

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

JEAN-YVES MEYER
Délégation à la Recherche
B.P. 20981
Papeete, Tahiti
French Polynesia
jean-
yves.meyer@recherche.gov.pf

CHRISTOPHE LAVERGNE
Association Palmeraie-Union
Domaine de Palmahoutoff
97432 Ravine des Cabris
La Réunion
France

AND

DONALD R. HODEL
University of California
P.O. Box 22255
Los Angeles, California
90022
USA

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.

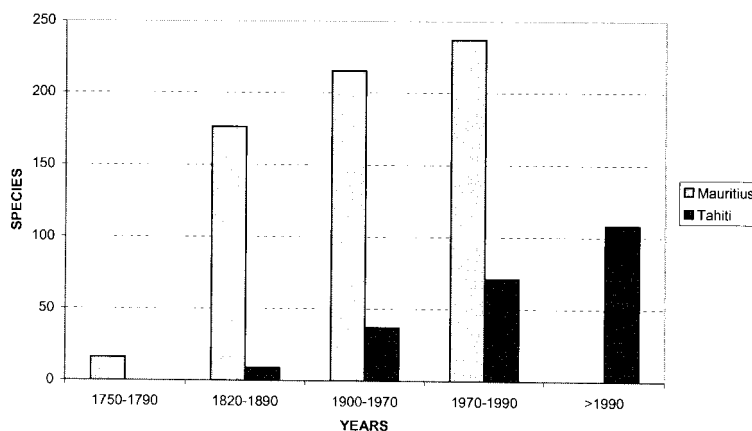
Major documented invasive palms

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
<i>Archontophoenix alexandrae</i>	Queensland (Australia)	Hawaii (Pacific Is.)	Wagner et al. 1990, 1999
<i>Archontophoenix cunninghamiana</i>	Eastern Australia	Brazil	www.institutohorus.org.br/download/fichas/Archontophoenix_cunninghamiana.htm
<i>Areca triandra</i>	India, SE Asia	Panama	Svenning 2002
<i>Elaeis guineensis</i>	West Africa	Pohnpei (Pacific Is.), Brazil	Space & Falanruw 1999, www.issg.org/database/species/www.hear.org/pier/species/elaeis_guineensis.htm
<i>Heterospathes elata</i>	Philippines	Guam (Pacific Is.)	Jones 1995, Space & Falanruw 1999 www.hear.org/pier/reports/mreport.htm
<i>Livistona chinensis</i>	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
<i>Nypa fruticans</i>	SE Asia, India, Sri Lanka, Australia, Solomon Is., Ryukyu Is.	Nigeria, Trinidad (Caribbean Is.)	www.africanconservation.org/ncftemp/nipa.html Kairo et al. 2003
<i>Phoenix dactylifera</i>	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
<i>Psychosema macarthurii</i>	New Guinea, Australia	Fiji (Pacific Is.), Barbados (Caribbean Is.), Panama	Fuller 1997, Kairo et al. 2003, Svenning 2002, Watling 2005
<i>Roystonea regia</i>	Cuba	Panama	Svenning 2002
<i>Washingtonia filifera</i>	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
<i>Washingtonia robusta</i>	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 (*Heterospatha 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/ncttemp/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. mitiarioana*, 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)
<i>Areca catechu</i>	Southeast Asia, Philippines	1754 (M) 1825 (R) 1930? (T)	Locally naturalized (Tahiti, FP)
<i>Dypsis lutescens</i>	Madagascar	1837 (M) 1856 (R)	Locally naturalized (La Réunion, MS)
* <i>Dypsis madagascariensis</i>	Madagascar	1768 (M) 1856 (R) 1937 (T)	Widely naturalized/invasive (Moorea, FP); naturalized (Mauritius, MS)
* <i>Elaeis guineensis</i>	West Africa	1780 (M) 1850 (T) 1825 (R)	Locally naturalized (Raiatea, Tahiti, FP)
* <i>Heterospatha elata</i>	Philippines	1930? (T)	Locally naturalized (Tahiti, FP)
<i>Licuala grandis</i>	Vanuatu	1936 (T)	Locally naturalized (Tahiti, FP), widely naturalized (Tahaa, FP)
* <i>Livistona chinensis</i>	Japan, Taiwan, Ryukyu Is.	1785 (M)	Widely naturalized/invasive (Mauritius, MS), locally naturalized (La Réunion, MS)
<i>Livistona australis</i>	Australia	1933 (T)	Locally naturalized (Tahiti, FP)
<i>Livistona saribus</i>	Southeast Asia	1930 (T)	Locally naturalized (Tahiti, FP)
* <i>Nypa fruticans</i>	Southeast Asia, India, Sri Lanka, Australia, Solomon Is. Ryukyu Is.	1825 (R) 1928 (T)	Locally naturalized (Tahiti, FP)
<i>Oncosperma tigillarum</i>	Sumatra, Borneo, Java, Malaysia	1930 (T)	Locally naturalized (Tahiti, FP)
* <i>Phoenix dactylifera</i>	North Africa & Middle East	1763 (M) 1825 (R)	Locally naturalized (Mauritius, La Réunion, MS)
<i>Phoenix sylvestris</i>	Pakistan to Himalaya, E. India to Myanmar	before 1764 (M)	Locally naturalized (Mauritius, MS)
<i>Pinanga coronata</i>	Indonesia	1980 (T)	Locally naturalized (Tahiti, FP)
<i>Ptychosperma elegans</i>	Queensland	1836 (M) 1896 (R) 1937 (T)	Locally naturalized (Tahiti, FP)
* <i>Ptychosperma macarthurii</i>	New Guinea, Australia	1905 (M) 1931 (T)	Locally naturalized (Tahiti, FP)
<i>Raphia farinifera</i>	Trop. Africa	before 1801 (M) before 1895 (R)	Locally naturalized (Mauritius, La Réunion, MS)
<i>Roystonea oleracea</i>	Lesser Antilles, Trinidad, Venezuela, Columbia	1825 (R) 1837 (M)	Locally naturalized (Mauritius, La Réunion, MS)
<i>Syagrus romanzoffiana</i>	Brazil to NE Argentina	1860 (M)	Locally naturalized (Mauritius, MS)
* <i>Washingtonia robusta</i>	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 tigillarum* (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 estuarine 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 shoebuttan 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 Koënic, 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,



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

especially mynas (*Acridotheres tristis* in many tropical islands, and *A. fuscus* in Fiji) the bulbuls (*Pycnonotus cafer* and *P. jocosus*), over long distances.

Indeed, several species have recently escaped from cultivation to become naturalized in Hawaii, including the cascade or cataract palm (*Chamaedorea 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).

Hypphaene 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*, *Dyopsis 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, *Pritchardia*, 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 guineensis*, *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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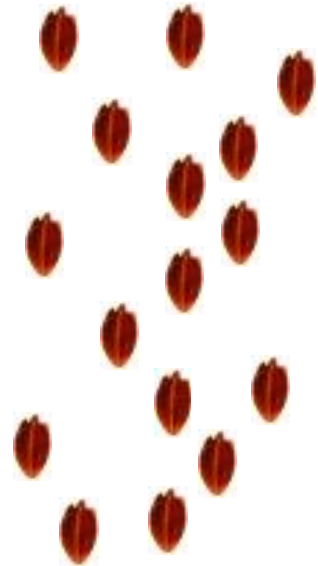
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