Principes, 36(2), 1992, pp. 84–93

Some Aspects of the Palms of Madagascar, and Their Cultivation at the Parc de Tsimbazaza, Antananarivo

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In Madagascar's national botanical garden, the Parc Botanique et Zoologique de Tsimbazaza (PBZT), a horticultural project based on the collection and cultivation of the island's native palms has recently successfully completed its first phase. Principal funding for the project was received from the World Wide Fund for Nature (WWF). Although the focus was on Madagascar's rich endemic palm flora, practical aspects of the project were seen as an opportunity to offer general horticultural training to the Parc staff. The rapid loss of native forest and the alarming rate of erosion and habitat degradation have stimulated a surge of international and local interest in Madagascar, and a concern for the conservation of the wealth of native plants and animals. The Parc is at the forefront of this movement; under strong direction an exciting educational program is emerging and the living collections of native plants and animals are undergoing reassessment and rehabilitation. With the support of international grants and technical advice, the collections will be able to play a major role in the education of the Malagasy people, in the orientation of short-term tourist visitors and possibly in the *ex situ* conservation of some of the more threatened species.

The palms of the island were chosen as the focus for the cultivation project because they are recognized as forming a particularly rich and interesting group, especially when compared with the palm flora of mainland Africa. There are 134 recognized palm species in Madagascar, of which 128 are considered to be endemic. At the generic level, endemism remains high: of the 23 genera 14 are considered endemic. In East Africa, by comparison, there are 11 indigenous palm genera, none of which are endemic. In Madagascar the palms have diversified to fill a range of niches and habitats. Unexpectedly, among the range of growth forms exhibited by Malagasy species, there are no climbing palms. *Calamus*, the most widespread climbing palm genus, is represented by 1 very variable species in East Africa which has not been recorded from Madagascar.

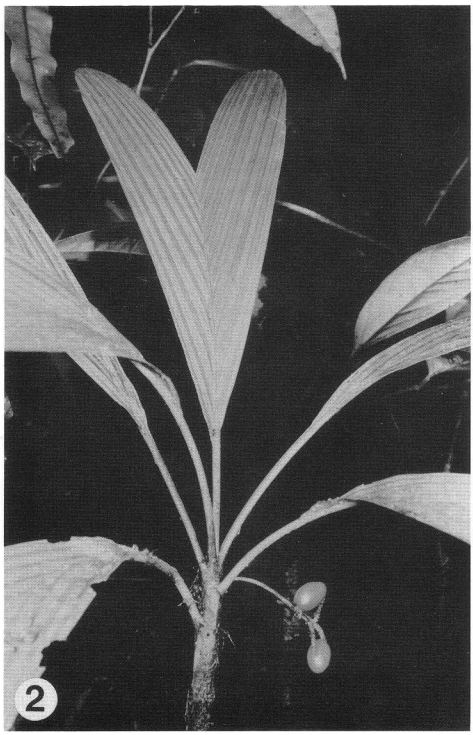
Eastern and Northern Moist Forest Domains

The greatest diversity in the native Malagasy palms is found in the moist forest domains of the east coast and the northerly Sambirano region. Tall solitary stemmed palms are a feature of the canopy in the low to mid altitude (0–1,000 m) forests. One such canopy palm with a robust crown of pinnate leaves is *Neodypsis lastelliana* which may grow to between 15 to 20 m and is distinguished by a thick rusty brown indumentum on the crown shaft. In the forest of Perinet, east of Antananarivo and accessible to visitors, *Ravenea robustior* is conspicuous due to its large clusters of brilliant red fruits. In this same region the

mixed, mid-altitude forest canopy is broken by the few remaining individuals of *Beccariophoenix madagascariensis*, a now rare emergent palm species. With equally limited distribution in an isolated forest region can be found *Marojejya darianii* which produces semi-erect, almost entire leaves forming a 'shuttle-cock', which, until the crown is raised up on a stocky trunk into the canopy, fills to almost a third with litter and debris falling from the canopy above. This trapped litter seems to rot rapidly and the released minerals may supplement the palm's nutritional requirements; *M. darianii* is only known from an area of white sand which is probably nutrient poor and seems to be constantly water-logged. It is from similar isolated moist forest regions along the northern east coast that two new monospecific palm genera have been collected: *Lemurophoenix*, the red lemur palm (Dransfield 1991) and *Voanioala*, the forest coconut (Dransfield 1989*a*); both generic names reflect the local Malagasy names used for these palms. *Lemurophoenix halleuxii* is a very large tree palm; the long pinnate leaves arise from a crown shaft which is up to 1.5 m long and covered in white wax. *Voanioala gerardii* is a spectacular palm in fruit. The fruits are ginger-red, arranged densely on long pendulous infructescences. With increasing altitude in the moist forest domains the forest canopy height falls, and the vegetation becomes more tangled. In these conditions the most common palm is *Neodypsis baronii*, a short, graceful clustering palm, very similar in habit to *Chrysalidocarpus lutescens*, the yellow cane palm of lowland and littoral conditions. The clustering habit is also displayed by members of the genus *Vonitra*, some species of which may also display dichotomously branched stems, such as *V. fibrosa*, the most widespread species of the genus. *Vonitra* palms may be frequent under moist forest conditions near streams or small rivers from sea-level to 900 m altitude and are often the only remaining plants in a recently felled forest patch; the leaves are used for roofing small cabins and dwellings. In the dense shade on the forest floor and in the understory, small single stemmed or clustering palms represent the genera *Dypsis* and *Neophloga*. Of these genera, *Dypsis pinnatifrons* is a frequent palm in the mid-story layer especially in the forests around the Bay of Antongil. It is a graceful, slender palm with a clustering habit and dark pinnate leaves, on which the leaflets are broad and unequal. In the understory of the forest at Perinet *Neophloga concinna* forms attractive small stands; members of the genus *Neophloga* usually have few leaves which are pinnate, divided into narrow or broad segments. *N. concinna* has pinnate leaves with numerous, fine leaflets almost evenly arranged along the midrib and the two terminal leaflets fused at their base.

Western and Southern Dry Forest Domains

On the west coast, in some localities, the palms are a spectacular feature of the landscape. In the savannah-like grasslands the endemic *Bismarckia nobilis*, with blue or green palmate leaves, forms dense stands. Clusters of arching *Hyphaene coriacea* are abundant on the outskirts of these stands and also on the more frequently burnt and impoverished grasslands. Between the western Mangoky and the Tsiribihina Rivers, *Borassus madagascariensis* palms mingle with the *Bismarckia*. These two palmate-leaved species may be distinguished at a glance due to the swollen trunks of the *Borassus* palms. A second endemic *Borassus* species, *B. sambiranensis*, occurs further north on the coastal plain of the Sambirano. *Phoenix reclinata* also occurs on these seasonally wet northern plains. In the western deciduous forests the robust and single-stemmed *Chrysalidocarpus rivularis* and the often clustering, variable *C. madagascariensis* are frequent species. *Chrysalidocarpus onilahensis* is prominent in



1. Malagasy people crowd the Parc on a national holiday. 2. *Dypsis humbertii* var. *angustifolia*, a moist forest understory palm with typically undivided leaves.

the sheltered gullies of the Isalo massif of southern central Madagascar growing with the graceful *Ravenea glauca*. Scattered stands of *Ravenea xerophila*, the most drought tolerant of the Malagasy palms, occur in the xerophytic vegetation of the south. The leaves of this palm are very stiff, the leaflets held in a steep V and covered with a white waxy bloom, and the trunk is obscured beneath the retained fibrous leaf bases. *Neodypsis decaryi*, from the southeast, is a striking palm due to the strong tristichous arrangement of its leaves. This species is endemic to a small patch of forest transitional between the wet and the dry domains.

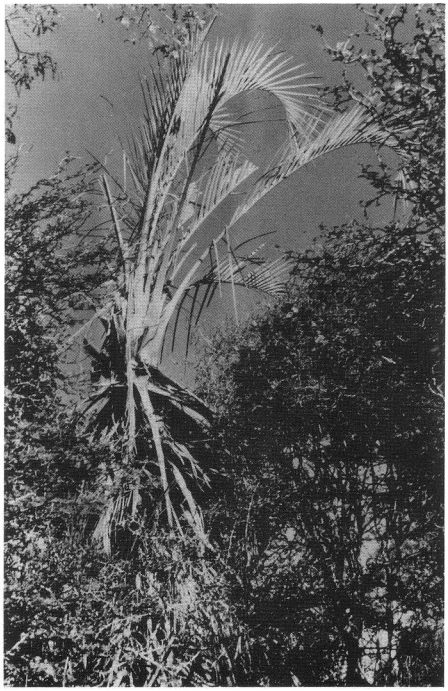
Ethnobotany of the Native Palms

Many of the native palms play an important role in the rural economies of the country; they are known and used by the local people as a source of food or materials. The young leaves of *Bismarckia nobilis* are used for roofing and their trunks for building. *Beccariophoenix madagascariensis* is valued for its leaves which are used to weave hats. The tough leaves of *Hyphaene coriacea* are widely used for weaving mats, and copious sugary sap is collected from its cut inflorescences and rapidly fermented into a heady beer. The sparse, stiff leaves of *Ravenea xerophila* are harvested for basket weaving. *Vonitra fibrosa* and *V. utilis* are important locally for the fiber that is associated with the leaf sheaths. The longer fibers from *Vonitra* may be twisted into ropes and used in the construction of small cabins, the shorter fibers are used in small 'mats' to pad or shield the bare shoulders of porters car-

rying heavy loads slung from horizontally held poles. The narrow stems of some of the *Dypsis* and *Phloga* species are said to have been used to make blow pipes, their narrow straight stems providing a suitable form. Edible fruits are gathered from some palms, such as those of the *Hyphaene*, *Phoenix* and *Borassus*. The trunk of *Ravenea robustior* is rich in carbohydrate and can be used as a source of sago. Palm hearts (the apical bud) of many native species, including *Ravenea madagascariensis* and *Chrysalidocarpus madagascariensis*, make a contribution to the diets of many rural people. Other palms are known to be poisonous or bitter. Malagasy forest people know that *Orania* produces poisonous seeds and bitter, poisonous apical buds; the apical bud of *Ravenea amara* is known to be edible but bitter. *Raphia farinifera*, the Raffia palm, is widespread, but only in secondary vegetation on the island; although it is thought to have been introduced to Madagascar with human settlement (Dransfield 1989*b*), its fiber and fruits are widely used throughout its distribution on the island. Raffia fruits are edible and refreshing, and the trees are further valued for the production of fiber from their young leaflets, which is used locally to weave baskets, and on the east coast a stiff 'cloth' is produced which is used to make simple garments. Fibers are used in the manufacture of fish traps and numerous other utensils; these fibers are produced in sufficient quantities to make a strong contribution to the national exports. The long petioles of this palm are used for roof joists and their rounded smooth structure suits them for use as carrying poles among west coast people.

Habitat Stresses, Endemism and Exploitation

The fragile soils of the island coupled with the traditional agricultural practices encourage a system of shifting cultivation, requiring a steady supply of fresh land, for which the forest is cut. This constant attrition of the forest is a major threat to the diversity of the palm flora. As a group the palms of Madagascar exhibit an extraordinarily high degree of island endemism. Several Malagasy palm species are only known from limited localities; this high level of micro-endemism or local endemism places such species as *Marojejya darianii* and *Borassus sambiranensis*, for example, in a position particularly vulnerable to stress due to habitat loss or habitat degradation. Exploitation by local users also places stress on a declining population of plants; the removal of leaves for weaving or as fodder for cattle reduces fruiting potential. Other endemic species, particularly attractive or rare species such as *Neodypsis decaryi*, *Ravenea xerophila*, and *Beccariophoenix madagascariensis*, are further threatened by the unrestrained collection of seed for palm enthusiasts.



3. The ravaged crown of a rare, mature *Ravenea xerophila*; the stiff grey leaves are cut for basket weaving.

The Parc Botanique et Zoologique de Tsimbazaza

The cultivation of Madagascar's native plant species at the Parc de Tsimbazaza has a long history. The existing botanical and zoological Parc is the modern extension of an ancient Royal garden originally constructed by the Malagasy Merina kings and queens of the 17th to the 19th century. Within the capital city, Antananarivo, and landscaped around a descending series of manmade lakes, the Parc has an air of tranquillity and seclusion created by the surrounding cliffs and steep hillsides and intensified by thick stands of bamboo and woodland areas. Lake Tsimbazaza, the largest of the Parc's lakes, is a place of national legend, the most frequently repeated of which is the story of the young Princes. Many years ago, the twin sons of a Merina king used to bathe in the refreshing waters of the lake. One day an unexpected wind stirred the normally calm waters, and the young men were drowned; their bodies were never recovered. The king, their father, had a gold coffin cast, and to symbolize their burial the coffin was launched into the lake.

Under French colonization, earlier this century, the Parc was developed as a botanical and zoological research center, and opened to the public as an educational resource. Living and dried collections of the fauna and flora of the island were gathered for study and display. The Parc, located towards the eastern slopes of the island's central High Plateaux, at an altitude of 1,250–1,450 m (a.s.l.) falls into a climatic zone where dry cold winters between April and September are followed by heavy summer rains. The average temperature is around 18° C, but winter nights can be cold, with temperatures close to the freezing point. The existing planting indicates that the French collected material from most of the vegetation types on the island. These established plantings set an important precedent in cultivation possibilities for any future redevelopment. Over the past few decades, a serious lack of both horticultural skill and financial support have resulted in the impoverishment of the plantings. Many specimens are over-mature or in need of pruning and others, debilitated by unsuitable cultural conditions, are infested with insect pests.

The Palmetum

On a steep hill, under a stern-faced statue of the French naturalist, Alfred Grandidier, a mixed palmetum has been developed. A structure of paths and open lawns is demarcated by avenues of the exotic Queen Palm *Syagrus romanzoffiana*, probably planted for its rapid growth. The palmetum not only contains palms, but also *Pandanus* plants and specimens of the native Traveller's Tree, *Ravenala madagascariensis*. Native palms include mature clumps of *Chrysalidocarpus lutescens* and the similar *Neodypsis baronii*. A specimen of *Vonitra fibrosa* also forms a dense clump, the stems covered in pale brown fibers. *Chrysalidocarpus decipiens*, native to the High Plateaux, is a valuable and healthy feature of the collection. This species may occur with twin cigar-shaped trunks, an indication of its apparent ability to branch dichotomously as a young plant in the rosette state; more usually one of these stems dies. Several specimens of *Neodypsis decaryi* have been discovered in the palmetum, none of them in good health. However, good cultivation of this species should be possible under the Parc's climatic constraints; a single fruiting specimen has been seen elsewhere in a sheltered garden in the city.

Many of the palms, especially the dense clumps of *Chrysalidocarpus lutescens*, are suffering from heavy infestations of scale insects including the sap sucking soft brown scale (*Coccus hesperidum*) and the coconut scale (*Pinnaspis* sp.) which resembles a sprinkling of shredded coconut on the leaflets. The brown scale is responsible for

further problems: the insects exude a sugary liquid which is colonized by black 'sooty molds' that cover the leaves and reduce photosynthetic efficiency.

The Palm Cultivation Project

The palm collection and cultivation project has four goals:

1. the organized and scientific collection of material to increase the native palm collection at the Parc;
2. to improve germination procedures and nursery cultivation techniques;
3. to assist with the development of general horticultural techniques to improve cultivation of specimens in the palmetum;
4. to assist with educational displays based on the native palm flora.

Seed and plantlet collections were carried out with the assistance of botanical teams from The Royal Botanical Gardens, Kew and from the Missouri Botanical Garden. Particular species considered to be under habitat stress or suitable for cultivation in the Parc were targeted. An expedition to the east coast enabled the recently described endemic *Marojejya darianii* to be accessioned to the Parc. Further expeditions yielded seed of both *Borassus* species, and later the canopy palm *Lemurophoenix halleuxii* was collected. The project resulted in twenty-two new palm accessions to the Parc. Each of these collections of living material was accompanied by an herbarium collection. These dried voucher specimens will facilitate the naming of the living material and will contribute to essential taxonomic studies of the palm flora now underway in Madagascar and at Kew.

Seed Germination

The germination of palm seed was found to be most successful when the seed was fresh and ripe. In these conditions 60–80% germination was achieved. Seed was cleaned immediately on collection and the germination process initiated. The established technique (Jones 1984) of placing cleaned seed, wrapped in moist moss into plastic bags, was followed. Numerous small plastic bags each with 5–10 seeds were used in order to limit the losses of seed to predatory insects hidden within apparently clean seed. Germination of most fresh seed was rapid; ripe seeds of *Marojejya darianii* which had been collected from fallen clusters around the base of the trees gave almost 85% germination after six to eight weeks. Most members of the Dypsidinae (*Dypsis*, *Chrysalidocarpus*, *Neodypsis* and *Vonitra*) produced smaller seed, which germinated within four to six weeks. In these small seeded species, germination is adjacent-ligular. The *Chrysalidocarpus* and *Dypsis* seedlings rapidly lost the radicle and produced several wiry adventitious roots from the base of the seedling. *Neodypsis* seedlings developed a single primary root or radicle which itself produced fine lateral roots. Subsequent development of these seedlings occurred relatively steadily and without undue difficulties. After approximately eleven weeks *Lemurophoenix* seeds also exhibited adjacent germination, but subsequent development of the radicle and plumule was very slow, and the seedlings were prone to rot before this could occur. Seeds of *Orania*, *Hyphaene* and *Bismarckia* provided examples of remote ligular germination. Fleshy, white cotyledonary stalks grew from the seeds, diving into the compost and carrying the seedling away from the large seeds; these cotyledonary stalks proved to be fragile structures, prone to rot and insect attacks. This germination mechanism ensures that the young crown of the seedling is sheltered below the soil surface and that it is well anchored by deep-set roots. The genera *Bismarckia* and *Hyphaene* both form dense stands on the western sedimentary plains of the island, regions that suffer from annual fires. This germination type, coupled with the characteristics of monocot-

yledon trunk morphology, may account for their ability to withstand the effects of the annual burn. *Borassus* species also have the same germination syndrome (Corner 1966). *Orania* occurs on steep, often precipitous slopes in the east coast forests where this plunging seedling development may ensure a secure anchorage which could be an advantage in maintaining position on the slope.

Seedling Cultivation

The palm seedling cultivation was carried out in a secure, shaded greenhouse in the Parc nursery. Seedlings were guarded in their moss wrapping in the bags, often until the first leaf emerged, or until the cotyledonary stalk reached a cumbersome and fragile length. At this point individuals were potted into a carefully developed compost and were weaned under humid conditions in a tent before standing in the open house. Humidity in the house was maintained by the regular spraying of water; the adoption of extra shading in the house and over planting-out beds created a suitably reduced level of light. The compost used was a modification of the basic mix established for the nursery: loam, grit, and humic compost on 1:1:1 ratios. For the palms, this general mix was supplemented with chopped coconut fiber or moss, and pieces of charcoal and brick shards, on the ratio of 2 parts of general mix: 1:1 in order to improve the drainage and structure of the mix. It was considered important that these compost ingredients should be easily available and inexpensive. Pots presented a problem in that containers of sufficient depth combined with a narrow diameter were difficult to locate. This was eventually solved by the use of narrow open weave plastic waste-paper baskets produced by a local factory. These baskets had a suitably low unit price and long life expectancy. The problems of loss of plants to marauding chickens and thieves will necessitate that young palms are cultivated under strict security until they reach a suitable size for planting out safely in the Parc. Seedlings will eventually be moved out of the house, to continue growth in shaded, locked wire cages.

The Project in the Palmetum

In the palmetum, work concentrated on the removal of non-palm specimens and the amelioration of conditions for the remaining plants. Dense, thick clumps of *Chrysalidocarpus lutescens* were thinned. The removal of stems should improve the air circulation, and reduce the shelter offered to insect pests. As a further means of combating the heavy infestations of scale, 'White Oil' was imported. This petroleum oil can be an effective treatment for many insect pests, and is of a sufficiently low level of toxicity for its use to be recommended where safety precautions are difficult. It is used at 1 part of White Oil to 60 or 80 parts of water; if more concentrated it is known to cause scorching, especially under conditions of bright light. Under a school participation program, the turf surrounding specimen plants was removed in a 2 m diameter circle and replaced with an 8 cm layer of organic compost, to improve the nutritional status of the lateritic soil. Most of the *Pandanus* and *Dracaena* plants were cut out, and their roots removed. This had the effect of opening up and accenting the planting, and will help to increase air movement and light levels for the remaining palm specimens. In a future co-operative program with forestry workers, some of the larger exotic palms will be removed. It has also been recommended that irrigation should be installed to supplement the light winter rains.

Leaflets, Labels and Notice Boards

Prior to the cultivation project, a leaflet (available in English, French and Malagasy) was produced as a result of funding

from WWF. This leaflet, distributed through the Parc, formed the pivot for the poster displays developed under the cultivation project.

Labels for the palms have been designed which indicate scientific and vernacular names and region of origin. These will be erected initially for the native palms and eventually for all the plants in the Parc. Notice boards, one of which was constructed in the palmetum, offer the opportunity for seasonal poster displays and information sheets. A series of six colorful cartoon posters was designed and a Malagasy artist commissioned to produce them with text both in French and Malagasy. These posters form part of a larger display highlighting the uses of the native palms.

Recommendations for Future Planting Development

There are many possibilities for the further development of the palmetum using the wide range of native species and their variability in form. It could also be valuable to develop the collection towards a display of palms with different growth habits, such as *Marojejya* with its litter collecting crown and the numerous small forest floor *Dypsis* and *Neophloga* palms. Many of these species could also be incorporated into suitable habitats in the general planting of the Parc. Riparian species such as *Vonitra crinita* could be planted by the lakes and shade-requiring species in the large display shade house. Under the planned redevelopment of the Parc, the palmetum will continue to be a focal area.

Conservation

To ensure the continued survival and diversity of the palms native to Madagascar a co-ordinated conservation policy should be considered and implemented. This policy should be directed into:

—protection of the population in the native habitat to encourage continuation and regeneration *in situ*;
—the *ex situ* cultivation of targeted species by the means of seed produced plants within Madagascar, to explore cultivation requirements and to form the basis of a conservation stock;
—the protection from excessive trade and the monitoring of existing trade as offered by CITES (Convention on International Trade in Endangered Species) listing.

Many of the native palm species are very attractive and would be exciting to see in cultivation. To limit the effects of seed collection from habitat plants a general policy of cultivation for seed harvest could be incorporated into the conservation policy.

Ex Situ Conservation

The restricted distribution of many of the native palm species, and the pressures on wild populations from collectors and enthusiasts, suggests particular species as suitable for the attention of *ex situ* cultivation conservation projects. *Ravenea xerophila*, from the xerophytic vegetation of the central south of the island, would be a suitable candidate for such a project. The remaining individuals are now restricted to small scattered stands all of which fall outside the region's protected areas. This species is thus considered to be in immediate threat of extinction in its native habitat. Most of the *R. xerophila* plants located have been severely debilitated by the removal of leaves or grazing. The populations are further stressed by the uncontrolled and usually unauthorized collection of seed for international collectors. A second threatened palm *Beccariophoenix madagascariensis* from the eastern forests, now probably limited to a single known stand of six adults, would also be a suitable candidate. Habitat loss, at least in principle, is not a threat in this case as

the stand is within a protected area, but the very tall, mature trees are still cut down to facilitate seed collections.

Strict conditions apply to *ex situ* cultivation (BGCS 1989), and if any real contribution to conservation is to be achieved, efforts must be made to adhere to these conditions. Guidelines are set out within the Botanical Garden Conservation Strategy, produced in 1989 by the IUCN Botanical Garden Conservation Secretariat. Among these guidelines is the basic requirement that as wide a range as possible of specimens representing a species should be cultivated, in order to conserve the range of genotypes. Thus seed should be collected and grown from various populations throughout the geographical and ecological range of the species. The limited range of some of the Malagasy endemic palms has already been assessed by preliminary surveys; for the targeted species these surveys could be developed. Following the suggested guidelines for *ex situ* conservation, the Parc could arrange for the designation of a locality within the country for the safe cultivation of these native species and could perhaps eventually facilitate the legal and controlled dispersal of seed from mature plants to overseas collections.

CITES Listing

Only two Malagasy palms are as yet protected by international law: *Neodypsis decaryi* and *Chrysalidocarpus decipiens*. Both these species are named on Appendix 2 of the CITES regulations controlling trade, although seed of both species is exempt. Appendix 2 listing requires that those wishing to export specimens obtain an export permit or certificate which is issued by the country of origin, prior to handling and after determination that "such exports will not be detrimental to the survival of the species" (CITES Secretariat 1982); this system allows the extent of the trade to be monitored. Although exempt from CITES restrictions, the CITES Annual Report for 1989 did indicate the export of 103 kg of *N. decaryi* seed and also reported the exportation of approximately 20 plantlets each of *C. decipiens* and *Ravenea xerophila*. In the case of other endangered groups the listing of a species on the CITES appendices does seem to have had some influence on reducing trade in habitat collected material and on encouraging the controlled cultivation and propagation of the species. Given the extent of the seed collections, and the pressures on existing populations it would seem advisable to remove the exception to CITES control for the seeds of the two listed species and to give CITES monitoring to further, rare Malagasy palm species by CITES listing. Appendix 2 listing would offer some degree of protection to *Marojejya darianii*, *Voanioala gerardii* and *Lemurophoenix halleuxii*, all of which are highly attractive species of very limited known distribution. The listing of species on Appendix 1 of CITES (a level of listing used for species considered to be under threat of extinction in their habitat) would strictly prohibit all commercial trade in wild specimens. This level of protection may be suitable for *Ravenea xerophila*, *Borassus sambiranensis*, and *Beccariophoenix madagascariensis*. The listing of these species on Appendix 1 of the CITES legislation would prohibit international trade and should deter collectors and enthusiasts from taking, buying or accepting specimens of these species.

Acknowledgments

We should like to thank the staff of the Parc Botanique de Tsimbazaza, in particular Jackie Andrianatina and Guy Rafamantanantsoa for their hard work and enthusiasm with the collection and cultivation of the palms. We are grateful to the World Wide Fund for Nature and to the Iris Darnton Foundation for grants awarded to the project; to the Royal Botan-

ical Gardens, Kew and Missouri Botanical Gardens, in particular to Mr. J. Simmons, Dr. J. Dransfield and Mr. D. N. Cooke of Kew and Dr. P. Lowry of Missouri, for all their advice and support over the term of the project.

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