previously described species of *Pinanga* from Vietnam by its leaf sheaths which do not form distinct crownshafts and inflorescences which are not infrafoliar. Instead the inflorescences push through the persistent, disintegrating, subtending leaf sheaths. In this it is similar to *P. humilis*, also described here. *Pinanga cattienensis* differs from *P. humilis* in its spirally (versus distichously) arranged triads, 90–95 cm long (versus 38–39 cm long) rachis and 9–13 (versus 5–7) pinnae per side of the rachis.

Additional specimens examined. VIETNAM. Dong Nai: Cat Tien National Park, road along Dong Nai river, 11°26′N, 107°26′E, 150 m, 28 May 2007, *Henderson et al. 3410* (HN, NY). Possible additional specimen. Vietnam. Lam Dong: Bao Loc, Loc Lam, no date, *Anon 1246* (LE).

Pinanga cupularis Henderson, N.K. Ban & N. Q. Dung, **sp. nov**., a speciebus omnibus *Pinangae* Vietnamensibus petalis florum staminatorum apice pilos longos ferentibus, staminibus 4, perianthio florum pistillatorum cupulari et endospermio homogeneo differt. Typus. Vietnam. Da Nang City: Hoa Vang District, Ba Na-Nui Chua Nature Reserve, near summit, 15°59′N, 107°59′E, ca. 1100 m, 20 Apr 2007, *A. Henderson, Nguyen Quoc Dung, Nguyen Canh, & Le Van Bo 3308* (Holotypus: HN! Isotypi: K! NY!). (Fig. 2)

Stems clustered, rarely solitary, to 2 m tall, 0.4–0.8 cm diam., densely covered with reddish-brown scales. Sheaths closed, forming a crownshaft, 6.5–12 cm long, densely covered with reddish-brown scales; ocreas 1.5–2 cm long; petioles 3.5–6 cm long, green with whitish scales; rachis 11.5–40 cm long; pinnae 2–4 per side of rachis, falcate, not contracted at the bases, middle pinna 10–15 cm long, 1–3 cm wide at the middle, apical pinna 4.5–5 cm long, 2–4 cm wide at the middle, lobed, rarely

2. *Pinanga cupularis*, showing pendulous, spicate inflorescence with distichously arranged flowers.

blade undivided, then blade 21 cm long and 8 cm wide at the middle; veins only slightly raised adaxially. Inflorescences infrafoliar, pendulous; peduncles 0.1–0.2 cm long, 0.2 cm wide; prophylls 5–6.5 cm long; rachis absent; rachilla 1, 3–6.4 cm long, rectangular in cross-section, glabrous; triads distichously arranged; staminate flowers 11 mm long; sepals forming a 3-lobed, flat, membranous calyx, 1.5 mm long; petals 10 mm long, irregularly lobed at the apices, one petal larger than the other two, fleshy, with 2 mm long, hyaline hairs at the apices; stamens 4; pistillate flowers 2.5 mm long; calyx 2.5 mm long, cupular, not split into 3 sepals, ciliate at the apices; corolla similar to the calyx; ovary 2.5 mm long; fruiting calyx briefly and irregularly split at the apices; fruits 1.2–2 cm long, 0.2–0.4 cm diameter narrowly ellipsoid, slightly curved, color unknown; endosperm homogeneous.

Local names and uses: *cay cau rung se, ca nui*.

Distribution and habitat: Vietnam in Kon Tum and Thua Thien-Hue and near Da Nang City, in lowland or montane rainforest at 200–1400 m elevation.

Notes: This species was identified as *Pinanga paradoxa* Scheff. by both Magalon (1930) and Gagnepain and Conrard (1937), who also recorded it from Lao. It differs from that species, occurring in Thailand and West Malaysia, in its cupular (versus imbricate) pistillate perianth and narrow fruits 0.2–0.4 cm (versus 1 cm) diameter. It is an unusual species of *Pinanga* in its staminate petals with long hairs on the apices, 4 stamens, cupular pistillate perianth, and homogeneous endosperm. Amongst Vietnamese species it most resembles *P. kontumensis*. It differs from this in its pendulous (versus erect) inflorescences, and cupular (versus free and imbricate) pistillate perianth.

Additional specimens examined. **VIETNAM**. DA NANG CITY: “Ba Na, près Tourane” [Hoa Vang District, Ba Na-Nui Chua Nature Reserve], 8 Jul 1923, *Chevalier 6969* (VNM), no date, *Magalon 8* (NY, VNM); Hoa Vang District, Ba Na-Nui Chua Nature Reserve, near summit, 15°59’N, 107°59’E, ca. 1100 m, 23 Apr 2007, *Henderson et al. 3313* (HN, NY);. **KON TUM**: Dak Gley, about 12 km to N of Dak Gley town, near Mang Khen village, 1000-1200 m, 13 Nov 1995, *Averyanov et al. VH 1655* (MO). **THUA THIEN-HUE**: Nam Dong Distr., Huong Son Commune, 16º09’N, 107º36’E, 300–450 m, 24 Mar 2005, *Averyanov et al. HAL 6843* (HN); Phu Loc, Huong Loc, 2 Sep 1980, *N. H. Nhan 880* (HN).

Pinanga declinata Henderson, N.K. Ban & N. Q. Dung, **sp. nov**., a *P. sylvestri* vaginis petiolisque luteis atque pinnis basaliter valde contractis differt. Typus. Vietnam. Lam Dong: Lac Duong District, Bi Dup-Nui Ba National Park, new road DT 723 from Da Lat to Nha Trang, 12°07’N, 108°37’E, 1670 m, 30 May 2007, *A. Henderson, Bui Van Thanh, Ton Thien An, & Duong Thanh Tuyet 3411* (Holotypus: HN! Isotypi: K! NY!). (Fig. 3)

Stems clustered, to 5 m tall, 3–5.5 cm diameter, densely covered with reddish-brown scales.

3. *Pinanga declinata*, showing spreading, branched inflorescences with distichosly arranged flowers and fruits.

Leaves 5–7; sheaths closed, forming crownshafts, 43–57 cm long, yellowish with reddish-brown scales; petioles 19–52 cm long, yellowish; rachis 105–111 cm long; pinnae linear, contracted at the bases, 20–21 per side of rachis, middle pinna 38–69 cm long, 3.5–5 cm wide at the middle, apical pinna 6.5–21 cm long, 3.5–5 cm wide at the middle, lobed; veins prominent adaxially. Inflorescences infrafoliar, spreading; peduncles 2.5–3 cm long, 0.5–1 wide; prophylls 14–17 cm long; rachis 3.5–4 cm long; rachillae 4–8, 15–22 cm long, glabrous, triangular in cross-section, with one flat surface with no triads, the triads arranged along the other two surfaces; triads distichously arranged, occasionally spirally arranged; staminate flowers not known; pistillate flowers 2 mm long; sepals 3, 2 mm long, imbricate, the margins ciliate, acuminate; petals 3, 2 mm long, imbricate, the margins ciliate, not acuminate; ovary 2.5 mm long; fruits 1.5–2 cm long, 0.5–0.7 cm diameter, narrowly ellipsoid, color unknown; endosperm ruminate.

Local names and uses: *cau chuot, cao cuo chuoc, cau rung.*

Distribution and habitat: Endemic to south-central Vietnam in Dak Lac, Khanh Hoa, Kon Tum, Lam Dong, and Ninh Thuan, in primary, evergreen, broad-leaved, montane forest, or pine forest, at 1100–1900 m.

4. *Pinanga humilis*, showing a spicate inflorescence pushing through the persistent leaf sheath and distichously arranged flowers.

Notes: *Pinanga* specimens from south-central Vietnam were identified as *Pinanga duperreana* Pierre by both Magalon (1930) and Gagnepain and Conrard (1937). This name is now regarded as a synonym of the widespread *P. sylvestris* (Lour.) Hodel, which occurs in Cambodia, China, India, Myanmar, Lao, and Thailand. *Pinanga declinata* is similar to *P. sylvestris* but differs in its yellow (versus green) sheaths and petioles and pinnae which are strongly contracted at the bases. It can be distinguished from the similar *P. annamensis* by its 20–21 linear (versus 8–12 falcate) pinnae which are contracted at the bases (versus not contracted), and spreading (versus pendulous) rachillae.

Additional specimens examined. VIETNAM. DAK LAK: Krong Bong District, Cu Pui Commune, from Dak Tour village to main peak of Chu Yang Sinh mountain, 12°30'N, 108°30'E, 8 May 2000, *Averyanov et al. VH 6230* (HN); 12 May 2000, *Averyanov et al. VH 6439* (HN, MO). KHANH HOA: Khanh Son Distr., 42 km NE from Da Lat, upper reaches of Lieng Ly river, 12°12'N, 108°44'E, 1100–1300 m, 22 Apr 1997, *Averyanov et al. VH 4157* (HN, K, MO); 24 Apr 1997, *Averyanov et al. VH 4327* (HN, K, MO). KON TUM: N slope of Ngoc Linh mountain, 1200 m, 12 Mar 1995, *Averyanov VH 693* (GH, K); Dak Gley Distr., about 12 km N of Dak Gley near Mang Khen village, 1100–1200 m, 14 Nov 1995, *Averyanov et al. VH*

1625 (K); Kon Plong Distr., Hieu Commune, Mang La Forest Enterprise, 14°39′N, 108°25′E, 1100–1200 m, 24 Apr 2000, *Averyanov et al. VH 5696* (HN); 25 Apr 2000, *Averyanov et al. VH 5725* (HN). LAM DONG: 14 km NNW of Da Lat city, 12°05′N, 108°22′E, 1740–1760 m, 11 Mar 1997, *Averyanov et al. VH 2550* (HN, K, MO); Lac Duong Distr., Da Chay Commune, 30 km NE of Da Lat city, 12°08′N, 108°39′E, 1700-1900 m, 24 Mar 1997, *Averyanov et al. VH 3171* (HN, K, MO); Lac Duong District, Bi Dup-Nui Ba National Park, new road DT 723 from Da Lat to Nha Trang, 12°10′N, 108°41′E, 1483 m, 30 May 2007, *Henderson et al. 3414* (HN, NY). NINH THUAN: Ninh Hai Distr., Vinh Hai Commune, E slopes of Nui Chua, 11°43′N, 109°08′E, 600–700 m, 27 Mar 2004, *Regalado et al. HLF 4183* (HN).

Pinanga humilis Henderson, N.K. Ban & N. Q. Dung, **sp. nov**., a speciebus omnibus *Pinangae* Vietnamensibus vaginis foliorum persistentibus reclusis, inflorescentiis interfoliaribus et triadibus distiche dispositis differt. Typus. Vietnam. Da Nang City: Hoa Vang District, Ba Na-Nui Chua Nature Reserve, road to summit, 16°00′N, 108°02′E, ca. 350 m, 19 Apr 2007, *A. Henderson, Nguyen Quoc Dung, Nguyen Canh, & Le Van Bo 3298* (Holotypus: HN! Isotypi: K! NY!). (Fig. 4)

Stems clustered, forming small clumps, to 0.9 m tall, 1 cm diameter, green with reddish-brown scales. Leaves 5; sheaths open, not forming crownshafts, 7–13 cm long, covered with reddish-brown scales; ocreas 1–2.5 cm long, early deciduous; petioles 59–78 cm long, green; rachis 38–39 cm long; pinnae 5–7 per side of rachis, linear, contracted at the bases, middle pinna 32–33 cm long, 2 cm wide at the middle, apical pinna 15.5–21 cm long, 2 cm wide at the middle, lobed; veins scarcely raised adaxially. Inflorescences interfoliar, pushing through the persistent, disintegrating, subtending leaf sheaths, erect; peduncles 0.5–0.8 cm long, 0.3 cm wide; prophylls 3–4.5 cm long; rachis absent; rachillae 1–3, 4–4.5 cm long, rectangular in cross-section, glabrous; triads distichously arranged; staminate flowers 6.5 mm long; sepals forming a 3-lobed, flat, membranous calyx 1.5 mm long; petals 3, 6 mm long, triangular, fleshy, acute; stamens 9–13; pistillate flowers 2.5 mm long; calyx 2.5 mm long with 3, free, imbricate, ciliate, non-acuminate sepals; corolla similar to the calyx; ovary 2.5 mm long. Fruits 1.7 cm long, 0.5 cm diameter, ellipsoid, color unknown; endosperm ruminate.

Local names and uses: *cay nui.*

Distribution and habitat: Endemic to central Vietnam in Quang Nam and near Da Nang City, in lowland forest on steep slopes at 350 m elevation.

Notes: *Pinanga humilis* differs from all previously described species of *Pinanga* from Vietnam by its leaf sheaths which do not form a distinct crownshaft and inflorescences which are not infrafoliar. In this it is similar to *P. cattienensis*, differing in its distichously (versus spirally) arranged triads; 38–39 cm long (versus 90–95 cm long) rachis; and 5–7 (versus 9–13) pinnae per side of the rachis.

Additional specimen examined. VIETNAM. QUANG NAM: Ta Bhing Commune, Song Thanh River, 16 Oct 2005, *N.K. Ban PA 164* (HN).

Pinanga kontumensis Henderson, N.K. Ban & N.Q. Dung, **sp. nov**., a *P. cupulari* inflorescentiis erectis atque perianthio florum pistillatorum libero imbricato late patenti differt. Typus. Vietnam. Kon Tum: Kong Plong District, Hieu Commune, Mang La Forest Enterprise, 14º39′N, 108º25′E, 1000–1200 m, 15 Apr 2000, *L. Averyanov et al. VH 5136* (Holotypus: HN! Isotypus: MO!).

Palm to 3 m tall. Stems 0.7 cm diameter, height and branching unknown, densely covered with reddish-brown scales. Sheaths closed, forming crownshafts, 7.5–8.5 cm long, densely covered with reddish-brown scales; ocreas 3 mm long; petioles 2–3.5 cm long, scaly as the sheaths; rachis 14.5–23.5 cm long; pinnae 3 per side of rachis, falcate, not contracted at the bases, middle pinna 15–18 cm long, 5.5–6 cm wide at the middle, apical pinna 5.5–7 cm long, 3–4 cm wide at the middle, praemorse; veins prominent and raised adaxially. Inflorescences infrafoliar, erect; peduncles 2–3 cm long, 0.2 cm wide; prophylls not known; rachis absent; rachilla 1, 9–10.5 cm long, ± rectangular in cross-section, glabrous; triads distichously arranged; staminate flowers not known; pistillate flowers (post-anthesis) 3 mm high; sepals 3, 2 mm long, widely spreading, not closely imbricate, not acuminate, minutely ciliate; petals 3, 3 mm long, widely spreading, not closely imbricate, acuminate, minutely ciliate; immature fruits 1.5 cm long, 0.4 cm diameter, ellipsoid, slightly curved, white or yellowish; endosperm homogeneous.

Local names and uses: None recorded.

Distribution and habitat: Endemic to south-central Vietnam in Kon Tum, in primary, evergreen, broad-leafed forest on steep slopes on sandstone and gneiss at 1000–1200 m elevation.

Notes: Similar to *Pinanga cupularis* in its small size, spicate inflorescences and homogeneous endosperm but differing in its erect (versus pendulous) inflorescences and free and imbricate (versus cupular) pistillate perianth. It differs from other Vietnamese *Pinanga* in its widely spreading (versus closely imbricate) pistillate perianth.

Additional specimens examined. VIETNAM. KON TUM: Kong Plong District, Hieu Commune, Mang La Forest Enterprise, 14°39’N, 108°25’E, 1000–1200 m, 1 Mar 2000, *Harder et al. 4628* (MO); Kon Plong District, Mang Canh Commune, 23 Nov 1978, *T.A. Ly 664* (HN).

Acknowledgments

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LITERATURE CITED

BECCARI, O. 1910. Palme dell‘Indo-China. Webbia 3: 191–245.

GAGNEPAIN F. & L. CONRARD. 1937. Palmiers. Pages 946–1056 in H. LECOMTE, Flore Générale de l’Indo-China. Vol. 6. Masson Paris.

GOVAERTS, R. AND J. DRANSFIELD. 2005. World Checklist of Palms. Royal Botanic Gardens, Kew, United Kingdom. 223 pp.

HOLMGREN, P., N. HOLMGREN AND L. BARNETT. 1990. Index Herbariorum Part I; The Herbaria of the World. Eighth edition. Regnum Vegetabile 120:1–693.

MAGALON, M. 1930. Contribution a l’Étude des Palmiers de l’Indochine Française. Les Presses Modernes, Paris.

PALM LITERATURE

TIMBER PRESS POCKET GUIDE TO PALMS. Robert L. Riffle, Timber Press, Portland, Oegon. 2008. ISBN 13:978-088192-776-4. US$19.95. Paperback. 237 pp.

Most palm books are large, heavy and unwieldy, seemingly more designed for the coffee table than for backpacks or pockets. Even so, attendees at any chapter meeting may well be lugging around one of these monster books, very likely Riffle and Craft's earlier success, *An Encyclopedia of Cultivated Palms* (2003).

Robert Lee Riffle was working on a cut-down version of that book at his untimely death in August, 2006. That whispery, husky voice with undertones of his native Louisiana will be heard no more. But his memory is well served by this guidebook, which is light, small (6 × 8.38 inches), and definitely portable. In some palm books, the intended audience is not entirely clear. For beginners? For veteran hobbyist-growers? The new Riffle book contains all the basic information on palm culture and landscape uses, together with lists for particular needs, locations or growth rates that is necessary and useful to those just starting out with palms. For those well beyond that stage, the selection of species offers an assortment of more rare and difficult palms. Common and scientific names appear together in the index.

Basic information is provided on 200 species of palms (including a few hybrids). Not only are the dimensions of trunks, leaves and inflorescences given, but also information on the habitat, salt tolerance, growth rate, seed germination and potential indoor use. Most entries end with little more than a sentence or two of comment, surely the hardest part of this book for Bob (not a clipped, short-winded person). Still, he manages – as in the previous book – to tell the reader, more often than not, that each palm is beautiful.

The pictures are particularly good, but there are a few puzzles. For one, the caption reads "*Arenga engleri* flowers" but there are no flowers, only petiole bases. For *Copernicia macroglossa,* the picture, inexplicably, shows an older individual that has no petticoat. For *Serenoa repens*, the only picture of the plant shows atypical, single, 15-foot trunks in deepest interior Central Florida rather than the shrubby individuals more commonly seen. Bob is impatient with *Serenoa,* which he thinks boring in the wild but much improved "in a shrub border or mixed with tall but not overly umbrageous trees." Were he alive, this phrase alone would have merited a phone call to him with my objections. The only leaf pictured of the species is the silver form, not the common green. Quite a few species of *Chamaedorea*, *Copernicia*, *Dypsis*, *Licuala* and *Pinanga* are listed.

Those who shepherded this book through publication have made a few mistakes – what is a palm book without mistakes? No, not *Phoenix roebelinii* but *P. roebelenii*. The old USDA cold hardiness zones are used for every listing; all those old palms in my Zone 9B Florida garden should not be growing here. Or, possibly, the palms know something the USDA zones do not. The individual entries do not always make clear that a species will grow in Mediterranean or in wet (read: Florida) climates.

Overall, Riffle's posthumous book is a quality production that most palm enthusiasts will want to have.

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Time Bombs in Gardens: Invasive Ornamental Palms in Tropical Islands, with Emphasis on French Polynesia (Pacific Ocean) and the Mascarenes (Indian Ocean)

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Although palms are much beloved handsome and striking components of tropical and subtropical gardens and landscapes, some species, like many other ornamental plants, are invasive and can pose a threat to native ecosystems if they escape cultivation.

Invasive alien species are recognized to be one of the major causes of biodiversity loss. Because of their long-term evolution in complete isolation, island biota are particularly vulnerable to foreign biological invasions. Humans have intentionally introduced a majority of plant invaders as garden ornamentals. Public or private botanic gardens, some of them established for many centuries in the tropics, for example the Jardin des Pamplemousses in the island of Mauritius in 1729 or the Cinchona Botanical Garden in Jamaica in 1868, have constituted major entry points for a large number of non-native plants, some of which became invasive (for example the tree *Litsea glutinosa* and the vine *Hiptage benghalensis* in Mauritius or the tree *Pittosporum undulatum* in Jamaica). Gardens still represent continual sources of potential (or incipient) invasive plants.

Some plant families are recognized as being "weedy" because they contain a high number of invasive species. Invasive legume trees (Fabaceae), such as *Leucaena leucocephala*, *Acacia* spp. or *Prosopis* spp., were widely planted for forestry and/or soil improvement in the past, and weedy grasses (Poaceae), such as *Melinis minutiflora*, were intentionally introduced as fodder or are accidentally introduced as contaminants. With the increase of the ornamental plant trade and the recent development of the landscape industry (the "green industry"), new "invasive families" are emerging. For instance, several Acanthaceae species, which are popular garden plants because of their showy and colorful flowers and bracts, are now being reported as invasive in Indo-Pacific tropical islands (Meyer and Lavergne 2004). The palm family (Arecaceae) has been regarded as under-represented in terms of the relative number of invasive species. Indeed, there are only a few species (ca. 12) which are reported to be widely naturalized or invasive in tropical islands or countries (Tab. 1).

The objective of this paper is to inform private and public botanical gardens, palm collectors and hobbyists, horticulturists, gardeners and landscapers of the risk of invasion posed by some introduced ornamental palms. Svenning (2002), who focused only on naturalized palms in a secondary tropical forest in Panama, raised the issue that popular palms have the potential to become problematic invasive species and recommended that a world-wide list of invasive, non-native species be compiled.

Herein, we listed the main naturalized and invasive species in tropical or subtropical countries and islands based on our personal knowledge and field-observations, extensive literature survey and personal communications of botanists, gardeners and palm collectors. We focused on French Polynesia, especially the island of Tahiti (Society Islands), and the Mascarenes, especially La Réunion and Mauritius islands. Potential (or incipient) invasive palm species that might present a risk of becoming invasive in the near future are also noted.

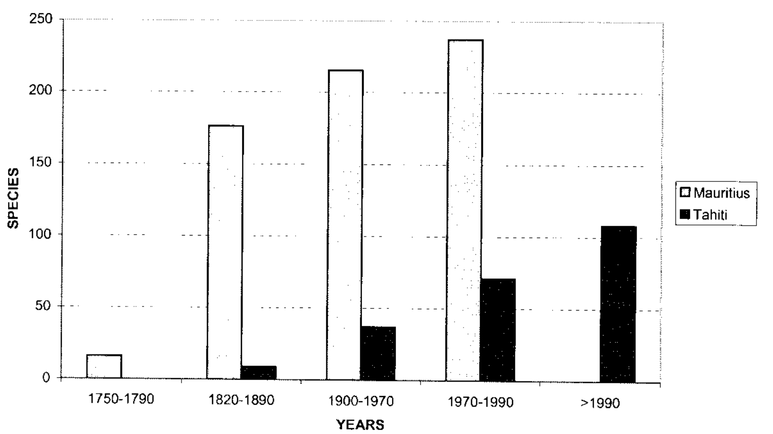
Major documented invasive palms

Twelve palm species are recognized as invasive in tropical regions and islands (Tab. 1), meaning they are well established in the wild away from the original introduction sites, form dense clumps or stands excluding the native vegetation and spread in primary (or native) or in secondary (or disturbed) forests.

The African oil palm (*Elaeis guineensis*) is spreading on Pohnpei (Federate States of Micronesia) particularly on drier sites (Space & Falanruw 1999).

The Chinese fan palm or fountain palm (*Livistona chinensis*) is considered invasive in Bermuda (Kairo et al. 2003) and in Mauritius and La Réunion Islands (Moore & Guého 1984, Strahm 1993, 1999). It is naturalized in Florida (www.fleppc.org/list/05List.htm), in Hawaii (Wagner et al. 1990, 1999) where it spreads in ditches, stream beds, wet gulches and shady understory of disturbed secondary forests (Starr et al. 2003a) and on the east coast of New Caledonia in riparian forest (MacKey 1985).

The California fan palm (*Washingtonia filifera*) is considered invasive in Hawaii (Starr et al. 2003b) and Australia in the Perth area (Hussey et al. 2007, Richardson et al. 2006), while the Mexican fan palm (*W. robusta*) is cited as invasive in Hawaii (Starr et al. 2003b) and Florida (www.fleppc.org/list/05List. htm).



1. Increase of the number of palm species introduced to Mauritius (Mascarenes, Indian Ocean) and Tahiti (French Polynesia, Pacific Ocean) during the last two centuries (after Baas Becking 1950, Jacquier 1960 and Nadeaud plant database, version 1992, for Tahiti, Rouillard & Guého 1981-1985, 1999 for Mauritius).

Table 1. The major documented invasive or widely naturalized palms in tropical islands and countries.

Scientific name	Origin	Invaded Region	Sources
Archontophoenix alexandrae	Queensland(Australia)	Hawaii (Pacific Is.)	Wagner et al. 1990, 1999
Archontophoenix cunninghamiana	Eastern Australia	Brazil	www.institutohorus.org.br/download/fichas/ Archontophoenix_cunninghamiana.htm
Areca triandra	India, SE Asia	Panama	Svenning 2002
Elaeis guineensis	West Africa	Pohnpei (Pacific Is.), Brazil	Space & Falanruw 1999, www.issg.org/database/species/ www.hear.org/pier/species/elaeis_guineensis.htm
Heterospathe elata	Philippines	Guam (Pacific Is.)	Jones 1995, Space & Falanruw 1999 www.hear.org/pier/reports/mreport.htm
Livistona chinensis	Japan, Taiwan, Ryukyu Is.	La Réunion (Indian Ocean Is.), Hawaii, New Caledonia (Pacific Is.), Florida (USA), Bermuda (Caribbean Is.)	Moore & Guého 1984, MacKey 1985, Strahm 1993, 1999, Kairo et al. 2003, Starr et al. 2003a www.hear.org/starr/hiplants/reports/html/ livistona_chinensis.htm http://plants.usda.gov/java/profile?symbol=LICH3
Nypa fruticans	SE Asia, India, Sri Lanka, Australia, Solomon Is., Ryukyu Is.	Nigeria, Trinidad (Caribbean Is.)	www.africanconservation.org/ncftemp/nipa.html Kairo et al. 2003
Phoenix dactylifera	North Africa & Middle East	Fiji, New Caledonia (Pacific Is.), Australia	Smith 1979, Fuller 1997, Lazarides et al. 1997, MacKee 1985, Watling 2005, Hussey et al. 2007
Ptychosperma macarthurii	New Guinea, Australia	Fiji (Pacific Is.), Barbados (Caribbean Is.), Panama	Fuller 1997, Kairo et al. 2003, Svenning 2002, Watling 2005
Roystonea regia	Cuba	Panama	Svenning 2002
Washingtonia filifera	California, Arizona, Mexico	Hawaii (Pacific Is.), Florida, Australia	Oppenheimer & Barlett 2002, Starr et al. 2003b, Lazarides et al. 1997, Hussey et al. 2007 www.hear.org/Pier/species/washingtonia_filifera.htm www.hear.org/Pier/pdf/pohreports/washingtonia_spp.pdf
Washingtonia robusta	Mexico	Hawaii (Pacific Is.), Florida (USA)	Oppenheimer & Barlett 2002, Starr et al. 2003b www.hear.org/Pier/species/washingtonia_robusta.htm www.hear.org/Pier/pdf/pohreports/washingtonia_spp.pdf

2. Seedlings of *Licuala grandis* in the understory of lowland rainforest on the island of Tahaa, French Polynesia (photo: Jean-Yves Meyer).

The Sagisi palm (*Heterospathe elata*), which was introduced to Guam between 1900 and 1920, is spreading in ravines and slopes (Jones 1995, Space & Falanruw 1999).

The MacArthur palm (*Ptychosperma macarthurii*) and the date palm (*Phoenix dactylifera*) are widely naturalized in Fiji (Smith 1979, Watling 2005), the first species along drainages, fence lines and vacant lots in urban areas and the second forming large populations of about 1000 adult trees in the Nadi area and surrounding cane fields (Fuller 1997). The MacArthur palm is also naturalized in Panama (Svenning 2002), Singapore (Hsuan Keng et al. 1998) and the islands of Guadeloupe and Martinique in the Lesser Antilles (Delnatte 2003,) and is considered invasive in Barbados (Kairo et al. 2003). The date palm, planted around settlements throughout the arid zone of Western Australia, forms dense thickets by suckering and seeds spread by birds, affects water flow and displaces the native *Livistona alfredii* (Hussey et al. 2007).

The Alexander palm (*Archontophoenix alexandrae*) is naturalized in Hawaii in low-elevation mesic valleys (Wagner et al. 1990, 1999, Lorence, pers. comm. 2007), while the bangalow palm (*A. cunninghamiana*) is naturalized in several regions of Brazil including submontane rain forest in Rio Grande (www.institutohorus.org.br/download/fichas/Archontophoenix_cunninghamiana.htm).

The Cuban royal palm (*Roystonea regia*) occurs in high abundance in secondary forests of Panama, where it is well naturalized in swamp or lakeside forests, and *Areca trianda* sometimes completely dominates the understory of secondary forests there (Svenning 2002).

The nipa or mangrove palm (*Nypa fruticans*) in Nigeria, which was introduced from Singapore in 1906, is currently displacing the native mangrove vegetation and impacting coastal plant communities (www.africanconservation.org/ncftemp/nipa.html). This species is also reported as naturalized in the island of Trinidad (Kairo et al. 2003) and Panama.

Naturalized and Invasive Alien Palms in French Polynesia (Pacific Ocean)

Beside the coconut (*Cocos nucifera*), which is considered native or a Polynesian introduction, only three native palms have been recorded from the remote oceanic islands of French Polynesia: *Pritchardia vuylstekeana* and *P. pericularum*, both reportedly from the Tuamotu Archipelago, and *Pelagodoxa henryana* in the Taipivai Valley on Nuku Hiva in the

Marquesas Islands. Recently, Hodel visited Makatea in the Tuamotus and was able to verify that the indigenous palm there was *P. mitiaroana*, which heretofore was thought to be endemic to Mitiaro in the Cook Islands. The origin of *Pelagodoxa henryana* is still somewhat controversial because all its known locations in the Marquesas and in Melanesia (Vanuatu and the Solomon Islands) are at sites currently or known to have been inhabited in the past.

About 108 species of non-native (or alien) palms were introduced to French Polynesia during the past century (Table 1). Nine species were planted in Tahiti from 1840 to 1890, including five by E. Raoul in the town of Papeete in a botanical garden called Jardin Raoul, which is now the Mamao Hospital. Harrison W. Smith introduced about 30 species in the 1920s to 1940s to his garden in Papeari, now the Jardin Botanique Harrison Smith (JBHS). Recently, more than 70 species have been introduced from 1970 to 1990 by Michel Guérin, former director of the JBHS, and hobbyists, collectors and those in the landscape industry. See Hodel (1982, 1993) for accounts of cultivated palms in Tahiti.

3. *Dypsis madagascariensis* naturalized in mid-elevation rainforest on the island of Moorea, French Polynesia (photo: Jean-Yves Meyer).

Twelve species of palms are sparingly or widely naturalized in French Polynesia (Table 2). Meyer (1998) reported that the ruffled fan palm or Vanuatu fan palm (*Licuala grandis*, locally called “palmier-cuillère” in Tahiti, which means “spoon palm” because of its large leaves), was established in wet, low-elevation secondary forest in a valley on the island of Tahaa (Society Islands) (Fig. 2). In its native range of Vanuatu (San Cristobal and Santa Cruz), *L. grandis* is known to be gregarious in shaded understory of rain forest and forms extensive colonies (Jones 1995, Whitmore 1975). Introduced to Tahiti in 1930, it was cultivated since 1936 in the JBHS, where it is currently locally naturalized.

Guérin observed the Lucuba palm (*Dypsis madagascariensis*) naturalized in wet, low-elevation secondary forests of the Opunohu Valley, Moorea (Society Islands) in the 1980s from a 1971 introduction. More recently Meyer observed this species naturalized in the Vaianae and Maharepa valleys of Moorea up to 400 m elevation in secondary and wet primary forests (Fig. 3). It is noteworthy that this species (under the name *Chrysalidocarpus lucubensis*) is also noted to be locally naturalized in low-elevation rain forest in Mauritius (Lorence & Sussman 1986) and in peripheral area of a secondary tropical forest in Panama (Svenning 2002).

Guérin also noted that the African Oil palm (*Elaeis guineensis*) was naturalized in the low elevation Fautaua Valley in Tahiti as early as the 1970s. In 2005 Meyer observed it locally naturalized in a wet secondary forest that was once a cultivated area in a deep valley on the island of Raiatea (Society Islands).

The small fleshy fruits (ca. 1 cm in diameter) of *Dypsis madagascariensis* and *Licuala grandis* might be dispersed over long distances by frugivorous birds, such as the common myna (*Acridotheres tristis*), introduced in the early 1900s in Tahiti and found at lower elevations, and the red-vented bulbul (*Pycnonotus cafer*), introduced in the 1970s and found at higher elevation (up to 2000 m), but also by the endemic fruit dove *Ptilinopus purpuratus*, which is a generalist frugivorous wild pigeon found in mid-elevation rain forests in the Society Islands. Meyer observed red-vented bulbuls feeding on mature fruits of *L. grandis* in the main town of Papeete. The larger fruits of *Elaeis guineensis* might be dispersed by alien rats or wild pigs, which are common in deep and wet valleys of Tahiti and Raiatea.

Table 2. Naturalized and invasive palms in French Polynesia (FP) and the Mascarene Islands (MS) (*known as naturalized or invasive in other tropical countries). Approximate date of introduction: T = in Tahiti; M = in Mauritius; R = in La Réunion.

Scientific name	Origin	Date of introduction	Status (island, archipelago)
Areca catechu	Southeast Asia, Philippines	1754 (M) 1825 (R) 1930? (T)	Locally naturalized (Tahiti, FP)
Dypsis lutescens	Madagascar	1837 (M) 1856 (R)	Locally naturalized (La Réunion, MS)
**Dypsis madagascariensis*	Madagascar	1768 (M) 1856 (R) 1937 (T)	Widely naturalized/invasive (Moorea, FP); naturalized (Mauritius, MS)
**Elaeis guineensis*	West Africa	1780 (M) 1850 (T) 1825 (R)	Locally naturalized (Raiatea, Tahiti, FP)
**Heterospathe elata*	Philippines	1930? (T)	Locally naturalized (Tahiti, FP)
Licuala grandis	Vanuatu	1936 (T)	Locally naturalized (Tahiti, FP), widely naturalized (Tahaa, FP)
**Livistona chinensis*	Japan, Taiwan, Ryukyu Is.	1785 (M)	Widely naturalized/invasive (Mauritius, MS), locally naturalized (La Réunion, MS)
Livistona australis	Australia	1933 (T)	Locally naturalized (Tahiti, FP)
Livistona saribus	Southeast Asia	1930 (T)	Locally naturalized (Tahiti, FP)
**Nypa fruticans*	Southeast Asia, India, Sri Lanka, Australia, Solomon Is. Ryukyu Is.	1825 (R) 1928 (T)	Locally naturalized (Tahiti, FP)
Oncosperma tigillarium	Sumatra, Borneo, Java, Malaysia	1930 (T)	Locally naturalized (Tahiti, FP)
**Phoenix dactylifera*	North Africa & Middle East	1763 (M) 1825 (R)	Locally naturalized (Mauritius, La Réunion, MS)
Phoenix sylvestris	Pakistan to Himalaya, E. India to Myanmar	before 1764 (M)	Locally naturalized (Mauritius, MS)
Pinanga coronata	Indonesia	1980 (T)	Locally naturalized (Tahiti, FP)
Ptychosperma elegans	Queensland	1836 (M) 1896 (R) 1937 (T)	Locally naturalized (Tahiti, FP)
**Ptychosperma macarthurii*	New Guinea, Australia	1905 (M) 1931 (T)	Locally naturalized (Tahiti, FP)
Raphia farinifera	Trop. Africa	before 1801 (M) before 1895 (R)	Locally naturalized (Mauritius, La Réunion, MS)
Roystonea oleracea	Lesser Antilles, Trinidad, Venezuela, Columbia	1825 (R) 1837 (M)	Locally naturalized (Mauritius, La Réunion, MS)
Syagrus romanzoffiana	Brazil to NE Argentina	1860 (M)	Locally naturalized (Mauritius, MS)
**Washingtonia robusta*	Mexico	1904 (M)	Locally naturalized (La Réunion, MS)

At least nine other palm species are locally naturalized in the JBHS. These include the Indo-Malaysian betel nut (*Areca catechu*); the solitaire palm (*Ptychosperma elegans*), native to Queensland, Australia, which is also known to be naturalized in the Caribbean Islands

4. *Heterospathe elata* naturalized in the shaded understory of a Tahitian chestnut *Inocarpus fagifer* secondary forest in the Jardin Botanique Harrison Smith in the island of Tahiti, French Polynesia (photo: Jean-Yves Meyer).

(Delnatte 2003, Kairo et al. 2003); the MacArthur palm (*P. macarthurii*), native to Queensland and New Guinea and also locally naturalized on the island of Kauai in the Hawaiian Islands (D. Lorence, pers. comm. 2007); *Heterospathe elata*, from the western Pacific, with many seedlings and young plants growing in the shaded understory of a Tahitian chestnut (*Inocarpus fagifer*) secondary wet forest (Fig. 4); the Taraw palm (*Livistona saribus*), native to Southeast-Asia, which is also well-established in Panama (Svenning 2006); and the Australian cabbage palm (*L. australis*) and *Oncosperma tigillarium* (Hodel 1982).

Whether these palms will spread into the surrounding vegetation or stay confined in the JBHS is not known, but there is often a time lag between the date of introduction and the naturalization event, and between naturalization and invasion in secondary or native forests. *Nypa fruticans*, introduced in JBHS in 1928, is locally naturalized in the garden but will not expand its distribution as suitable esturine habitat is scarce or lacking in French Polynesia.

Another species, *Pinanga coronata*, from Indonesia and introduced around 1980, may pose a threat because seedlings and saplings have been observed in the JBHS and in nearby private gardens. It has naturalized in similar wet habitats in Fiji (Hodel, personal observation), especially in ColoiSuva where it was introduced in a garden in the 1970s and is now spreading aggressively through the ColoiSuva Forest Park (Watling 2005). Dense stands of this palm species are observed in the Lyon Arboretum in Hawaii (R. Baker, pers. comm. 2007). Seedlings of *P. coronata* were recently observed in secondary wet forest at 450 m elevation in a gulch located under a residential area of the north coast of Tahiti.

The JBHS is also the source of some of the most notorious and aggressive invasive plants in French Polynesia. Introduced in 1937, the tropical American tree *Miconia calvescens* now covers more than 80,000 ha of secondary and native wet forest, including endemic species-rich cloud forest (Meyer & Florence 1996). The invasive trumpet tree (*Cecropia peltata*), the African tulip tree (*Spathodea campanulata*), and the shoebutton ardisia (*Ardisia elliptica*) were all first introduced to the JBHS in the 1920s and 1930s. Other species have recently shown first signs of invasion, including the liana *Anodendron paniculatum*, which was introduced in 1934 (Meyer in press).

Alien Naturalized and Invasive Palms in the Mascarenes (Indian Ocean)

Thirteen native palm species are recognized in the Mascarene Islands (Moore & Guého 1984).

A new endemic species, *Acanthophoenix rousselii*, was recently been described in La Réunion, and *A. crinita* was recognized to be a native species in the Mascarenes (Ludwig 2006). The origin of *A. rubra* is still controversial because all its known locations in La Réunion are at or near places of past or current human habitation or other activity, although in Mauritius wild populations are still found in the southern part of the island. This species may have been introduced from Mauritius to La Réunion in the past for its much esteemed edible apical meristem, locally called "choux palmiste."

Five *Hyophorbe* species have been described in the Mascarenes: one endemic to La Réunion (*H. indica*), one to Rodrigues (*H. verchaffeltii*) and three from Mauritius (*H. lagenicaulis*, *H. vaughanii* and *H. amaricaulis*). The genus *Latania* is endemic to the Mascarenes, and each island has its own endemic species: *L. lontaroides* in La Réunion, *L. loddigesii* in Mauritius and *L. verchaffeltii* in Rodrigues. *Tectiphiala ferox* is endemic on Mauritius and is represented by fewer than 25 individuals in the wild (Lavergne et al. 2007). *Dictyosperma album* is still common and currently cultivated on the three islands.

Among the 274 species of palms introduced to the Mascarenes during the last three centuries, only 93 are still growing in the archipelago (Moore & Guého 1984, Rouillard & Guého 1981–1985, 1999). Palm introductions to the Jardin des Pamplemousses in Mauritius included 16 species by Fusée Aublet, Charpentier de Cossigny, Juge, Abbé Rochon and Céré & Le Brasseur from 1754 to 1785; 160 species by, Falquhar, Thompson, Duncan, Bojer and Cantley; 160 species from 1815 to 1892; 39 species by Koënig, Wiehé, Regnard, Rouillard, Val Ory and the forestry service from 1904 to 1964; and 22 species from other sources in the 1970s–80s (Rouillard & Guého 1999). Only 72 species are still growing in this botanical garden.

The gardeners N. Bréon and Jean-Marie Richard planted about 45 species in the Jardin d'Acclimatation of La Réunion from 1825 to 1856. About 35 non-native palm species are still growing in this botanical garden, now called Jardin de l'État, located in the main town of Saint-Denis.

According to Moore and Guého (1984), about 15 palm species are widely cultivated as ornamentals in La Réunion and Mauritius. Nine of them are naturalized (Table 2), including an invasive species, the Chinese fan palm *Livistona chinensis*. On Mauritius it is widely naturalized in the secondary and the native forests (Rouillard & Guého 1981-1985, 1999; Strahm 1993, 1999) and in the southeast part of La Réunion it has spread in streambeds, shady understory of disturbed secondary forests, and in coastal areas (Fig. 5). Local land managers often mistake it for the endemic palms *Latania* spp.

The Lucuba palm, *Dypsis madagascariensis*, which is a very old introduction in Mauritius (1768), is naturalized in mid-elevation wet forests of Bel Ombre (J.-C. Sevathian, pers. comm. 2006). Seedlings and saplings of the golden cane palm *D. lutescens*, a very popular palm used for hedges in the gardens of Mauritius and La Réunion, have been observed in a streambed near Saint-Leu (J. Hivert and C. Fontaine, pers. comm. 2006). Frugivorous birds or water have probably dispersed the fruits from a garden down to the valley bottom.

The cabbage palm or West Indian royal palm, *Roystonea oleracea*, often planted in rows as avenue trees, is naturalized in La Réunion around the Saint-Paul pond and on a cliff near a waterfall. This large palm is also reported to be naturalized in the Province Sud of New Caledonia (MacKey 1985) where it forms small populations, especially in the valley of Moindou near a river (R. Amice, pers. comm. 2007). It is naturalized in Guyana, Surinam and French Guiana (Zona 1996) where an important population is found near the village of Kaw (C. Delnatte, pers. comm. 2007).

Members of "Palmeraie-Union," a local palm amateur group, reported that a population 50 individuals of *Raphia farinifera*, native to tropical Africa and north and east Madagascar, is established in La Réunion along the Rivière Saint-Louis (Martz & Martz 2001). The botanist E. Jacob de Cordemoy (1895) also observed this species naturalized along the streams of Bras-Panon in La Réunion in the 19th century. However some *Raphia* populations have regressed because of increasing urbanization. It is also naturalized along many streams and riverbanks in Mauritius, particularly around Mare aux Vacoas and Moka plain (Rouillard & Guého 1981–1985, 1999), and is considered a potential invasive palm in the Seychelles (Dunlop et al. 2005).

The date palm, *Phoenix dactylifera*, is widely planted along roadsides on the leeward coasts of Mauritius and La Réunion. It is naturalized in the driest region, particularly around Port

Louis in Mauritius and on the leeward coast of La Réunion (Cordemoy 1895). It can be encountered near Saint-Leu along the Ravine des Poux in a remnant native dry forest (Lavergne, personal observation). The wild date palm, *P. sylvestris* from southern and eastern Asia is locally naturalized in Mauritius near Port Louis (Rouillard & Guého 1981–1985, 1999).

The queen palm, *Syagrus romanzoffiana*, is reported to be sub-spontaneous at the base of Montagne Ory in Mauritius (Rouillard & Guého 1981-1985, 1999). The Mexican fan palm, *Washingtonia robusta*, is locally naturalized in Saint-Gilles, La Réunion on a roadside near a plant nursery. According to A. Hoarau (pers. comm. 2005), a palm collector in La Réunion, this species could become a serious plant invader as it produces small fruits easily dispersed by the Indian myna, *Acridotheres tristis*, or the red-whiskered bulbul, *Pycnonotus jocosus*, two widespread non-native birds in the Mascarenes.

Discussion

Only a few introduced palm species are naturalized in French Polynesia (12 out of 108 introduced species, ca. 12%) and in La Réunion Island (9 out of 93 species, ca. 10 %). It is also the case in Fiji (Pacific Ocean), which has more than 100 palm species in cultivation but only four documented naturalized species (Fuller 1997, Watling 2005), and Hawaii with more than 650 species of palms cultivated in botanical gardens including four well-documented invasive species (Staples & Herbst 2005).

However, we predict that more and more species will become naturalized and invasive in French Polynesia and the Mascarenes in the near future, and more generally in tropical islands worldwide as they are becoming very popular landscape and garden plants. The number of introduced species in these islands has dramatically increased in the last decades (Fig. 1). Also, an increase in the number of individuals per species, in the number of localities where they are planted (which together constitute the "propagule pressure" concept) and potential suitable habitat for their establishment and naturalization enhance the risk of invasion. Moreover, several palm species with small fruits (*Ptychosperma macarthurii* in Fiji [Watling 2005], *Licuala grandis* and *Dypsis madagascariensis* in Tahiti, *Washingtonia robusta* in La Réunion) are actively dispersed by alien frugivorous birds, especially mynas (*Acridotheres tristis* in many tropical islands, and *A. fuscus* in Fiji) the bulbuls (*Pycnonotus cafer* and *P. jocosus*), over long distances.

5. *Livistona chinensis* naturalized in coastal secondary forest of Saint-Philippe, La Réunion, Mascarenes (photo: Christophe Lavergne).

Indeed, several species have recently escaped from cultivation to become naturalized in Hawaii, including the cascade or cataract palm (*Chamaedora cataractarum*) (Staples & Herbst 2005), the West Indian royal palm (*Roystonea oleracea*) and the wild date palm (*Phoenix sylvestris*), which has formed locally extensive stands in mesic habitats in Hawaii (Hodel, personal observation).

The Auckland Regional Council of New Zealand has recently planned to add three palm species in its list of 119 banned invasive plants: the bangalow palm (*Archontophoenix cunninghamiana*), the Chinese windmill palm (*Trachycarpus fortunei*) and the Canary Island date palm (*Phoenix canariensis*), because they are spreading in the wild (www.arc.govt. nz/arc/). The two last species are also naturalized in disturbed areas in the region of Victoria, Australia (Groves & Hosking 1997, Lazarides et al. 1997). The Canary Island date palm, which is widely planted as an ornamental and a street tree, has started to spread along waterways across south-east Australia (Richardson et al. 2006).

The Senegal date palm (*Phoenix reclinata*), the queen palm (*Syagrus romanzoffiana*), the solitaire palm (*Ptychosperma elegans*) and the bamboo palm (*Chamaedorea seifrizii*) are reported to be naturalized in Florida (www.fleppc.org/list/05List.htm). The Senegal date palm, native to tropical Africa, is reported to be naturalized in Bermuda (Kairo et al. 2003). Doubts persist on the origin of *Phoenix reclinata* in the Comoros archipelago. It could be native, but it is more frequent around villages and cultivated areas (Pascal 2000) and in coastal forests. However, the fruits are dispersed by the native lemurs, and the palm populations are increasing in the inland forest in the last ten years (N. Ludwig, pers. comm. 2006). The queen palm, native to Brazil and Argentina, is also naturalized in the New South Wales and southern Queensland region of Australia, the latter in urban shrubland in the suburbs of Brisbane (Csurhes & Edwards 1998).

Hyphaene thebaica, native from west tropical Africa to Egypt and the Arabian peninsula, is reported as a potential invasive palm in Curaçao in the West Indies (Delnatte 2003). The rattan, *Calamus caesius*, a climbing, vine-like, spiny species native to Southeast Asia, is reported to have started to naturalize on the island of Upolu, Western Samoa in the South Pacific where it was intentionally introduced in the early 1990s (Mark J. Bonin, pers. comm. 2007). The clustered fishtail palm *Caryota mitis* and the African oil palm *Elaeis guineensis* are naturalized and considered moderately invasive on the island of Mayotte in the Comoros archipelago, Indian Ocean (F. Barthelat, pers. comm. 2006).

Other naturalizing palms in botanical gardens include the Sugar palm *Arenga pinnata* and *Aiphanes horrida* in the Amani Botanic Garden located in the East Usambara Mountains of Tanzania, first established in 1902 (W. Dawson, pers. comm. 2007).

Management of invasive species begins with prevention, early detection and rapid response (e.g. eradication) because control of large infestations is often very expensive and difficult. "Black lists" of noxious (or harmful) species and Weed Risk Assessment (WRA) systems are now commonly used in Australia and New Zealand to prevent introduction of potentially invasive species. WRAs are mainly based on climate matches and life history traits of species, and their "behavior" or invasive history elsewhere in the world (i.e. "black listed species"), but published information on many plants species in specific regions or countries are often lacking or not easily available, often being only found in "gray literature."

For example, the WRA for Hawaii and Pacific Islands (www.botany.hawaii.edu/faculty/daehler/WRA/, version January 2007) evaluates only a relatively few number of palm species (64, but some of these are synonyms) including 10 cited in our study. Three of them (*Ptychosperma macarthurii*, *Washingtonia filifera* and *W. robusta*) are considered invasive, "causing significant ecological or economic harm in Hawaii."

Three other species (*Archontophoenix alexandrae* [syn. *Ptychosperma alexandrae*], *Ptychosperma elegans* [syn. *Seaforthia elegans*] and *Livistona chinensis*), which are considered invasive in our study, need further evaluation according to the WRA "because of important missing data or because the species possesses a combination of traits that makes its behavior difficult to assess."

Four other species (*Archontophoenix cunninghamiana*, *Dypsis lutescens*, *Roystonea regia* and *Syagrus romanzoffiana*) are considered "not currently recognized as invasive in Hawaii and not likely to have major ecological or economical impact on other Pacific Islands" by this WRA system. However, two of these are reported and known as invasive (*D. lutescens* and *R. regia*), and the other two are already naturalized in tropical regions or islands (*A. cunninghamiana* and *S. romanzoffiana*).

We strongly recommend avoiding the introduction and planting of the 12 well-documented invasive species (Table 1) and the two widely naturalized species in French Polynesia and the Mascarene Islands (Table 2) that are able to form dense stands excluding the native vegetation, as well as the other locally naturalized species in tropical islands or regions, which constitute real "time bombs" that can escaped from cultivation and gardens and invade native habitats (dry and mesic forests, rain forests, riparian forests) in the near future. By forming very dense stands or clumps, palm species have the potential to displace native plant communities and change the functioning of natural ecosystems (light or water regime, soil nutrients). Remote oceanic islands with a disharmonic flora might be more vulnerable to invasion by palms as this functional group is scarce (only one genus in Hawaii, *Pitchardia*, and two in French Polynesia *Pritchardia* and *Pelagodoxa*) whereas dwarf, understory, climbing and clonal palms are common in continental rainforests (Denslow 2003).

In 1990, Hodel, alarmed by John Dransfield's observation that the Wanga palm, *Pigafetta elata* (as *P. filaris*) was a colonizer of disturbed areas in its native range of Sulawesi, cut down the staminate tree he had planted to eliminate seed production and any possibilities of its escaping from cultivation and becoming naturalized in Tahiti (Hodel 1993). The eradication of *Dypsis madagascariensis* in the island of Moorea (French Polynesia) still seems possible before dense stands are formed or before individuals are found at higher elevation and on steep slopes.

In 1999, Meyer officially advised the Department of the Environment of French Polynesia to ban introduction of *Licuala grandis*, *Washingtonia* spp. and *Elaeis guineensis*. All new importation of palms of the genera *Adonidia*, *Areca*, *Arenga*, *Borassus*, *Dypsis*, *Corypha*, *Howea*, *Livistona*, *Ptychosperma* and *Roystonea*, as well as *Elaeis guinensis*, *Washingtonia robusta* and *Phoenix dactylifera*, are officially illegal in French Polynesia (Decree N°276 CM 23 May 2005), primarily because of the risk of disease to the coconut, the most economically important plant of the islands.

More recently, 421 additional palm species belonging to 130 genera and representing more than 51,000 individuals have been officially introduced from 2000 to 2006 to La Réunion for a "Palm Botanical Garden" project carried out by the Commune du Tampon (A. Hoarau, pers. comm. 2007). A careful screening of all these species, currently cultivated in a plant nursery, should be conducted before planting them out. Gardeners, horticulturists and landscapers could become key allies in the prevention and control of invasive alien plants in tropical islands, thus preserving their unique biodiversity.

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Literature Cited

Baas Becking, L.G.M. 1950. Liste préliminaire de plantes introduites à Tahiti. Commission du Pacifique Sud, Document Technique N°7, Nouméa, 20 pp.

Cordemoy, E.J. de 1895. Flore de l'île de la Réunion. Paul Klincksieck, Paris, 574 pp.

Csurhes, S. and R. Edwards. 1998. Potential Environmental Weeds in Australia. Environment Australia, Biodiversity Group, Canberra, 208 pp.

Delnatte, C. 2003. La Guadeloupe face aux espèces allochtones. Etude préalable d'évaluation de la menace des espèces végétales invasives dans le Parc National de Guadeloupe. DESS Ressources Naturelles et Environnement, Université de Metz. Unpublished thesis,189 pp.

Denslow, J.S. 1998. Weeds in paradise: thoughts on the invisibility of tropical islands. Ann. Missouri Bot. Gard. 90: 119–127.

Dunlop, E., J. Hardcastle and N.J. Jivan Shah. 2005. Cousin and Cousine Islands. Status and management of alien invasive species. Nature Seychelles, Victoria. Unpublished report, 65 pp.

Fuller, D. 1997. Conservation Status, Diversity and Systematics of the Indigenous Palms of Fiji. University of the South Pacific, Suva, Fiji, Unpublished MSc. thesis, 152 pp.

Groves, R.H. and J.R. Hosking. 1997. Recent incursions of weeds in Australia 1971–1995. Technical Series N°3, CRC for Weed Management Systems, Australia, Adelaïde, 74 pp.

Hodel, D.R. 1982. Cultivated palms in Tahiti and The Jardin Botanique de Papeari. Principes 26: 77–85.

Hodel, D.R. 1993. The growth of some palms in Tahiti. Principes 37: 127–138.

Hsuan Keng Chin, S.C. and H.T.W. Tan. 1998. The Concise Flora of Singapore. Volume II: Monocotyledons. Singapore University Press, National Park Board, Singapore, 215 pp.

Hussey, B.M.J., G.J. Keighery, J. Dodd, S.G. Lloyd and R.D. Cousens. 2007. Western Weeds. Second Edition. The Weeds Society of Western Australia (Inc.), Perth, 294 pp.

Jacquier, H. 1960. Enumération des plantes introduites à Tahiti depuis la découverte jusqu'en 1885. Bull. Soc. Etud. Océan. 130: 117–146.

Jones, D.L. 1995. Palms Throughout the World. Smithsonian Institution Press, Washington, DC., 410 pp.

Kairo, M.A.B., O. Cheesman, K. Haysom And S. Murphy. 2003. Invasive Species Threats in the Caribbean Region. CAB International, Trinidad & Tobago. Unpublished report to the Nature Conservancy, 132 pp.

Lavergne, C., C. Duret, L. Gigord, L. Grosset and L. Reichsteiner 2007. Les palmiers menacés de l'Ile Maurice et de ses îlots (22 mars–2 avril 2006). Association Palmeraie-Union, La Réunion. Unpublished report, 36 pp.

Lavergne, R. 2001. Plantes du Jardin d'Acclimatation: mise à jour de la nomenclature utilisée au siècle dernier par les deux jardiniers-botanistes dans leurs catalogues: Nicolas Bréon en 1825 et Jean-Marie Richard en 1856. Unpublished report, 109 pp.

Lazarides, M., K. Cowley and P. Hohnen. 1997. CSIRO Handbook of Australian Weeds. CSIRO, Canberra, 264 pp.

Lorence, D.H. and R.W. Sussman. 1986. Exotic species invasion into Mauritius wet forest remnants. J. Trop. Ecol. 2: 147-162.

Ludwig, N. 2006. *Acanthophoenix* in Réunion, Mascarene Islands. Palms 50: 82–98.

Mackee, H.S. 1985. Les plantes introduites et cultivées en Nouvelle-Calédonie. Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, 159 pp.

Martz, C. and B. Martz. 2003. Les *Raphia farinifera* de la Rivière Saint-Louis. Magazine de Palmeraie-Union Latania 5: 10–11.

Meyer, J.-Y. and J. Florence. 1996. Tahiti's native flora endangered by the invasion of *Miconia calvescens* DC. (Melastomataceae). J. Biogeography 23: 775–781.

Meyer, J.-Y. 1998. Mécanismes et gestion des invasions biologiques par des plantes introduites dans des forêts naturelles à Hawai'i et en Polynésie française : une étude de cas. Rapport d'étude post-doctorale, Délégation à la Recherche, Papeete. Unpublished post-doctoral report, 72 pp.

Meyer, J.-Y. In press. The snake-like climber *Anodendron paniculatum* (Apocynaceae), a "new" invasive liana in the rainforests of Tahiti (Pacific Ocean). Aliens (IUCN/ISSG).

Meyer, J.-Y. and C. Lavergne. 2004. Beautés fatales: Acanthaceae species as invasive alien plants on tropical Indo-Pacific Islands. Diversity & Distrib. 10: 333–347.

Moore, H.E., Jr. and L.J. Guého. 1984. Famille 189. Palmiers. In: T.L. Bosser, J. Cadet, J. Guého and W. Marais (eds.), Flore des Mascareignes. The Sugar Industry Research Institute, Mauritius, ORSTOM, Paris, and the Royal Botanic Gardens, Kew.

Oppenheimer, H.L. and R.T. Barlett. 2002. New plant records from the main Hawaiian Islands. In: N.L. Evenhuis and L.G. Eldredge (eds.), Records of the Hawaii Biological Survey for 2000. Part 2: Notes. Bishop Mus. Occas. Papers 69:1–14.

Richardson, F.J., R.G. Richardson and R.C.H. Shepherd. 2006. Weeds of the South-East. An Identification Guide for Australia. R. G. and F. J. Richardson, Meredith, 438 pp.

Rouillard, G. and J. Guého. 1981–1985. Histoire des Plantes d'Intérêt Horticole, Médicale et Economique à l'Ile Maurice 1. Henry & Cie, Ltée, Les Pailles, 289 pp.

Rouillard, G. and J. Guého. Eds 1999. Les Plantes et leur Histoire à l'Ile Maurice. MSM Ltd., Port-Louis, 752 pp.

Smith, A.C. 1979. Flora Vitiensis Nova. A New Flora of Fiji, Vol. 1. Pacific Tropical Botanical Garden, Lawai, 495 pp.

Space, J.C. and M. Falanruw. 1999. Observations on invasive plant species in Micronesia. USDA Forest Service, Honolulu. Report to the Pacific Islands Committee, Council of Western State Foresters. USDA Forest Service, Honolulu. 32 pp.

Staples, G.W. and D.R. Herbst. 2005. A Tropical Garden Flora. Plants cultivated in the Hawaiian Islands and in other tropical islands. Bishop Museum Press, Honolulu, 908 pp.

STARR, F., K. STARR AND L. LOOPE. 2003a. *Livistona chinensis*. Chinese fan palm, Arecaceae. USGS-BRD, Haleakala Field Station, Maui, Hawai'i. Unpublished report, 4 pp.

STARR, F., K. STARR AND L. LOOPE. 2003b. *Washingtonia* spp. Mexican fan palm and California fan palm, Arecaceae. USGS-BRD, Haleakala Field Station, Maui, Hawai'i. Unpublished report, 5 pp.

STRAHM, W. 1993. The conservation and restoration of the flora of Mauritius and Rodrigues. University of Reading. Unpublished PhD thesis, 240 pp.

STRAHM, W. 1999. Invasive species in Mauritius: examining the past and charting the future, pp. 325–347 In: O.T. SANDLUNG, P. SCHEI AND A. VIKEN. (eds), Invasive Species and Biodiversity Management. Kluwer Academic Publishers, Dordrecht, 448 pp.

SVENNING, J.-C. 2002. Non-native ornamental palms invade a secondary tropical forest in Panama. Palms 46: 81–86.

WAGNER, W.L., D.R. HERBST AND S.H. SOHMER. 1990. Manual of the Flowering Plants of Hawaii. Volume 2. University of Hawaii Press, Bishop Museum Press, Honolulu: 989–1853.

WATLING, D. 2005. Palms of the Fiji Islands. Environmental Consultants, Fiji. Ltd. 192 pp.

WHITMORE, T.C. 1973. Palms of Malaya. Oxford University Press, London, 148 pp.

ZONA, S. 1996. *Roystonea* (Arecaceae: Arecoideae). Fl. Neotrop. Monogr. 71: 1–36.

Leucothrinax morrisii, a New Name for a Familiar Caribbean Palm

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New DNA data are forcing scientists to reconsider the taxonomy of all groups of organisms, including palms. As we learn more about the relationships among palm species, we are finding instances where the current taxonomy does not reflect those relationships accurately. One of these is the genus *Thrinax*, which in recent taxonomic classifications included seven species. We have evidence to suggest that these seven species do not belong to a single group of closely related palms but instead may be divided into three distinct lineages. The familiar Keys Thatch Palm, *Thrinax morrisii* (Fig. 1), appears to be independent of other *Thrinax* species. We therefore describe the genus *Leucothrinax* to accommodate its sole species, *Leucothrinax morrisii*. Our data also support the resurrection of the genus *Hemithrinax*.

The Caribbean is one of the world's 34 biodiversity hotspots (Mittermeier et al. 2004), home to an array of unique plants and animals. It is the center of diversity for a large group of thatch palms that includes *Coccothrinax* Sarg., *Thrinax* Sw., and *Zombia* L.H. Bailey. Although most of these palms are rare in the wild or have restricted distributions (Zona et al. 2007), many are widely cultivated in the region and are well represented in botanic gardens, including Fairchild Tropical Botanic Garden.

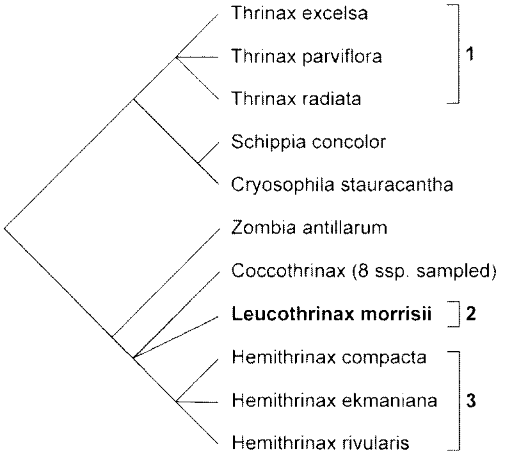
The availability of cultivated palms at Fairchild, along with recent field collections, afforded an excellent opportunity to revisit the relationships among palms in this group. We used DNA to address some lingering questions about these palms, including whether *Zombia* is distinct from *Coccothrinax*, and whether the Cuban endemic species of *Thrinax* might be distinct from other members of the genus. Our work with Caribbean palms is part of a large, collaborative effort to build a new classification of palms. The results of this work are to be published in a forthcoming new edition of *Genera Palmarum* (Dransfield et al. in press)

Methods and Results

To explore the relationships of Caribbean palms, we sequenced the DNA of *Coccothrinax*, *Thrinax*, *Zombia* and other palm genera that appeared to be related based on recent molecular studies (e.g. Asmussen et al. 2006). Our methods and results were reported by Roncal et al. (in press), and the phylogenetic results that pertain to *Coccothrinax*, *Thrinax* and *Zombia* are summarized in Figure 2. Our morphological descriptions of *Thrinax* and its comparison with related palms are based on the observations of Read (1975). We also examined living plants at Fairchild Tropical Botanic Garden to observe characteristics that may be useful for identifying the genera in the field.

From the molecular analyses, we found that the genus *Coccothrinax* is distinct and does not include *Zombia*. Surprisingly, we also found that the seven species of *Thrinax* do not form a single group. Instead, these species appear to represent three distinct evolutionary lineages (groups 1, 2 and 3 in Figure 2).

1. *Leucothrinax morrisii* in Big Pine Key, Florida, USA.



2. Presumed relationships among the genera of the thatch palms and their closest relatives. The relationships were resolved based on nuclear DNA sequences (Roncal et al. in press).

The species *Thrinax excelsa*, *Thrinax parviflora* and *Thrinax radiata* (Fig. 2, group 1) are closely related to one another. All occur in Jamaica, but *T. radiata* is also widespread in the Greater Antilles and adjacent areas of Florida and Central America. The three species may be related to the genera *Schippia* Burret and *Cryosophila* Blume, but evidence for this relationship is weak (Roncal et al. in press.).

The Cuban species *Thrinax compacta*, *Thrinax ekmaniana* and *Thrinax rivularis* (Fig. 2, group 3) are closely related to one another. All three were once classified in the genus *Hemithrinax* Hook.f. (Muñiz & Borhidi 1982), and it appears that this genus should be resurrected to accommodate them.

Thrinax morrisii, the Keys thatch palm (Fig. 2, group 2), is related to *Coccothrinax* and to the three species of *Hemithrinax*. However, it does not fall within either genus, and its precise position is unclear. It is clearly distinct from *T. radiata* and its relatives (Fig. 2, group 1). Without any evidence that this species belongs in an existing genus, a separate genus is needed to build a phylogenetic classification. Cook (1937) previously recognized *Thrinax morrisii* as a unique lineage and applied the name *Simpsonia microcarpa* but without valid publication. Therefore, our new classification of these palms includes the new genus *Leucothrinax* C.E. Lewis & Zona.

A new classification of *Thrinax*, *Hemithrinax* and *Leucothrinax*

The new classification of the thatch palms *Thrinax, Hemithrinax* and *Leucothrinax,* including the distribution of each species, is outlined in Table 1. We propose a more narrowly defined genus *Thrinax* to include *T. excelsa, T. parviflora* and *T. radiata*. We also propose to resurrect the genus *Hemithrinax* and recognize the species *H. compacta*, *H. ekmaniana* and *H. rivularis*. *Hemithrinax* is one of the 180 flowering plant genera that are found only on islands of the Caribbean (Francisco-Ortega et al. 2007). They are rare palms that are found only in specialized habitats of Cuba, where they likely evolved. Zona et al. (2007) listed *H. compacta* and *H. ekmaniana* (Fig. 3) as “vulnerable,” and *H. rivularis* as “endangered.”

We propose a new genus, *Leucothrinax*, to include only *Leucothrinax morrisii* (H. Wendl.) C.E. Lewis & Zona. The name is derived from the Greek prefix “*Leuco-*,” meaning white, and *Thrinax*, the genus it most closely resembles and which *L. morrisii* had long been associated. *Leucothrinax* has conspicuous waxy scales on the emerging leaves, emerging inflorescences,

Table 1. The thatch palms and their distribution

Species	Distribution
Thrinax radiata Lodd ex. Schult. & Schult. f.	Yucatan Peninsula, Honduras, Florida, Jamaca, Hispaniola, Cuba, Bahamas
Thrinax excelsa Lodd. ex Griseb	Jamaica
Thrinax parviflora Sw.	Jamaica
Hemithrinax compacta (Griseb. & H. Wendl.)	Cuba
Hemithrinax ekmaniana Burret	Cuba
Hemithrinax rivularis Léon	Cuba
Leucothrinax morrisii (H. Wendl.) C.E. Lewis & Zona	Florida, Bahamas, Cuba, Puerto Rico, Hispaniola, western Lesser Antilles

and the undersides of mature leaves, giving the plant a whitish appearance not seen in *Hemithrinax* and *Thrinax*.

Leucothrinax C.E. Lewis & Zona, **gen. nov.**

A *Thrinax* foliis glaucis, hastulis indumento albo sericeo caduco et floribus sessilibus vel subsessilibus difert – TYPE: *Leucothrinax morrisii* (H. Wendl.) C.E. Lewis & Zona

Solitary, unarmed, hermaphroditic palm to 11 m tall. Stems to 35 cm in diameter. Leaves palmate, induplicate. Petioles split basally with netlike fibers, elongate, usually longer than the leaf blade. Abaxial surfaces of petiole and leaf blade covered with whitish waxy scales. Hastula and inflorescence bracts covered with silky, white caducous scales. Inflorescences arching, exceeding the leaves. Flowers sessile or borne on very short pedicels less than 1 mm in length. Fruits white, globose. Endosperm homogeneous, embryo lateral.

Leucothrinax morrisii (H. Wendl.) C.E. Lewis & Zona, **comb. nov**. Basionym: *Thrinax morrisii* H. Wendl., Gard. Chron. 1891(1): 700. 1891.

Key to *Hemithrinax*, *Leucothrinax*, and *Thrinax*

Leaf cross veins inconspicuous, flowers ebracteolate; stamens sessile, inflexed in bud; anther connective broad . . . . . . *Hemithrinax*

Leaf cross veins conspicuous; flowers bracteolate; filament subulate; stamens erect in bud; anther connective slender

Leaves glaucous adaxially; adaxial hastula silky upon leaf emergence (but pubescence caducous); leaf blade composed entirely of palisade cells; flowers sessile or subsessile . . . . *Leucothrinax*

Leaves green adaxially; adaxial hastula glabrous or glabrescent upon emergence; leaf blade composed of either mesophyll cells or both mesophyll and palisade cells; flowers pedicellate . . . . *Thrinax*

Discussion

Leucothrinax morrisii is one of the most familiar cultivated palms of the Caribbean region and is also found in tropical gardens and conservatories worldwide. Its status as a distinct, monotypic genus had been, until now, unrecognized, as it shares many visible features with *Thrinax excelsa*, *T. parviflora* and *T. radiata*. Using molecular tools that were unavailable to earlier taxonomists, we were able to show a clear distinction between *Leucothrinax* and related palms.

3. *Hemithrinax ekmaniana*, a vulnerable species endemic to Las Villas, Cuba.

Widespread and common in the Caribbean region, *Leucothrinax morrisii* occurs across a range of habitats in Florida, the Greater Antilles, and the western Lesser Antilles. It has a conservation status of “least concern” (Zona et al. 2007) under the World Conservation Union criteria (IUCN 2006). Nevertheless, it represents unexpected diversity in the Caribbean palm flora and suggests that further phylogenetic research may uncover additional surprises. This research must be done quickly, as many Caribbean palms are in rapid decline, along with the threatened areas they inhabit (Zona et al. 2007).

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Literature Cited

ASMUSSEN, C.B., J. DRANSFIELD, V. DEICKMANN, A.S. BARFOD, J.-C. PINTAUD, AND W.J. BAKER. 2006. A new subfamily classification of the palm family (Arecaceae): evidence from plastid DNA. Bot. J. Linn. Soc. 151: 15–38.

MUÑIZ, O. AND A. BORHIDI. 1982. Catálogo de las palmas de Cuba. Acta Bot. Acad. Sci. Hungarica 28: 309–345.

DRANSFIELD, J., N. UHL, W.J. BAKER, C.B. ASMUSSEN, M. HARLEY AND C.E. LEWIS. Genera Palmarum: The Evolution and Classification of Palms. In press.

FRANCISCO-ORTEGA, J., E. SANTIAGO-VALENTÍN, P. ACEVEDO-RODRÍGUEZ, C. LEWIS, J. PIPOLY, A.W. MEEROW, AND M. MAUNDER. 2007. Seed plant genera endemic to the Caribbean Island biodiversity hotspot: A review and a molecular phylogenetic perspective. Bot. Rev. 73: 183–234.

MITTERMEIER, R.A., P. ROBLES GIL, M. HOFFMANN, J. PILGRIM, T. BROOKS, C.G. MITTERMEIER, J. LAMOREUX, AND G.A.B. DA FONSECA. 2004. Hotspots Revisited. Mexico: CEMEX.

READ, R.W. 1975. The genus *Thrinax* (Palmae: Coryphoideae). Smithsonian Contrib. Bot. 19: 1–98.

RONCAL, J., S. ZONA, AND C.E. LEWIS. Molecular phylogenetic studies of West Indian Palms (Arecaceae) and their relationships to biogeography and conservation. Bot. Rev., in press.

ZONA, S., R. VERDECIA-PEREZ, A. LEIVA-SANCHEZ, C. LEWIS AND M. MAUNDER. 2007. Conservation status of West Indian palms. Oryx 41: 300–305.

The Decline of the Bankouale Palm in Djibouti: El Niño and Changes in Architectural Fashion

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1. A group of *Livistona carinensis*.

The Bankouale palm, *Livistona carinensis*, is in serious decline in Djibouti. This paper documents the current status of the palm and discusses possible conservation measures.

In 2004 a partial survey of the Bankouale palm, *Livistona carinensis* (Chiov.) J. Dransf. & N.W. Uhl, was undertaken (Ford & Bealey 2004). It is very limited in its worldwide distribution having been reported from only two other areas, the Yemen and Somalia, and is currently classed as "vulnerable" in the IUCN/WCMC World List of Threatened Species. The Somali population consisted of 38 plants in 1998, and the Yemeni population was described as being replaced by a date plantation (Welch & Welch 1998).

In Djibouti the palm exists, typically, in populations of from 3–50 plants, as shown in Figure 1, as populations of closely grouped individuals in a wadi bed or spring side. These populations are distributed amongst three wadi systems, each on the upland plateau of the Goda Massif (1700 m) to the sea of the Gulf of Tadjoura to the east and south. The 2004 survey revealed an overall decline of some 23–30% in those populations measured. The populations were found to be over-mature, consisting of adults and few juveniles and rosettes, though they flower and fruit freely. Most populations had no juveniles at all. It was therefore decided to make a complete survey of all the extant populations in Djibouti and to collect samples for genetic analysis with a view conserving the palm for the future.

Results and Discussion:

Our survey revealed that there was a total of 314 adults, 20 juveniles, 134 rosettes, 210 small rosettes (more than six leaves) and 465 seedlings (<3 leaves) living in the Bankouale area of Djibouti. These are distributed unequally amongst three valley systems (Fig. 2). From Table 1 and Figure 2, one can see that most of the plants occur in the Bankouale valley. In percentage terms, 65% of the adults, 85% of the juveniles, 75% of the rosettes, 76% of the small rosettes and 93 % of the seedlings were found in the Bankouale valley.

Table 1: Numbers of individuals in life history classes of all populations of *Livistona carinensis* in Djibouti with % change since 1985 where applicable (* since 1990, ** since 1988, ***1987). Site numbers refer to Fig 2.

	<3 lvs	<6 lvs	Rosette	Juvenile	Adult	% change
Randa						
Santaba (25)	23	7	2	0	15	
Randa (17,18,19,20)	13	11	8	1	18	-25
Eewali (21,22,23,24)	0	2	1	0	5	-55
Ribtaleh (26,27,28)	5	5	31	0	21	
Total	41	51	20	1	59	
Bankouale						
Satabou Lower (13)	3	3	3	2	6	-50
Satabou Upper (11,12)	42	10	10	0	32	77
Aggorogouba* (4)	37	0	12	1	22	-12
Disay (3)	175	106	35	7	22	-43
Ribta Aibole* (16)	9	0	2	0	25	-20
Ribta** (15)	0	0	0	0	3	-62
Bankouale (5–10, 14)	173	42	53	1	91	-54
Total	439	161	105	11	201	
Ditilou						
Wer (2)	0	0	9	2	39	-23
Ditilou*** (1)	0	0	0	0	10	-28
Total	0	0	9	2	49	

Table 2: Life history class structures in garden and non-garden sites.

	<3 lvs	<6 lvs	Rosette	Juvenile	Adult
Garden sites	459	199	109	14	171
Non-garden sites	54	13	25	6	151

Table 2 and Figure 3 show the population structures associated with garden and non-garden sites. The majority of the seedlings were in or associated with gardens, but the numbers of adults in garden and non-garden sites are similar.

Site Descriptions.

Randa Valley:

Randa (sites 17, 18, 19, 20, Welch sites 1–6): The site is in four parts. A couple of plants are situated in the village, with a juvenile by the school. A dramatic cliff population making up most of the plants in the area is found by the tourist camp. This has an associated spring and small tank acting as a reservoir. A second cliff population is on the road some 400 m west of the tourist camp. This seems to be in an incongruous position, being very dry and not near any other palms but up a shallow side valley from this last population are two individuals in a wadi by some gardens.

Santaba: (site 25) This site had not been visited by the Welchs. The palms are situated around small spring some 20 m above the wadi bottom facing south. There are no gardens near by but the area is grazed.

Ribtaleh: (sites 26, 27, 28) Not visited by the Welchs this is a site of three parts. In the lower site, the palms occupy a wadi site with the young in the adjacent gardens. In the upper site there are three palms remaining round a well. Three large rosettes are in the gardens just downstream on the northern side.

Eewali: (sites 21, 22, 23, 24) This is a scattered site along a long shallow valley. Downstream, around an abandoned tourist camp site area, is a group of three juveniles, an adult and another adult up a side valley. Upstream (Silbili) by gardens are three more living palm trees (two very mature) with three stumps and two dead trunks. The gardener has protected the base of one of the trees.

Bankouale Valley:

Agorogouba: At the spring site the palms share an elevated position above the wadi with dense *Phoenix reclinata*. The Welchs' lower three sites are subsumed into the garden site, which therefore includes several adults in the wadi bottom. The rest of the palms are scattered in and around the gardens downstream of the spring site, where we recorded two adults in the wadi, six adults and 36 seedlings were found in the gardens, a solitary palm further down and a seedling some 300 m downstream.

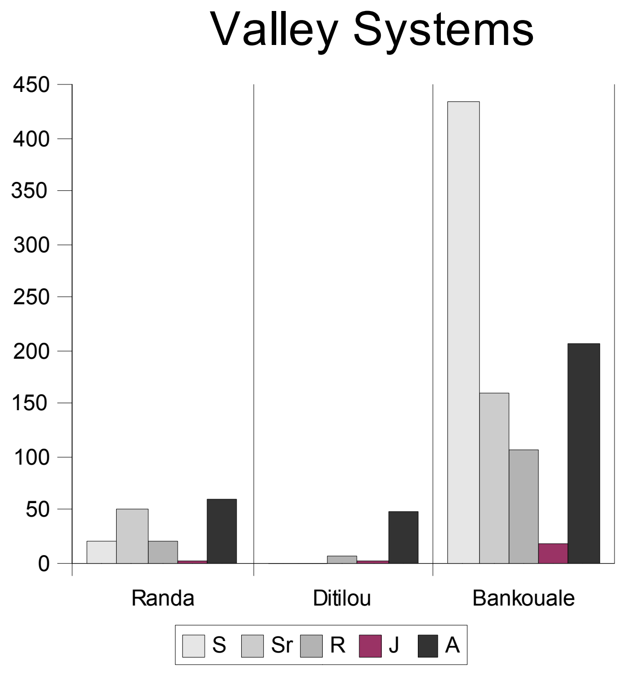
Disay: In this site the gardens extend either side of a sharp ravine which is quite difficult to explore. The adults and juveniles are mainly in the ravine and rosettes and seedlings scattered around. Neither the Welchs nor HF in 2004 fully explored the ravine, and the numbers do not represent an increase over previous years but reflect a proper search. Two dead adults were found in 2006, yet the adult numbers have declined markedly in 20 years.

Bankouale:

Cascade and Gardens (sites 5, 6, Welch sites 1–6): This site is at the side of a spring situated a little above the wadi. Originally the palms spread on both sides of the wadi but they are now restricted to garden side (SW). Seedlings and rosettes are found in the gardens, and a few seedlings were found by the spring. Site 6 is a cluster of six palms at the entrance to a side wadi some 50 m downstream from the cascade.

Main (site 7, Welch 7, 8): This site is of some 30 adults situated in the middle of the Wadi opposite Houmet Ali's Tourist camp. A few seedlings were present at the beginning of our visit, but very few were left two weeks later, presumably grazed.

Side (site 8, Welch 9, 10, 11, 13): This site is primarily a linear site some 100m long on the south side of the wadi adjacent to the gardens with over 30 adults. The Welchs reported rosettes in the gardens of site 11 that we think are the same plants that we record as the south gardens. They do not mark them on their map nor count the plants but do mark the garden. The South gardens are particularly important as they have a developing population of juveniles, rosettes and seedlings. We did not record these in 2004. The North Garden plants were not recorded by the Welchs and represented a new site in 2004.



2. Life history structures of populations within each of the main valley systems of the Goda Massif.

Satabou Lower (site 13): A cluster of six palms adjacent to and in two gardens by the entrance of the Satabou Wadi. The Ethiopian gardener asked us "Why are you interested in these palms? They don't do anything."

Satabou Upper (sites 12, 11): This site is a linear site along the upper part of the wadi. There must have been be a miscount at some stage as the Welchs counted 18 adults and we counted 28 in 2004 and 32 in 2006. The seedlings and small rosettes were found in the garden, opposite our overnight camp.

Ribta Aibole (site 16): The Welchs did not visit the site but counted the adults from the road. The site is centered on a spring and several pools, but there are no adjacent gardens . There were five young adults included in the 29 adults recorded. Grazing is a particular problem.

Ribta West (site 17): This is a group of 3 palms with two dead trunks on the ground situated in a valley similar to and adjacent to Aibole.

Ditilou Valley:

Wer (site 2): The site is immediately above the gardens, but unlike the Welchs visits, we found no seedlings. Gardens are well tended and there is a large water reservoir between the gardens and the Palm grove.

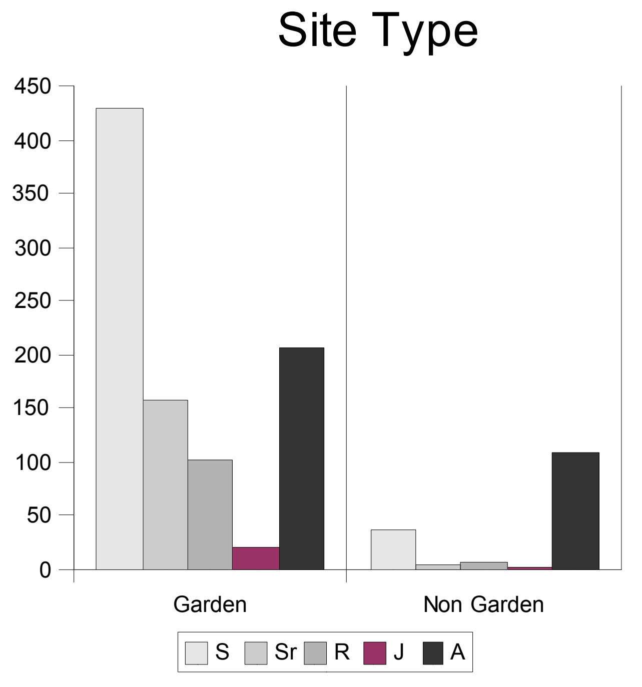
Ditilou (site 1): The site, called Toha by the Welchs, is to the north side of the wadi and by the gardens. No seedlings or young plants were found. This spring, storm waters took away considerable areas of the bank both opposite and downstream.

Factors Controlling the demography:

Flowering and Fruiting: All populations were flowering abundantly while we were there. We saw no floral visitors, in contrast to the swarms of bees that visited the flowers of *Phoenix reclinata,* but the plants fruit abundantly according to the locals, and this is evidenced by the large numbers of seedlings occasionally observed. The fruits are hard and pea-like (Monod 1955).

Germination and Establishment: The large number of seedlings occasionally recorded shows that germination is a frequent if not annual occurrence. Some of this variation may be accounted for by differences in the timing of the observations as it is clear that the seedlings are very susceptible to grazing. This susceptibility may account for the frequent association of *Livistona carinensis* and *Phoenix reclinata*, as the latter forms dense thickets impenetrable to the primary grazers, fat-tailed sheep, goats, cattle, camels and donkeys, and may thus provide shelter during early stages.

Seedlings and small rosettes will also be taken away in flash floods which occur with regularity. Adults can sustain damage as boulders are brought down by such floods,



3. Life history class structure within garden and non-garden sites.

and these floods are further discussed below. The gardens, which are constantly tended and protected from grazing, also provide a vital refuge for the developing seedlings and rosettes. They illustrate the second feature of establishment: seedlings here are mainly found along irrigation channels suggesting the requirement for water for good establishment as well as possibly dispersal. Very few seedlings are found away from spring sites or gardens.

Small Rosettes and Juveniles: The transitional stages are heavily grazed outside the garden sites, but once the plants make the transition from rosette to juvenile the leaves are lifted out of the reach of grazers. Juveniles in Eewali, and Randa show that this can occur. However, the majority of sites have no juveniles.

Adults. Once the plants reach adulthood they appear to be fairly resistant to damage, and major flash floods are probably their only threat until they reach senility and natural death.

Grazing:

The opening of the Suez canal in 1869 accelerated the development of the colony the French had established in Obock in 1862. The capital of the colony was moved to Djiboutiville in 1892. Over this period, the demands and opportunities provided by a large trading city have resulted in the decrease in traditional nomadic practices, whereby grazing was migratory moving from the hills of Goda and Mabla in November and May to the Ethiopian foothils in June and October. Nomadism is now rarely practiced and grazing by cattle, fat tailed sheep, goats, camels and donkeys is continuous in the Goda Massif in general. The palm is particularly vulnerable to grazing in its young stages and over 80% of the seedlings in the wadi had disappeared in three weeks

Flood Years and El Niño:

In 1973, the village of Ribta, some 3 km downstream from Bankouale, and its associated terraces were washed away. The event remains in local history as a villager ran down the valley to warn the inhabitants and there was no loss of life or livestock. There no trace of the village remains and the site has not been repopulated. Subsequently there have many bad floods. Villagers describe how the agricultural land has been taken away. The Palms in Bankouale Wadi were in fields, and now they lie in the middle of the boulder wadi. The Bankouale cascade, currently 1 m high, was 5 m high, and the wadi filled up with boulders after heavy rain in 1997 when many of the gardens in the valley were destroyed. The wadi was dramatically widened and filled with boulders, whereas it had previously been lined with alluvial deposits. The wadi is 50 m across in many places. We asked the locals for the major rain years and in particular they mentioned 1983. The years 1973, 1983 and 1997 correspond to the three major El Niño events in the last 40 years (University of Illinois Online Meteorology Guide). Though we have no weather records on site, this is indicative of a global effect. The ability of palms to withstand boulder damage is illustrated in Fig 4 but several palms were washed away in Bankouale in 1997 (Welch & Welch 1998), and though adults may survive, seedlings will not.

Architectural Fashion:

The disruption of the Ethiopian economy during the rule of the Derg, and then Mengistu following the famine in Wollo province (1974–1991) led to an influx of Ethiopian migrants. The Afars and Somalis are primarily nomadic peoples and many of the gardens stem from the employment of the migrant Ethiopian farmers. The traditional Afar winter house consists of a beautiful upturned coracle-like framework covered with matting woven from the leaves of Doum Palm. This can be erected by four women in eight hours. The summer houses and pavilions are a loose framework of Acacia poles with branches laid across for shade. The Ethiopian fashion was for a round house of poles about five feet (1.5 m) high, with a thatched conical roof supported on longer poles. The only suitable material for this was the Box (*Buxus hildebrandtii*) and each house requires the cutting of about 300 Box shrubs. We were told that for about ten years the valley was stripped of its Box bushes, and this cutting was stopped when the locals realized the increase in runoff that was resulting in worse flash floods. Box is recovering well in the valley, and little is being cut at the present.

Conclusions

It is clear that the Bankouale palm is under considerable threat in Djibouti. All populations are in decline, most populations have no seedlings, rosettes or juveniles and even those populations that have replacement potential are declining. Most populations have a bias towards mature individuals, which is typical of the age structure of populations which are fully stocked in the first year of recruitment resulting in an even-aged stand with doomed juveniles (Harper 1977). Throughout the site numbers of adults have declined 12–62%, with only one site showing an increase in numbers, which we believe is due to earlier miscounting. The restricted distribution of this palm may reflect a relict status from a wider distribution, but the current decline has more specific causes associated with the occupation of the spring sites by gardens since the 1970s, the increase in devastation caused by flooding in rain years (possibly related to El Niño), which is exacerbated by removal of the Box understorey, and no doubt increased grazing since the founding of Djibouti in the 1880s.

However, the trees are long lived (Welsh & Welch 1998) and prolific. The gardens are well tended and could provide nurseries for palms as part of a conservation and education program. The gardeners also protect the palms from the worst of the flooding by banking boulders round their bases, so there is clear evidence of an awareness of the importance of the palm to the local environment, if not its global rarity. The school at Arbo, the Bankouale tourist Camp, the Arbo Association and the various gardens together provide an infrastructure which with appropriate help can be harnessed to conserve the palm.

We hope to organize such a conservation program and have been awarded a Darwin Initiative Scoping grant for the conservation of the Dai Forest, of which the conservation of the Bankouale Palm forms an important part. To initialize this effort, 3.5 kg of seeds have been collected for the Millennium Seed Bank at Wakehurst Place from an expedition funded in part by the International Palm Society. Good germination has been reported. Seed has been distributed to six botanic gardens around the world, and we hope that palm has been saved in cultivation.

Full details of the expedition, a photographic record of each palm site and tables of life history stages for all sites from 1985 to 2006 can be found at www.djiboutiflora.org by selecting Bankouale Palm from the menu.

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LITERATURE CITED

AUDRU, J., J. CESAR, G. FORGIARINI AND J.P. LEBRUN. 1987. La vegetation et les potentialites pastorales de la Republique de Djibouti, pp. 376, Institut d'elevage et de Medecine Veterinaire des Pays Tropicaux, Ministere de lAgriculture et du Developpement Rural, Republique de Djibouti.

FORD, H. AND C. BEALEY. 2004. Status of the Bankouale Palm, *Livistona carinensis*, in Djibouti. PALMS 48: 94–101.

HARPER, J.L. 1977. The Population Biology of Plants, Academic Press.

LEBRUN, J.-P., J. AUDRU AND J. CESAR. 1989. Catalogue des plantes vasculaires de la Republique de Djibouti. I.E.M.V.T. No 34.

MONOD, T. 1955. Remarques sur un palmier peu connu: *Wissmannia carinensis* (Chiov. 1929) Burret 1943. Bull. Inst. Franc. Afr. Noire. 17a: 338–358.

University of Illinois Online Meteorology Guide. http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/eln/def.rxml.

WELCH, H. AND J. WELCH. 1998. A report on the birds of Djibouti and the Bankouale Palm *Livistona carinensis*. Ministère de l'environment, du Tourisme et de l'Artisanat, Direction de l'Environment, Biodiversity Report no 4, IUCN Djibouti Biodiversity Project DJI/95/A/1G/99.

Ceroxylon echinulatum in an Agroforestry System of Northern Peru

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1. *Ceroxylon echinulatum*, slender habit and pendulous pinnae.

This paper records *Ceroxylon echinulatum* in northern Peru and describes its use in agroforestry.

PALMS 52(2): 96–102

The genus *Ceroxylon* currently comprises 11 species restricted to the Andes, from 800 m to 3500 m elevation but most common between 1500 and 3000 m, from Venezuela to Bolivia. *Ceroxylon* is still incompletely known in the southern part of its range (Peru and Bolivia). Henderson et al. (1995) reported four species of *Ceroxylon* from Peru (*C. parvifrons*, *C. parvum*, *C. vogelianum* and *C. weberbaueri*). However, recent field work in the Peruvian Andes has shown that the genus is much more diverse in this country and includes species previously known from Ecuador and possibly Colombia, as well as undescribed ones (Fig. 2). *Ceroxylon echinulatum* was considered to be endemic to Ecuador (Borchsenius et al. 1998), although it was collected in Zamora-Chinchipe province very close to the border with Peru. We encountered this species on the other side of the border, in Cajamarca region of Peru. Other fieldwork data (K. Mejía pers. com.) suggest that this species is relatively widespread but very patchily distributed in northern Peru. It is easily recognized by its tall and slender habit, regularly arranged pendulous pinnae and warty fruits (Figs. 1 & 2).

Many *Ceroxylon* species are considered endangered due to habitat loss and destructive use throughout the range of the genus (Galeano & Bernal 2005). However, these beautiful and useful palms are often cultivated or managed in some way, preventing local extinction in many places. Documented threats on the species and sustainable uses are summarized in table 1. *Ceroxylon echinulatum* in northern Cajamarca is a good example of both the destructive and sustainable use of these Andean palms. The region has been heavily deforested during past decades so that the only remnants of the original *Ceroxylon* populations are tall, old specimens left in pasture, where they cannot regenerate and progressively die (Back Cover). However, *Ceroxylon echinulatum* is now integrated in coffee agroforestry as a cultivated component, allowing its survival despite the progressive extinction of the natural populations.

The agroforestry system of the upper Urumba valley

According to local farmers, this sector of northern Cajamarca was almost pristine 50 years ago. People, especially from the city of Huancabamba and other localities of the north-western Andes of Peru, began to move in search of new income sources, establishing pastures and coffee plantations, and progressively developing San Ignacio from a small village to a significant urban centre. During the process, they ended up cutting almost all primary forest. By the end of the 1980s, the upper Urumba valley was facing serious problems of loss of soil fertility and widespread erosion, so that the future of agriculture in the area seemed bleak. However, a conjunction of institutional and non-governmental initiatives since the early 1990s allowed a spectacular move toward long-term sustainability of agriculture and land management in the valley (Gallo 2005). This was largely achieved through participative programs managed by the inhabitant

Table 1. Threats and uses of *Ceroxylon* species.

Species	Habitat loss (including forest clearance leaving adult palms in pastures)	Destructive use (stem and young leaves)	Non-destructive uses (a: fruits; b: inflorescences)	Cultivation (a: in agroforests; b: as ornamental)
C. alpinum	severe	severe	a	a, b
C. amazonicum	low	minor uses	minor uses	not cultivated
C. ceriferum	moderate to severe	severe	a	b
C. echinulatum	severe	severe	a, b	a
C. parvifrons	moderate	moderate to high	minor uses	b
C. parvum	moderate	severe	minor uses	not cultivated
C. quindiuense	severe	moderate	a	b
C. sasaimae	habitat destroyed	low	minor uses	a, b
C. ventricosum	severe	severe	a	b
C. vogelianum	moderate	moderate to high	a	b (rarely)
C. weberbaueri	severe	not documented	not documented	not cultivated

2. Small verrucose fruits of *Ceroxylon echinulatum* (left) compared with the larger and smooth ones of another, undetermined species growing in the same region (right).

themselves, in the form of cooperatives, mothers' and students' clubs, agroforestry commities etc. The diversity of action implemented is astounding. Some of them aim at biodiversity conservation, such as the protection of the spectacled bear (previously hunted) and of remnant patches of cloud forests, while others are more directly profit-oriented such as timber plantations of *Schizolobium amazonicum* (fast-growing legume tree). However, what really reshaped the landscape is the evolution of coffee production, which reached new international markets, especially that of high-quality organic fair-trade coffee, resulting in a continuous need for new cultivation space. With the disappearance of natural forests, organic coffee cultivation developed finally at the expense of pasture. Such cultivation is established under the cover of *Inga edulis*, a legume tree that provides the appropriate shade while occupying limited space at ground level thanks

3. Material from *Ceroxylon* sp. trunks prepared for sale at Ocol village, Peru.

Table 2. Main components of the agroforestry system at San Ignacio, Peru. (C = cash crop, D = domestic use).

Species	Familly	Vernacular name	Use
Canopy and emergent trees			
Inga edulis	Fabaceae	Guabo, huabo	Shade, nitrogen fixation, edible fruits, wood (C, D)
Erythrina edulis	Fabaceae	Pajuro	Shade, nitrogen fixation, edible fruits, wood (C, D)
Cedrela odorata	Meliaceae	Cedro	Timber (C & D)
Ceiba sp.	Bombacaceae	Ceibo	Not recorded
Ochroma pyramidale	Bombacaceae	Balsa	Timber (C & D)
Mangifera indica	Anacardiaceae	Mango	Fruits (C & D)
Bactris gasipaes	Arecaceae	Chonta	Fruits, palm-hearts, wood (C & D)
Bactris setulosa	Arecaceae	Chontilla	Not recorded
Ceroxylon echinulatum	Arecaceae	Palma	Wood (construction, C, D)
Guadua angustifolia	Poaceae	Guadua	Wood (construction, C, D)
Upper understory (large shrubs and small trees, vines)			
Coffea arabica	Rubiaceae	Café	Fruits (C)
Bixa orellana	Bixaceae	Achiote	Stain, food color, D
Psidium guayava	Myrtaceae	Guyava	Fruits (C & D)
Caesalpinia spinosa	Fabaceae	Tara	Fruits (gum & tannins), C
Passiflora sp.	Passifloraceae	Granadilla	Fruits (C, D)
Lower understorey (small shrubs and herbs)			
Solanum sessiliflorum	Solanaceae	Cocona	Fruits (C, D)
Solanum quitoense	Solanaceae	Naranjilla	Fruits (C, D)
Saccharum officinarum	Poaceae	Caña azucar	Stem juice (sugar, D)
Ananas comosus	Bromeliaceae	Piña	Fruits (C, D)
Nicolaia elatior	Zingiberaceae	Not recorded	Stem juice (medicinal, D)
Colocasia esculenta	Araceae	Vituca	Arrow root (C, D)
Xanthosoma sagittifolium	Araceae	Songo Jivaro	Arrow root (D)
Musa × paradisiaca	Musaceae	Platano	Fruits (C, D)
Musa acuminata × balbisiana	Musaceae	Guineo grano de oro	Fruits (C, D)

to its spreading habit, and simultaneously enriching the soil as a nitrogen-fixing plant. Moreover, it produces edible fruits and useful wood. The result is an almost complete reforestation of the area, but in the form of a totally artificial and carefully managed agroforestry system (Perfecto et al. 2005). While the system is basically two-layered with a monodominant canopy of *Inga edulis* and an understorey of coffee trees, there is a multitude of minor species distributed from the herbaceous to the emergent layers of the agroforest, each one having a specific use, but also contributing to ecosystem functioning by restoring the diversity of life forms of a natural forest. This complex organization ultimately controls pests naturally and maintains soil fertility, while providing many domestic

4 (top). Young plantation of *Ceroxylon echinulatum* for domestic use in an agroforestry plot, established from the seeds of the mature individuals visible in the background. 5 (bottom). Farm house showing the use of material from the outer part of the trunk of *Ceroxylon echinulatum*.

resources to the farmers and a variety of year-round side incomes (Table 2). Nowadays, the management of the upper Urumba valley, which began as an ecological disaster, is regarded as a model of sustainable development.

Management of *Ceroxylon echinulatum* in coffee agroforestry systems

With the disappearance of natural forest, the need for wood, especially for construction became acute in the upper Urumba valley. In order to supply wood, timber species were introduced (*Cedrela odorata*, *Schizolobium amazonicum*, *Eucalyptus* spp.), but local wild species, in particular *Ceroxylon echinulatum*, were also put into cultivation. *Ceroxylon* species are very much appreciated for construction in the Andes, but are most often used destructively for this purpose, eventually eliminating natural populations. Only when this happens, the option of cultivation sounds attractive to local people. The rarity of *Ceroxylon* plants also means an important increase in stem price, which makes cultivation a good business. In San Ignacio, one stem from a cultivated plant is sold for $50, while in Ocol, another place where there are still extensive natural populations, the stem price from wild plants is only $10 (Fig. 3). In the upper Urumba valley (1600–1800 m elevation), farmers have an interesting way of managing *Ceroxylon echinulatum*. Their dilemma is that they need the wood to build their houses, but the root system of the palm is extensive, absorbs much of the soil water and is ultimately detrimental to coffee cultivation, the basic source of income. As *Ceroxylon echinulatum* is a fast growing species, farmers tend to cultivate it temporarily for their specific needs; it needs to be planned at least 15 years in advance. Such long term planning is not widespread in the rural Andes. For example, if a farmer needs 30 *Ceroxylon* trees to build a new, larger house, he will plant them in a plot (Fig. 4), accepting a decrease of coffee yield, until cutting them and increasing again the coffee's productivity. A few adult specimens are however conserved as seed source for future uses (Fig. 4). The palm is mainly propagated by transplanting the seedlings that grow spontaneously in the agroforest. Alternatively, the seeds are sown after digestion of the fruits by parrots that live and feed in the agrosystem. Some aspects of the use of trunk material can be seen in Figs. 5 and 6.

6. Wall made of *Ceroxylon* material.

In conclusion, we confirmed the presence of *Ceroxylon echinulatum* in Peru and documented its inclusion in agroforestry systems. As with other Andean palms (Svenning 1998), the genus *Ceroxylon* in general is endangered because its distribution is restricted to a region of South America that has suffered a high level of human pressure for a long time. A large part of the natural habitat of *Ceroxylon* has been converted into agricultural systems, and thus its survival relies increasingly on propagation by farmers, and several species have already been included in coffee agroforestry systems (Galeano & Bernal 2005).

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Literature Cited

Borchsenius F., H. Borgtoft Pedersen and H. Balslev. 1998. Manual to the Palms of Ecuador. AAU Reports 37. Aarhus University and PUCE. 217 p.

Galeano G. and R. Bernal. 2005. Palmas. *In*: Calderon E., G. Galeano and N. Garcia eds. Libro rojo de plantas de Colombia Vol. 2: Palmas, frailejones y zamias. Instituto Alexander von Humboldt, Bogota, Colombia.

Gallo L. M. 2005. La institucionalidad regional en el corredor económico Jaen–San Ignacio–Condorcanquí, Perú. Tésis de grado de magister en gestión de desarrollo rural y agricultura sustentable. Universidad Católica de Temuco, Chile, 61 p.

Henderson A., G. Galeano and R. Bernal. 1995. Field guide to the palms of the Americas. Princeton University Press, USA.

Perfecto J., J. Vendermeer, M. Mas and L.S. Pinto. 2005. Biodiversity, yield, and shade coffee certification. Ecological Economics 54: 435–446.

Svenning J.C. 1998. The effect of land use on the local distribution of palm species in an Andean rain forest fragment in northwestern Ecuador. Biodiversity and Conservation 7: 1529–1537.