

## The decline and conservation management of the threatened endemic palms of the Mascarene Islands

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**Abstract** The conservation status of the five genera and 11 species of palm endemic to the Mascarene Islands (Mauritius, La Réunion and Rodrigues) are reviewed. All species are threatened with extinction; nine taxa are classified as Critically Endangered and four as Endangered on the 2000 IUCN Red List. Two taxa survive as single wild specimens (*Hyophorbe amaricaulis* and *Dictyosperma album* var. *conjugatum*); an additional seven taxa have wild populations of 100 or fewer. Although the historical phase of large-scale forest clearance has passed, the remaining palm populations in the Mascarenes are under threat from the effects of

population fragmentation, invasive plants and animals, and high levels of seed predation that prevent natural regeneration. The advantages of *in situ* management for the recovery of these palm populations are discussed. Without a long-term conservation programme, utilising both *in situ* and *ex situ* management, extinction of wild populations will occur.

**Keywords** *Acanthophoenix*, *Dictyosperma*, *ex situ*, *Hyophorbe*, *in situ*, *Latania*, Mascarene Islands, palms, *Tectiphiala*.

### Introduction

The Mascarene Islands are situated to the east of Madagascar in the south-west Indian Ocean (Fig. 1). They consist of three main islands: Mauritius and Rodrigues, comprising The Republic of Mauritius, and La Réunion, a French Overseas Department. The islands are recognised as part of the Madagascar biodiversity hot spot (*sensu* Myers *et al.*, 2000) and as an IUCN Centre of Plant Diversity (CPD Site 102) (Strahm, 1994). The importance of conserving the Mascarene palm flora was recognised by Cadet (1977), Moore (1977) and the IUCN/SSC Palm Action Plan (Strahm, 1996a). The conservation needs of the Mascarene palms illustrate many

of the challenges in managing threatened island plants, and the endemic species include some of the most widely cultivated commercial and ornamental palm species in the world (Maunder *et al.*, 2001).

The palm family *Arecaceae* is represented in the Mascarenes by 11 species in five endemic genera (Moore & Guého, 1984) (Table 1). Three tribes belonging to three sub-families are represented in the Mascarenes, the *Coryphoideae* (*Latania* in *Borasseae*), *Ceroxyloideae* (*Hyophorbe* in *Hyophorbeae*) and the *Arecoideae* (*Acanthophoenix*, *Tectiphiala* and *Dictyosperma* in the *Arecaceae*) (Uhl & Dransfield, 1987). The genus *Hyophorbe* has a remarkable distribution, with its closest allies in the *Ceroxyliidaeae* restricted to northern South America, Central America and the Caribbean (Uhl & Dransfield, 1987; Uhl *et al.*, 1995). The highest palm diversity occurs on the oldest island, Mauritius, with seven species and eight taxa, six of which are endemic. La Réunion has four species, of which two taxa are endemic; and Rodrigues has three species of which three taxa are endemic (Table 1). The genera *Dictyosperma*, *Hyophorbe* and *Latania* are found on all three islands. *Acanthophoenix* occurs on both Mauritius and La Réunion and *Tectiphiala* is endemic only to Mauritius. Two of the endemic genera, *Tectiphiala* and *Acanthophoenix*, are monospecific.

The original distribution and ecology of the Mascarene palms is difficult to assess because the major period of habitat destruction preceded any formal botanical or ecological studies (Cheke, 1987). For instance, the coastal woodlands of Mauritius were subject to heavy exploitation of ebony (*Diospyros* spp.) in the mid seventeenth century

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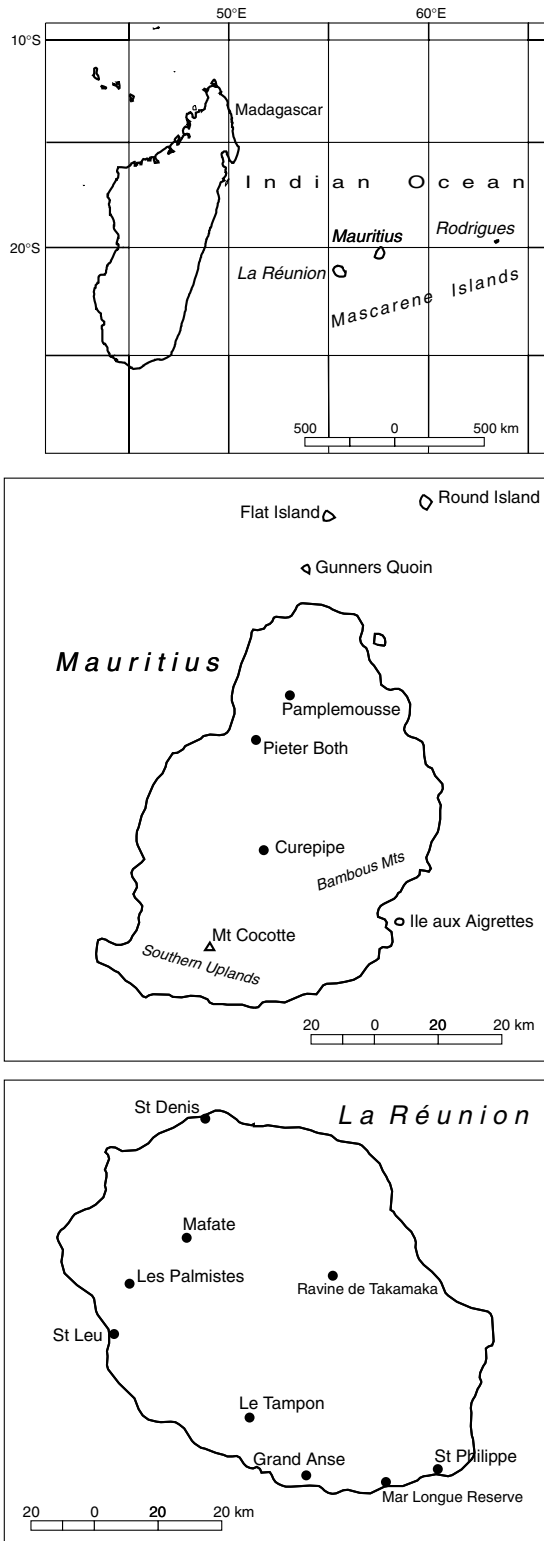
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**Fig. 1** The location of the Mascarene Islands of La Réunion (a French Overseas Department), and Mauritius and Rodrigues (together the Republic of Mauritius) to the east of Madagascar in the south-east Indian Ocean, and Mauritius and La Réunion with locations and islands mentioned in the text.

and clearance for sugar cane plantations after 1709. The original composition of the lowland Mauritian forests is hinted at in a Dutch manuscript of 1677 that illustrates large numbers of palms (both pinnate and fan leaved) in the forest (Algeneen Staatsarchief, reproduced in Grove, 1995). It is possible that species or populations became extinct prior to the initial botanical surveys of the eighteenth and early nineteenth centuries. For instance, it is difficult to reconcile some early descriptions of palms on Rodrigues by Leguat (1708) with extant species (Strahm, 1989). Following the extinction of endemic bird and reptile species, and decline in fruit bat populations, it is likely that pollination and fruit dispersal ecologies have been modified (Vaughan & Wiehe, 1937; Witmer, 1991). Observations on Round Island suggest that endemic reptiles play at least a peripheral role in the pollination of palms; individuals of the endemic day gecko *Phelsuma guentheri* have been observed dusted with pollen and moving between inflorescences on adjacent trees of both *Latania* and *Hyophorbe* whilst hunting insects (M. Maunder, pers. obs.). Early human colonists of the Mascarenes utilised the palms for construction, as a valuable source of edible palm heart ('palmiste' or 'cabbage'), and some palms, probably *Latania*, were tapped for their 'wine' (Leguat, 1708; Brouard, 1963).

The area of original habitat in the Mascarenes has been dramatically reduced; in Mauritius less than 5% survives (Safford, 1997). Today Mauritian lowland palm woodland survives, albeit in a degraded form, only on Round Island, where three palm taxa occur: *Latania loddigesii*, *Hyophorbe lagenicaulis* and *Dictyosperma album* var. *conjugatum*. On La Réunion the coastal palm forest has been cleared for coffee and sugar plantations, and these areas are now covered by fire-influenced savannahs (Thébaud & Strasberg, 1997). In the east and south of La Réunion some lowland wet forest survives, although this is still subject to some illegal clearance and the impact of invasive plants. Leguat (1708) described Rodrigues as "richly spread with great and tall trees. The rivers that we saw run from them water'd valleys, whose fertility we could not doubt". As a result of extensive forest clearance, fire, grazing and invasive weeds Rodrigues has lost all indigenous forest except for a few small fragments at Gran Montagne and Anse Quittor (Strahm, 1983).

Populations of all the Mauritius upland palm species occur as isolated sub-populations in areas where forest is fragmented by stands of exotic weeds, forestry plantations or agricultural areas. Mountains in the north, east and south-west of Mauritius, previously linked by contiguous forest, are now effectively isolated by housing, industrial development and agriculture. In contrast, La Réunion still supports extensive areas of upland forest.

**Table 1** The names, occurrence, IUCN Red List category (Oldfield *et al.*, 1998; Hilton-Taylor, 2000) and criteria (see IUCN, 1994 for explanations of criteria), and estimated wild populations of the Mascarene endemic palms.

Taxon	Vernacular name	Mauritius	La Réunion	Rodrigues	Red List category (criteria)	Estimated wild population
<i>Acanthophoenix rubra</i> (Bory de Saint-Vincent)	palmiste	X	X		CR (B1 + 2c)	c. 1300
<i>Dictyosperma album</i> (Bory de Saint-Vincent)	princess palm, white hurricane palm	X	X		CR (D)	c. 30
<i>Dictyosperma album</i> var. <i>aureum</i> Balf. F.	golden hurricane palm			X	CR (D)	<10
<i>Dictyosperma album</i> var. <i>conjugatum</i> H. E. Moore & L. J. Guého	hurricane palm	X			CR (D)	1
<i>Hyophorbe amaricaulis</i> Mart.	lonely palm	X			CR (B1 + 2abde, C1 + 2b, D)	1
<i>Hyophorbe indica</i> Gaertn.	poison palm		X		EN (D)	c. 500
<i>Hyophorbe lagenicaulis</i> (L. H. Bailey) H. E. Moore	palmiste gargoulette, Round Island bottle palm	X			CR (D)	c. 400
<i>Hyophorbe vaughanii</i> L. H. Bailey	Vaughan's bottle palm	X			CR (D)	3
<i>Hyophorbe verschafeltii</i> H. Wendl.	Rodrigues bottle palm, palmiste marron, palmiste bouteille, spindle palm			X	CR (C2a)	40–60
<i>Latania loddigesii</i> Mart.	latania	X			EN (C2a)	c. 8000
<i>Latania lontaroides</i> (Gaertner) H. E. Moore	pomme latanier, latanier rouge		X		EN (A1c)	c. 100
<i>Latania verschafeltii</i> Lem.f.	Rodrigues latanier			X	EN (C2a)	c. 500
<i>Tectiphiala ferox</i> H. E. Moore	palmiste bouclé	X			CR (A1ac + 2ce, B1 + 2e, C1 + 2ab, D)	c. 40

Continued degradation of natural vegetation is occurring as a result of introduced invasive plants and animals (Lorence & Sussman, 1986; Strahm, 1996b). In Mauritius plants such as *Psidium cattleianum* and *Ligustrum robustum* are invading indigenous forest, reducing available habitat for palms. Introduced animals such as feral pig *Sus scrofa*, Javan deer *Cervus timorensis*, crab-eating macaque *Macaca fascicularis* and rats (*Rattus rattus* and *R. norvegicus*) can cause severe damage to the vegetation. Predation of fallen palm fruit and seedlings by rats, introduced snails (*Achatina* spp.) and pigs are major problems. During the early eighteenth century Dutch administrators commented on huge plagues of rats on Mauritius (Grove, 1995); these might have had a major impact on the regeneration of wild palm populations.

Over the last two centuries the indigenous palms have been moved around the Mascarene Islands both for planting in gardens and for plantations for edible palm hearts, the endemic palms are frequently used for landscaping in all the Mascarene Islands, and have been widely cultivated overseas. *Hyophorbe indica* was recorded in cultivation at the Calcutta Botanic Gardens by 1839, Buitzenborg, Java, by 1854, Adelaide Botanic Garden, Australia, by 1859, and Singapore Botanic Garden by 1880 (M. Maunder, unpublished data). Nurseries and

seed dealers still trade in the endemic taxa from both wild and cultivated sources, and thus the genetic status of many cultivated stocks is not clear.

This paper reviews the available information on the conservation status of the endemic Mascarene palms. We describe the status of both wild and cultivated populations, review management options, and recommend an integrated approach to the conservation of these species. We do not provide exact locations for wild populations in order to reduce the risk of illegal seed collection.

## Species profiles

### *Acanthophoenix rubra*

Endemic to Mauritius and La Réunion. A monoecious palm found in upland forest and heath sites in the south-west and eastern mountain ranges of Mauritius above 500 m altitude. Principle localities in south-west Mauritius include the Black River Gorge area, Macchabee, Brise Fer Mountain, Mare Longue Plateau, Plaine Champagne, Montagne Cocotte, and the Savanne Range, and in the east it has been recorded from the

upland forests at Chasse Etoile, Pic Grand Fond and Montagnes Bambous. The total number of reproductive wild individuals in Mauritius is *c.* 100, with the majority occurring as isolated individuals throughout the upland sites of Macchabee and Brise Fer Mountain. An additional population of *c.* 20 mature individuals was recently discovered in a 2 ha block of forest on privately owned land at Chasse Etoile in the eastern Bambous mountain range. The forest in this region is poorly surveyed and more individuals may yet be found. Immature and seedling plants have only been recorded in the south-west at Macchabee, Brise Fer and the Mare Longue Plateau. The factors restricting natural regeneration have not been identified, although we suspect that predation of both fruits and seedlings may be occurring. On La Réunion the species is restricted to the south-east of the island over 0–1500 m, especially at Rivière de l'Est, Anse aux Cascades, Rivière des Remparts, Le Brûlé, and Mare Longue Réserve Naturelle. Historically clearance for sugar plantations destroyed much of the original habitat on La Réunion, and currently the greatest threat is over-harvesting for palm hearts. Mature trees are uncommon, but locally abundant, and probably number 1000–2000. The species is common in cultivation on both islands, although there is concern that some of the old trees in cultivation on Mauritius may originate from La Réunion. Plants of Mauritian wild source are cultivated in the Sir Seewoosagur Ramgoolam Botanic Garden, Mauritius. The Office National des Forêts on La Réunion has undertaken a cultivation programme for this palm.

### *Dictyosperma*

The Hurricane palms are found on all three Mascarene Islands. The taxonomy of this group is poorly understood, with the taxonomic status of the different populations based on relatively minor morphological features (Moore & Guého, 1980). Here we use the taxonomy of Moore & Guého (1984). Further morphological and molecular studies are required to identify conservation management units for this group. The genus is monoecious. The species is widely grown for both palm hearts and as an ornamental on Mauritius and La Réunion. The provenance of plantations are largely unknown.

#### *Dictyosperma album* var. *album*

Endemic to Mauritius and La Réunion. Known on Mauritius from only three wild individuals in a managed forest reserve on the Mare Longue Plateau at *c.* 600 m, with a single tree at Barkley Experimental Station. On La Réunion it is restricted to low altitude mesic forest below 600 m, with recent records (l'Herbier de La Réunion-Université de La Réunion) from Mafate in 1998, Terre

Rouge in 1979 and La Grand Tampon in 1972. No natural regeneration has been observed recently on either Mauritius or La Réunion. This variety is extensively cultivated for palm heart on both islands, although the cultivated stocks on Mauritius originate from La Réunion. The Conservatoire Botanique National de Mascarin on La Réunion has established plantings and there are old fruiting trees in the collection at the Sir Seewoosagur Ramgoolam Botanic Garden, Mauritius.

#### *Dictyosperma album* var. *aureum*

Endemic to Rodrigues, described as “common” by Balfour (1879), as “rare” by Wiehe (1949), and is today reduced to *c.* 10 individuals in the wild. The surviving trees are in exposed situations, are extremely old and are unprotected. Goats are frequently tethered around the trees, and any seedlings that appear are grazed. In 1999 we observed several young *Dictyosperma* palms of unknown provenance in local gardens. Seedlings have been observed at Grande Montagne Reserve, having been carried there by birds, including feral pigeons, probably from nearby gardens. To avoid mixing the different island taxa seeds are being collected from two old trees in the north of Rodrigues. Other individuals tentatively identified as *D. album* var. *aureum* grow along the basaltic ridges of Rodrigues, but their unconfirmed taxonomic identity currently preclude their utilisation in conservation programmes. Seed collected from taxonomically verified trees is propagated at the Solitude Nursery, and a total of 292 seedlings have been transplanted to the two main island reserves during 1996–1999. The establishment of reproductive populations will be dependent upon the establishment of rat control measures.

#### *Dictyosperma album* var. *conjugatum*

Endemic to Round Island, off the north-east coast of Mauritius, where it survives as one wild adult individual. Described as “abundant” by Lloyd (1846), but introduced goats and rabbits, and possibly harvest of the hearts, devastated the population. In February 1994 one of the last two known reproductive trees was killed during a storm, although seed from this individual had been harvested and propagated *ex situ* by the National Parks and Conservation Service. Some 300 seedlings have been produced, and 50 of these have been introduced to Ile aux Aigrettes, a rat-free islet reserve off the east coast of Mauritius. A trial reintroduction undertaken on Round Island in 1998 was unsuccessful due to drought. There is an extensive mature planting of this taxon at the Sir Seewoosagur Ramgoolam Botanic Garden and in private estate gardens on Mauritius. Following taxonomic verification and controlled seed production these can be utilised to supplement the surviving tree on Round Island.

### *Hyophorbe*

The genus *Hyophorbe* consists of five monoecious species, distinguished from each other by growth form, fruit colour and floral morphology (Moore, 1978a; Uhl, 1978).

#### *Hyophorbe amaricaulis*

Endemic to Mauritius, this species now survives as a single individual growing in the Curepipe Botanic Gardens, south-west Mauritius. Historically recorded as abundant in the upland evergreen forest of the northern mountain chain at Pieter Both (Commerson, 1772; Martius, 1823–1853). However the species was eradicated on Pieter Both and was thought to be extinct until rediscovered by Dr. R. E. Vaughan in 1942 at the Curepipe Botanic Garden (Moore, 1978a). The Curepipe region was once upland evergreen forest and the single tree, which flowers and fruits regularly, is reputed to be original to the site. All attempts to propagate from this tree, using both micropropagation and conventional horticultural techniques, have been unsuccessful (Douglas, 1987; Wyse-Jackson *et al.*, 1987). A programme to collect and store pollen from this species for self-pollination under controlled conditions has been initiated by the National Parks and Conservation Service of Mauritius. Cloning of the remaining genotype is desirable, with somatic embryogenesis the most likely option (Rosario *et al.*, 1990), and research has begun at the Royal Botanic Gardens, Kew, on the *in vitro* propagation of the taxon. *H. amaricaulis* was recorded from the botanic garden catalogues of Adelaide in 1859, Singapore in 1880, Durban in 1892, Jamaica in 1904, Fairmount Park, Philadelphia, USA, in 1906, Buitzenborg, Java in 1914, Dominica in 1915, Saigon in 1919, Peradeniya, Sri Lanka in 1926, and Harvard Botanical Gardens, Cuba in 1933 (M. Maunder, unpublished data), and promoted in the European horticultural literature (Van Houtte, 1865). However, these references invariably relate to specimens of *H. lagenicaulis* distributed over the last 150 years from Mauritius under the misnomer of *H. amaricaulis*. The specimens of *H. amaricaulis* reported from Cuba (Kyburz, 1998) proved, after morphological and molecular verification, to be *H. lagenicaulis* (Lewis & Barboza, 2000).

#### *Hyophorbe lagenicaulis*

Endemic to Round Island (Plate 1), off the north-east coast of Mauritius, and might have originally occurred on mainland Mauritius and some of the small offshore islets such as Ile aux Aigrettes (Moore, 1978a). Traveller's reports (Baker, 1877; Lloyd, 1846; Johnston, 1895) and photographs from the 1920s suggest that this species was formerly an abundant component of the island's palm community. However, the population declined following the introduction of goats and rabbits, and



**Plate 1** Regenerating *Hyophorbe lagenicaulis* in *Latania loddigesii* woodland, Round Island (M. Maunder).

Vinson (1964) and Bullock (1977) recorded only a few specimens. Following the removal of goats in 1978 and rabbits in 1986 there was a dramatic recovery of both plant cover and the endemic reptilian fauna (Merton *et al.*, 1989; North & Bullock, 1986; North *et al.*, 1994). Moore (1978a) recorded *c.* 15 individuals, and North *et al.* (1994) recorded a population of <20 over 1975–1989. The population has subsequently increased, with *c.* 850 seedlings and at least four trees observed in 1999. In addition seeds have been planted around the island. The species has been introduced to Ile aux Aigrettes as part of a long-term restoration programme (Dulloo *et al.*, 1997). The old garden plantings on Mauritius, such as those at the Pamplémousse Botanic Garden, are derived from collections made on Round Island prior to the population bottleneck that occurred in the early-mid twentieth century. Following genetic fingerprinting it is planned to use these cultivated stocks to supplement the populations on Round Island.

#### *Hyophorbe vaughanii*

Endemic to Mauritius and restricted to upland wet forest. It once occurred in the upland evergreen forests of Brise Fer, Gouly, Florin, Mare aux Joncs, La Gouardette and Flacq. Moore (1978a) records a wild population of about 50 trees, with 44 at Mare aux Joncs. The original population and type locality at La Gouardette is extinct. Seedlings from this population were established in cultivation but their current status is unknown. A second population discovered at Mare aux Joncs in 1977 has died out. Only three wild trees are now known, in the upland reserve of Florin on the Mare Longue Plateau, south-west of Mauritius. An adult tree that originated from Gouly is growing at La Gourdet Forestry Quarters. The wild population has declined as a result of habitat loss to exotic plants, development of forestry plantations during the 1960s and 1970s, and probably rat predation.

The wild trees are growing well and produce viable fruits, although no natural regeneration has been observed. Fruits are currently 'bagged' to prevent introduced monkeys taking them. Some *in-situ* seed sowing has occurred in the managed reserve at Brise Fer and Macchabe. Seed collected from wild individuals has been grown in the National Parks and Conservation Service nursery and young plants reintroduced into the managed reserves of Brise Fer, Macchabee and Mare Longue in south-west Mauritius.

#### *Hyophorbe verschaffeltii*

Endemic to Rodrigues. Descriptions by Leguat (1708), Balfour (1879) and Wiehe (1949) indicated that this palm was formerly abundant, but the population declined due to loss of forest. Moore (1978a) recorded <50 trees, and Strahm (1989) recorded *c.* 60. About 40 mature trees now survive, with little natural regeneration, in 17 locations in unfenced areas that are prone to overgrazing or invasion by exotic weeds. One individual grows within Grande Montagne Reserve. This species produces large quantities of seed, and germination success under nursery conditions has been high, with >8,000 plants produced in 1999. The cultivated stocks on Rodrigues are derived from all available and verified founder individuals to ensure that as much variation as possible is maintained. At the Solitude Nursery 15,000 seedlings have been produced for planting as part of a habitat restoration project, and these have been used in community planting programmes for their ornamental value. The introduction of congeners *H. lagenicaulis* and *H. indica*, respectively endemic to Round Island and La Réunion, to Rodrigues is a cause for concern. These closely related species may hybridise with *H. verschaffeltii*, although there is no unequivocal evidence of this having occurred in the Mascarenes. However, a putative hybrid between *H. lagenicaulis* and *H. verschaffeltii* grows at the Forster Botanical Garden, Honolulu. Other threats to this species are the predation of seeds and seedlings by rats, and cyclonic winds during the wet season that can kill old trees.

#### *Hyophorbe indica*

Endemic to La Réunion, occurring in remnants of low altitude forests and ravines of the east coast up to 600 m, and up to 800 m on the west coast. Although Baker (1877) recorded this species on Mauritius, this was probably a confusion with either *H. vaughanii* or *H. amaricaulis*. Moore (1978a) recorded a large population at Ravin de Takamaka (St Philippe), and there are herbarium records (l'Herbier de La Réunion-Université de La Réunion) from Takamaka in 1972 and Brûle du Baril (St Philippe) in 1972. Historically the habitat of this species decreased with the expansion of sugar cane

plantations, although it survives in reasonable numbers and is regenerating in the wild in the Réserve Naturelle Mare Longue (St Philippe). The heart of this palm is not edible, therefore it has not been over-harvested. The Conservatoire Botanique National de Mascarin has specimens in cultivation.

#### *Latania*

A genus of three dioecious palms (Uhl & Dransfield, 1987).

#### *Latania lontaroides*

Endemic to La Réunion, with small scattered populations in the south and west of the island, including populations on sea cliffs. Populations have been recorded at La Rivière Saint Etienne and in Grande Anse, in the south, and two wild plants were found on a cliff at Saint Leu. According to Cordemoy (1895) the palm was already rare in the wild, but established in cultivation, by the late nineteenth century. The fruits are edible, the hearts are still occasionally harvested, there is heavy rat predation on fruits, and regeneration is uncommon in the wild. The wild population is thought to total *c.* 100 mature trees. It is in cultivation on La Réunion as a garden plant and in the Conservatoire Botanique National de Mascarin.

#### *Latania loddigesii*

Endemic to Mauritius and its offshore islands, and widely cultivated on Mauritius and elsewhere, but now restricted to the islands of Gunner's Quoin and Round Island (Plate 2). A Dutch illustration of 1599 shows what appears to be a highly stylized *Latania* as part of a coastal forest (reproduced in Strickland & Melville, 1848). Johnston (1895) recorded this species from Round Island, Flat Island and Coin de Mire. Regeneration on Round Island increased following the eradication of rabbits and



**Plate 2** *Latania loddigesii* woodland on Round Island, Mauritius (M. Maunder).

goats (North *et al.*, 1994) and it is now the dominant tree species on the island with *c.* 7,000 individuals. There are 15–20 mature trees on Gunner's Quoin, and although there is currently little regeneration, the eradication of rats in 1996 should allow the population to recover. Seeds collected from Round Island have been used in restoration work on the Ile aux Aigrette island reserve, where the species may have occurred naturally (Dulloo *et al.*, 1996, 1997).

#### *Latania verschaffeltii*

Endemic to Rodrigues. Balfour (1879) described *L. verschaffeltii* as occurring in abundance, and noted that the palm was used for thatching, basket making and as a food source. About 500 trees survive on the island with *c.* 120 in one location, and 12 in smaller, fragmented populations. The leaves are still harvested for thatching, regulated by the Ministry for Rodrigues, Forestry Service, but the greatest threats are predation by rats and potential hybridisation with *L. loddigesii* from Mauritius. There is a viable population in the Anse Quittor Nature Reserve, a coastal coralline valley, that was threatened by a planned extension of the airport runway until plans were changed in September 2001. No regeneration has been recorded in the wild, probably a result of rat predation on fruit and seedlings. Mature populations of both *L. verschaffeltii* and introduced *L. loddigesii* grow in Baie aux Huitres, along with a suspected hybrid population that shows morphological characters of both species. The establishment of larger hybrid populations on Rodrigues is kept in check only by rat predation of seed and seedlings. To avoid hybrid seedlings being utilised in restoration, collection of *L. verschaffeltii* seed is limited to areas where *L. loddigesii* is absent, reducing the number of available founders for new populations. More than 15,000 seedlings were produced during 1996–99, with 240 planted in 1997 and 1999.

#### *Tectiphiala ferox*

Endemic to Mauritius, this monotypic and monoecious genus was described in 1978 (Moore, 1978b). Wild populations are recorded from the wet upland forest communities of south-west Mauritius, including the Mare Longue Plateau, Florin, Bois Sec, Petrin, Montagne Cocotte, Crown Land Declerc, and Plaine Champagne region in south-west Mauritius. Moore (1978b) recorded *c.* 28 individuals, and it is now estimated that *c.* 35 adult trees survive in the wild. Some unexplored areas of suitable habitat in the south-west of Mauritius may harbour more individuals. The habitat of this species is vulnerable to invasion by exotic plants, and feral pigs predate the fruit. Recent seed production by wild plants

has enabled successful *ex situ* propagation. Nursery-raised plants have been introduced to the Mare Longue reserve and the recent completion of weeding in the Petrin and Florin reserves will make further sites available for this species. Although the species is not securely established in cultivation on Mauritius, the National Park and Conservation Service have propagated the species for use in native plant gardens within the Black River National Park.

## Discussion

Without active intervention the endemic palm lineages of the Mascarene islands will soon be represented only by senescent, non-reproducing relictual wild populations and extensive but largely unmanaged cultivated stocks. To help prevent this we make five broad recommendations, which are also of relevance to other oceanic islands with threatened palm floras such as New Caledonia (Pintaud *et al.*, 1999).

### 1. Maintain existing wild populations

A traditional approach to protected areas will not secure the surviving Mascarene palm populations. The conservation of viable wild populations depends upon the sustained management of habitat plots that are protected from introduced mammals and exotic weeds. This requires, at least in the immediate future, the supplementation of fencing and weeding with fruit protection ('bagging') for the nursery production of seedlings, and rat control to encourage regeneration. The highest palm diversity occurs in the upland forest communities of Mauritius at Brise Fer, Macchabe and the plateau communities of Mare Longue, Florin and Montagne Cocotte (Page, 1995) with four species, *Acanthophoenix rubra*, *Dictyosperma album*, *Hyophorbe vaughanii* and *Tectiphiala ferox*, in conservation management areas. However, these plots are small and the long-term demographic security of the populations is not assured. Two offshore Mauritian islands, Ile aux Aigrettes (25 ha) and Round Island (151 ha), are managed as nature reserves, and the latter contains expanding populations of *L. loddigesii* and *H. lagenicaulis*.

### 2. Establish new wild populations

Existing wild populations are vulnerable to stochastic impacts such as cyclone damage, introduction of exotic predators such as rats and pigs, and disease. We recommend that new populations be established in safe locations within natural and semi-natural habitats. These would necessitate reintroductions *sensu strictu* and conservation introductions (*sensu* IUCN, 1998). Further

research is required on cost-effective horticultural techniques for reintroduction, such as direct sowing versus planting of nursery grown seedlings. We are currently basing the location of potential reintroductions on historical records. However it is likely that prior to colonisation and habitat clearance wild palms were more widely distributed and occurred in habitats from which they are now absent. Ile aux Aigrettes is being used as a site for the establishment of *Hyophorbe lagenicaulis*. Further reintroduction opportunities for the establishment of secure regenerating populations exist on offshore islands, and this is a particular priority for Rodrigues.

### 3. Establish effective *ex situ* populations

The value of cultivated collections is demonstrated by the existence of genetically important stocks of Critically Endangered endemic palms, notably *H. lagenicaulis* and *Dictyosperma alba* var. *conjugatum* in private gardens, public parks and botanic gardens in the Mascarene Islands. However, the utility of these populations is compromised by lack of collection data, and exposure to potentially inter-fertile congeners. We recommend that documented gene banks be established adjacent to protected areas. An important resource for palm conservation in Mauritius is the Sir Seewoosagur Ramgoolam Botanic Garden, which contains important nineteenth and early twentieth century plantings of *Hyophorbe lagenicaulis* and *Dictyosperma alba* var. *conjugatum* derived from wild collections. Similarly the Jardin de l'État, St. Denis, La Réunion, holds mature specimens of *Lantania lontariodes*. These plantings bear fruit, and could be used for recovery activities, but the plantings are undocumented and vulnerable to hybridisation, and many are old and senescing. Overseas botanic gardens widely cultivate Mascarene palms, and whilst the status of these stocks is largely unassessed, they may contain valuable genetic material (Maunder *et al.*, 2001).

### 4. Undertake conservation biology research

We recommend four research areas as priorities to support the conservation of wild palm populations: (1) the identification of conservation management units that reflect phylogenetic lineages, particularly for the *Dictyosperma alba* complex, (2) the assessment of patterns of genetic diversity for wild and cultivated populations to guide conservation management, (3) reproductive biology research to identify pollination and seed dispersal syndromes, and to allow managed seed production from reproductively isolated individuals, and (4) the application of *in vitro* propagation and storage techniques for palm seeds, pollen and tissue for highly threatened taxa such as *Hyophorbe amaricaulis* (Dickie *et al.*, 1992).

### 5. Establish pest management and quarantine procedures

All of the above conservation measures could be undermined through the inadvertent introduction of exotic pests and pathogens. Pest and disease management will be of increasing importance, both to maintain endemic invertebrate biota associated with wild palms, such as the endemic scale insect (*Asterolecanium* sp.) found only the Round Island hurricane palm (Williams & Mamet, 1986), and to protect wild palm populations from exotic pests and diseases. An increasing range of horticultural palm species is being introduced to the Mascarenes, often for hotel landscaping, and these could introduce a new suite of pests (e.g. aphids, scales and nematodes) and diseases (e.g. Lethal Yellowing Disease). Three endemic genera (*Dictyosperma*, *Hyophorbe* and *Latania*) are known to be susceptible to the latter (Chase & Broschat, 1991). The importation of all potted palms into the Mascarenes should be prohibited. In addition, the movement of palms between islands should be controlled to reduce opportunities for pest and pathogen transfer and hybridisation between island provenances. The management of pests and diseases in cultivation and during reintroduction requires further research. For instance, both cultivated and reintroduced seedlings of *H. verschaffeltii* on Rodrigues are susceptible to infestations of an unidentified hard scale insect. Spot-spraying with insecticides within reserves may be necessary, with biological control agents investigated as a possible long-term solution.

The palm flora of the Mascarenes illustrates many of the challenges facing island floras, and some species, most notably *Hyophorbe amaricaulis*, could be dismissed as beyond help. However, effective conservation interventions have led to the successful recovery of some species, with rabbit and goat eradication on Round Island resulting in an increase in the wild population of *H. lagenicaulis*. Under prevailing conditions, namely the presence of invasive weeds and exotic seed predators, it is likely that all Mascarene palm populations will need long-term management to ensure their survival. This management will need to utilise habitat restoration, reintroduction, *in situ* horticultural management and *ex situ* conservation. It is sadly ironic that the Mascarene palm species, grown and traded throughout the world as valued ornamentals, are amongst the most threatened palms in the world.

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