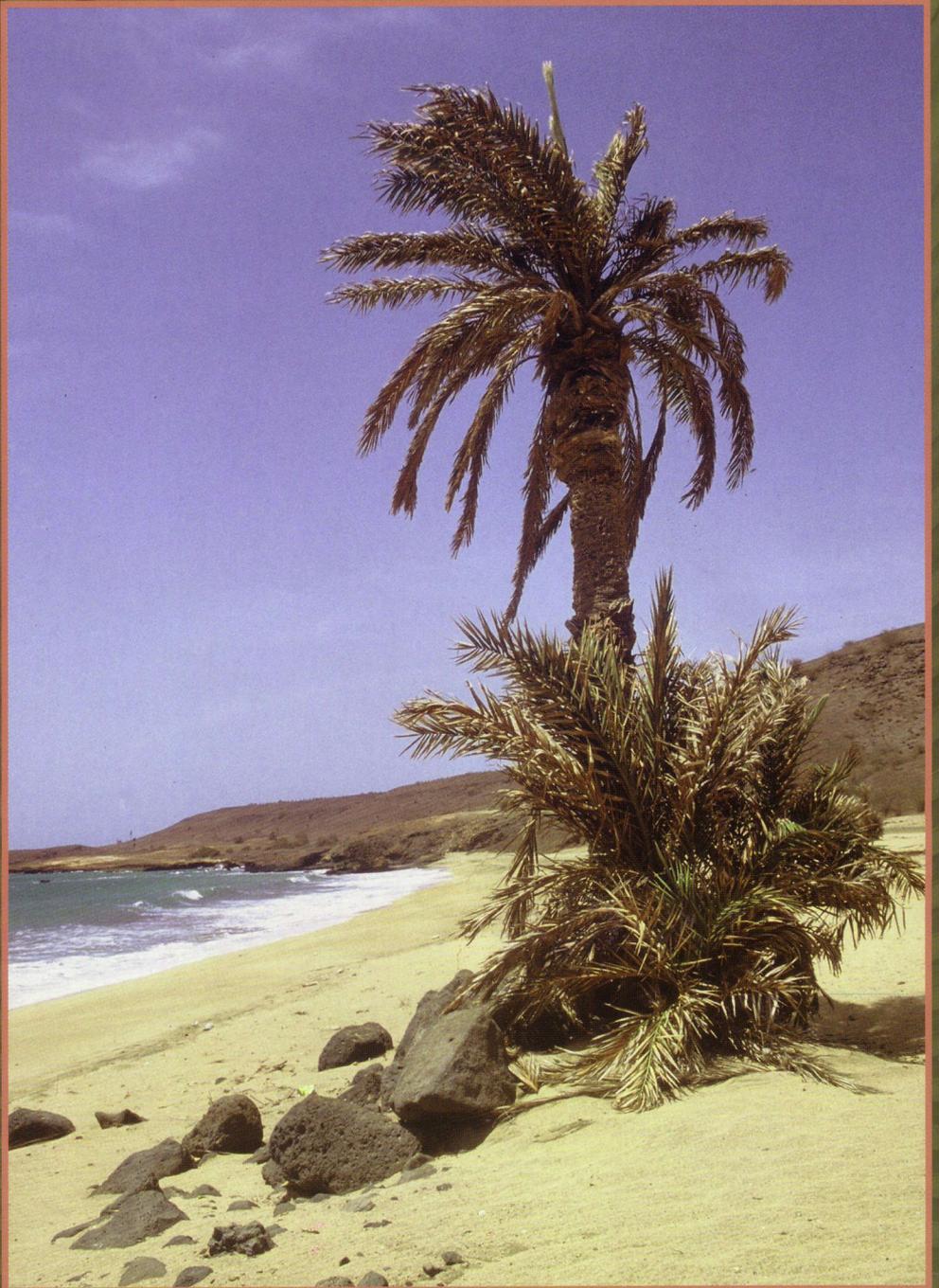


# Palms

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# THE INTERNATIONAL PALM SOCIETY, INC.

## The International Palm Society

**Founder:** Dent Smith

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### FRONT COVER

*Phoenix*, Baía de São Francisco, Santiago, Republic of Cape Verde. See article p. 5. (Photo: Bill Baker)

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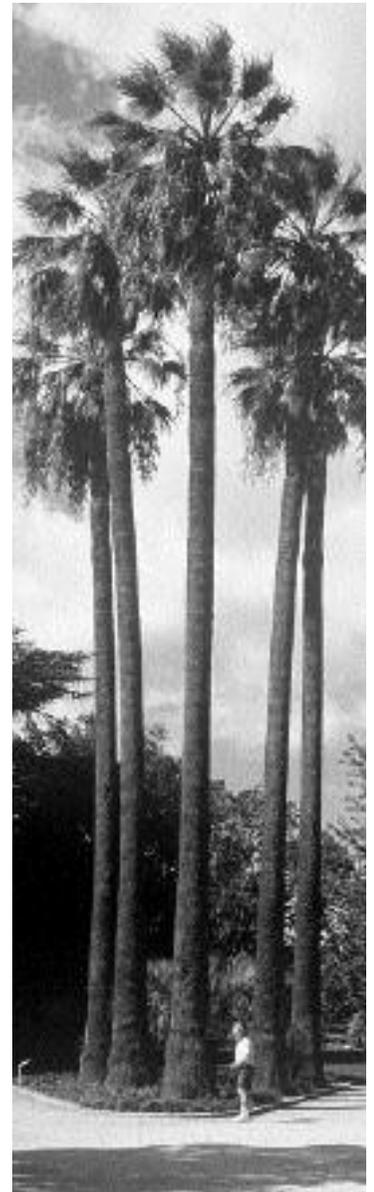


## BACK COVER (AND RIGHT)

This towering stand of *Washingtonia filifera* was a memorable sight for IPS members attending the 2002 Biennial in France. For an account of the Biennial and Post Tour, see Katherine Maidman's article p. 21. Photo by S. Zona.

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# NEWS FROM THE WORLD OF PALMS

The last few months have seen a flurry of palm-related publications of interest to IPS members.

While we all know that palms are unique in the plant kingdom, we are just now learning that they have an unusual root anatomy. Kerstens and Verbelen, working with palms cultivated in Belgium, used sophisticated microscopy to reveal a random pattern to the cellulose fiber orientation in secondary cell walls of the roots, an orientation found in no other flowering plants (*Annals Bot.* 90: 669–676. 2002). Their preliminary results, using only Coryphoid palms, will no doubt stimulate interest in the anatomy of palm roots, which make up, after all, nearly half of every plant.

Dr. Andrew Henderson, of the New York Botanical Garden, has produced a new scholarly book, *Evolution and Ecology of Palms*, available from The New York Botanical Garden Press. Look for a review of the book in a future issue of PALMS. He also has published a phenetic study of *Reinhardtia* (*Amer. Jour. Bot.* 89: 1491–1502. 2002) and, with Evandro Ferreira, a morphometric study of *Synechanthus* (*Syst. Bot.* 27: 693–702. 2002). Both studies use statistical approaches to examine species boundaries in these two Central American genera.

Charlie Heatubun, of the Herbarium Manokwariense, Papua, Indonesia, has recently published a monograph of the little-known Papuan endemic genus, *Sommieria* (*Kew Bull.* 57: 599–611. 2002). Previous authors, working with limited material and field experience, recognized three species, but Heatubun's careful analysis revealed only one, *S. leucophylla*.

Dr. Tom D. Evans and colleagues have produced the first modern account of the rattans of Laos and

neighboring areas of Indochina (*Kew Bull.* 57: 1–84. 2002). The paper recognized 50 species and provided keys, distributions, synonymy and other important information. It is the basis for a newly published field guide to the area's rattans, *A Field Guide to the Rattans of Lao PDR*, which was mentioned in PALMS 46(3).

IPS Board Member José Antonio del Cañizo has produced a profusely illustrated guide to palms, *Palmeras*, which is reviewed by Carlo Morici in this issue (p. 25). Even those who do not read Spanish can enjoy the beautiful color photographs that fill the book.

Timber Press has just released a book that will no doubt be of interest to palm lovers in colder climates. *Palms Don't Grow Here and Other Myths: Warm-Climature Plants for Cooler Areas* by Dr. David A. Francko gives a full account of his growing techniques used in the normally palm-free state of Ohio. Francko has reported on his experiments in the pages of this journal. We hope to have a review of the book in an up-coming issue of PALMS.

The newest book from the IPS' Revolving Publication Fund will soon be rolling off the presses. We are very excited that *The Palm Book of Trinidad and Tobago* by P.L. Comeau, Y.S. Comeau and W. Johnson will be the latest title published by the IPS. The IPS sees its primary product as information about palms, and this exciting, fully illustrated guide to the palms of Trinidad and Tobago amply fulfills that purpose. The book is expected to be ready for shipment in the very near future. Look for an order form to be included in the next issue of PALMS, or order directly on-line ([www.palms.org](http://www.palms.org)).

THE EDITORS

# Phoenix in the Cape Verde Islands

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1. *Phoenix* at Algodeiro, Sal;  
one of Chevalier's syntype  
localities for *Phoenix atlantica*.  
This female specimen had more  
than ten mature stems and  
reached a height of over 20 m.  
Sally Henderson provides scale.

The taxonomic status of *Phoenix atlantica* A. Chev., the elusive date palm of the Cape Verde Islands, has been in doubt for some time. In 2002, field work was carried out on the islands as a first step towards unravelling the mystery of the Cape Verde date palm (Fig. 1).

The African Republic of Cape Verde consists of nine inhabited and several uninhabited volcanic islands set out in the Atlantic Ocean, about 500 km off the most westerly point of the African mainland and 1500 km south of the Canary Islands (Fig. 2). Most are rugged and mountainous; three (Sal, Maio, and Boavista) are flat, desert islands with sand beaches. Precipitation is meagre and very erratic; indeed Cape Verde can be seen as an island extension of the arid Sahel zone.

Three species of the genus *Phoenix* are recorded from the Cape Verde Islands, *P. dactylifera* L., *P. canariensis* Chabaud and *P. atlantica* A. Chev. While the former two species have almost certainly been introduced by man, the latter is said to be endemic to the islands. Perhaps because the Cape Verdes are a particularly isolated set of islands or because palms are notoriously awkward to collect, little is known about the taxonomy, origins and natural history of this species.

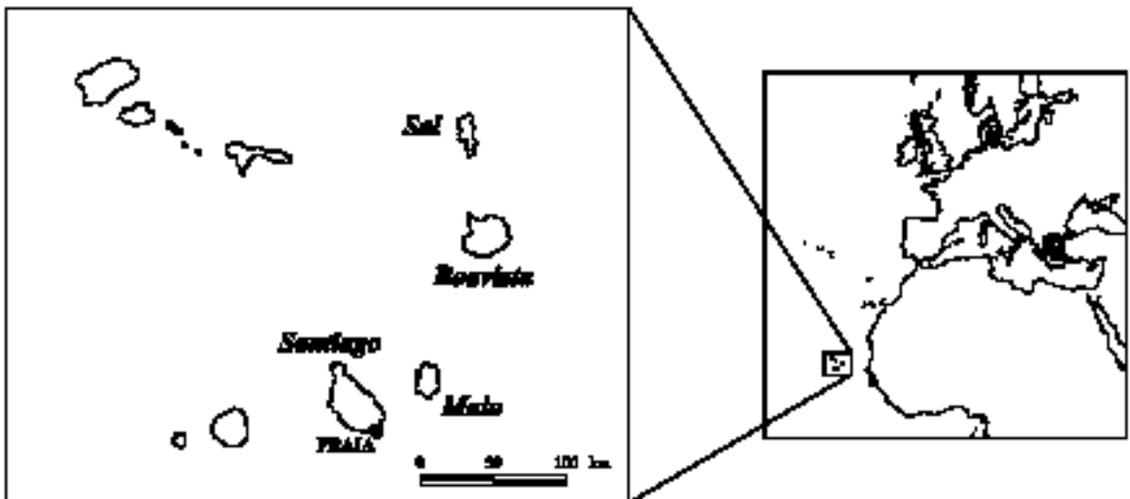
*Phoenix atlantica* was described by the French botanist Auguste Chevalier (1935a) following field exploration in the Cape Verdes in 1934 (Chevalier 1934: 1153). Chevalier provided limited diagnostic characters, defining the species as a clustering palm with 2–6 trunks, 5–15 m in height with dark green leaves 2–3 m in length. He considered it to be most similar in form to *P. dactylifera* and *P. canariensis*, possessing characters of both (Chevalier 1935a). Chevalier's description indicates that *Phoenix atlantica* can be distinguished easily from *P. canariensis* by its clustering growth form (*P. canariensis* always has a single, stout trunk) and its shorter, straighter leaves. However, the differences between *P. atlantica* and *P. dactylifera* appear much more

subtle. For example, while *P. dactylifera* is usually observed as single-stemmed, when left undisturbed for a number of years it becomes clustering like the Cape Verde *Phoenix*, so this character on its own is unreliable. Further alleged distinctions include acuminate (*P. atlantica*) versus rounded (*P. dactylifera*) petals in the male flowers (Chevalier 1935a, b, Greuter 1967: 249, and Brochmann et al. 1997), fruit 2 cm long (*P. atlantica*) versus fruit more than 2.5 cm long (*P. dactylifera*) (Brochmann et al. 1997), leaves green (*P. atlantica*) versus leaves glaucous (*P. dactylifera*).

The somewhat ambiguous characters defined by Chevalier have raised suspicions that *Phoenix atlantica* is not a distinct species. Barrow (1998), in her monograph of *Phoenix*, suggested that it could be a feral form of the date palm (*P. dactylifera*) or a product of hybridisation and introgression between *P. dactylifera* and *P. canariensis*. However, she was unable to resolve the question because the material available to her was inadequate. The problem is intensified by a lack of knowledge of the full extent of morphological variation in *P. dactylifera*. Fortunately, genetic variation in *Phoenix* is being investigated more fully at CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) and IRD (Institut de Recherche pour le Développement) in Montpellier (see also, for example, Trifi, Rhouma & Marrakchi [2000] and references therein), providing an alternative basis for making comparisons with the Cape Verdean *Phoenix*.

With this in mind, a collaborative project was set up between The Natural History Museum, London and Instituto Nacional de Investigaçao e

## 2. Cape Verde Islands (named islands were visited by the authors).



Desenvolvimento Agrário (INIDA), Santiago, with the aim of clarifying the taxonomy of *Phoenix atlantica* using morphological and molecular tools. The initial phase of the project entailed collection of primary data – leaf material for DNA extraction, herbarium specimens, photographs and ecological notes. After consulting literature and herbarium specimens for collecting localities and flowering times, we arranged a field trip for May 2002. The four most easterly islands of Sal, Boavista, Maio and Santiago were visited.

## The Islands

### Santiago

“The neighbourhood of Porto Praya, viewed from the sea, wears a desolate aspect. The volcanic fires of a past age, and the scorching heat of a tropical sun, have in most places rendered the soil unfit for vegetation. A single green leaf can scarcely be discovered over wide tracts of the lava plains; yet flocks of goats, together with a few cows, contrive to exist.”

Charles Darwin (1845)

Charles Darwin's first vision of Santiago in 1832 rings only too true today. The island's capital, Praia, has an undeniably West African feel – lively markets flanked by roadside kitchens selling rice and bean stew for breakfast, sweet sellers on the roadsides and shops in doorways.

Outside the city, heading up to the hills one travels through barren and desolate land dotted with planted *Prosopis juliflora* (Fabaceae) and the ubiquitous *Calotropis procera* (Asclepiadaceae). Near São Jorge dos Orgãos the higher elevations bring somewhat lush vegetation and a more tranquil atmosphere. Here, small numbers of *Phoenix* line the valleys next to settlements, suggestive of their being planted, but they are many-stemmed and at least superficially like *P. atlantica*.

Field work on Santiago centred around the area from which Chevalier's syntypes of *Phoenix atlantica* were collected, “around Praia and São Martinho, near to the shore, at the edge of the valleys...” (Chevalier 1935b, translation) to the south of the island. The sites visited by us (from west to east) were: Ribeira Grande, São Martinho (Pequeno and Grande), Praia Baixo and São Francisco.

Passing through Cidade Velha, where the 16th century ruins of the old capital of Santiago are found, we reached Ribeira Grande, a deep, lush valley brimming with mango trees, coconuts and date palms. Here, we observed numerous cultivated *Phoenix* including a striking individual,

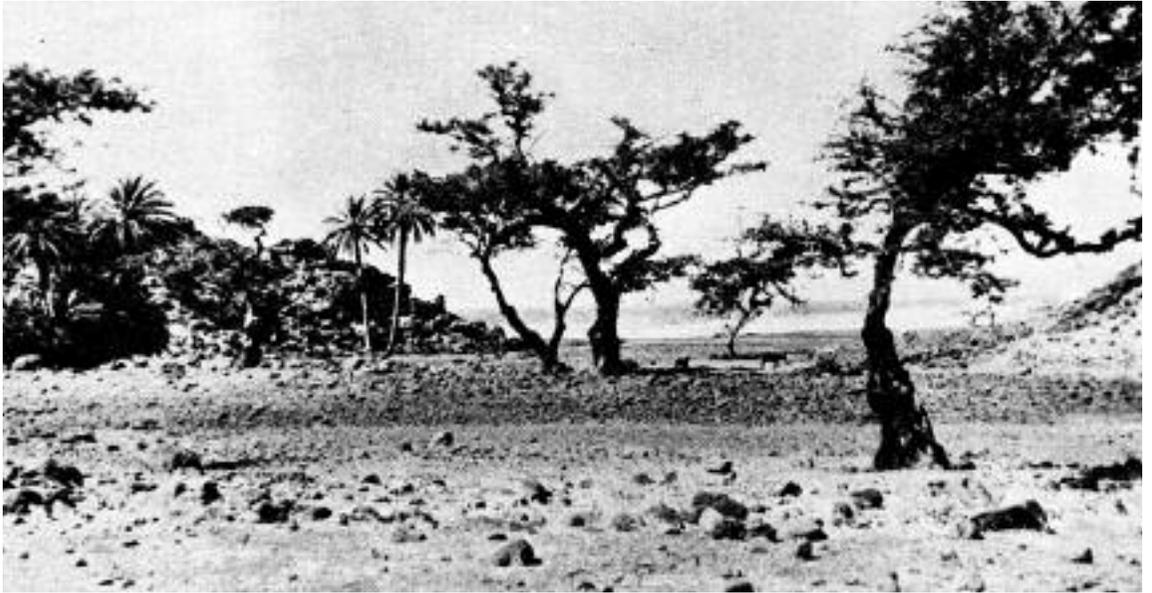
with large plumose, glossy leaves and bright orange leaf bases. Around São Martinho, the palms are mainly found in two spectacular, barren, dry river valleys (ribeiras) known as São Martinho Pequeno and São Martinho Grande. A handful of apparently untended *Phoenix* stand proud against the landscape of rock and dust (Figs. 3–5). The vast *Phoenix* populations at São Francisco extend from a dense, managed grove into a population with a more natural appearance on the shore. There is a striking morphological difference between the inland and the coastal palms; moving away from the tall, archetypal palms inland onto the dunes and the beach, we encountered remarkable stunted individuals, many-stemmed and with short, glaucous leaves (Front Cover). These palms are undoubtedly exposed to sea spray and some of those growing closest to the shore may even experience salt water at their roots at high tides. Whether or not they were originally natural, the *Phoenix* groves at Praia Baixo, as at Ribeira Grande, are now quite obviously managed with some clearly cultivated *Phoenix* seedlings, signs of irrigation, burning of *Prosopis* and further plantings of coconuts and mangoes reinforcing our convictions that these are agricultural systems, not natural populations. In São Francisco and Ribeira São Martinho, however, the distinction was far less obvious.

In Santiago began what we discovered to be extremely dusty work, often made less appealing by rubbish left under the palms; in these relatively populated areas the palm groves provide welcome shade for people and their livestock. *Phoenix* is important to the Cape Verdeans in other ways; leaves may be cut and used (sometimes sold) by villagers as thatch, fencing or fodder for livestock. At some localities (e.g. Praia Baixo) the fruit is apparently eaten by the locals while at others the fruit is fit only for the goats. The best fruit is said to be traded throughout the islands.

Brief respite from fieldwork was provided in Ribeira Grande in the form of locally produced *grogue*, a spirit made from sugar cane (grown in the fertile valleys). *Grogue* is figuratively and literally a way of life to many; not only is it an extremely popular drink on the islands, but it is also produced on a small-scale by many farmers. Oxen or mules are used to drive the *trapiche*, the machine which squashes the sugar cane. It is said that the pressing of the cane, with its steady rhythm, has been a strong source of inspiration for the famous Cape Verde music, although the *grogue* itself has probably proved to be equally stimulating! The hoteliers on the islands must have been surprised at our morning orders for



3 (top). Ribeira São Martinho Grande looking south, one of Chevalier's syntype localities for *Phoenix atlantica*, Santiago. A very similar photograph, taken by Chevalier in 1935 (looking north), indicates that little has changed since then in terms of landscape and vegetation (see Fig. 5). 4 (bottom). *Phoenix* in Ribeira São Martinho Grande, Santiago. This clustering male specimen had at least seven mature stems, which reached ca. 9 m.



5 (above). Chevalier's photograph of Ribeira São Martinho Grande in 1935 (1935b, pl. IX b) (looking north) The palms in this photo are still living and can be seen in Figs. 3 and 4. 6 (below, left). Moribund *Phoenix* plants growing next to the planted *Prosopis juliflora*, Sal Rei, Boavista. 7 (below, right). *Borassus aethiopum*, planted in front of *Phoenix* in a smallholding at Forte Vicente, Boavista. The fence is constructed from *Phoenix* leaves.



local *grogue* from the bar, but in fact we had found an alternative use for it – for preserving *Phoenix* flowers.

All our herbarium material was prepared using the Schweinfurth method, which involves pressing the specimens between newspaper before drenching them in 70% alcohol and sealing them in robust plastic bags. At the end of our fieldwork on Santiago, and indeed on the other islands, the bundles were packed in boxes and posted back to the UK. Palm specimens can take a long time to dry out, even using proper herbarium drying facilities, and if the material is not processed properly, the fruit, flowers and leaves will rot. Where drying facilities are not available, preservation in alcohol maintains the quality of the plant material until further processing can take place back in the herbarium. The processed collections have now been deposited in the herbaria at INIDA, The Natural History Museum, London and the Royal Botanic Gardens, Kew.

### Maio

Our flight from Santiago to Maio lasted ten minutes, hardly worth the one and a half hour check-in time! We were met and given a warm welcome by Augusto Alves from the local office of the Ministério de Agricultura e Peixes (Ministry of Agriculture and Fisheries). Augusto drove us into Vila do Maio, the sleepy main town, flanked by a stunning beach of the whitest sand and the most turquoise of seas. Here, young boys played among the brightly painted fishing boats, crowding round to help the fishermen as they came onto shore with their catch. On the street above the beach sat two or three traders with trays of sweets or selling dark lumps of fresh tuna. Women came and went from the town's well, a place of great socialising, balancing buckets of water on their heads.

So we embarked on a tour of the island in the Ministry's 4WD vehicle. The flatter parts of the island's interior have been completely afforested with *Prosopis juliflora*, creating the biggest *Prosopis* plantation in the Cape Verde Islands. Plagues of locusts of near-biblical proportions occur in the plantation, although, according to Augusto, the infestation is not problematic. The new woodland is immensely important, although the success of the afforestation programme comes at a cost as *Prosopis* is notoriously water-greedy. The plantation was developed primarily to provide fodder to livestock in the highly degraded landscape. In addition, the timber from *Prosopis* is made into charcoal by the locals for use in cooking and is also sold to other islands.

On the dunes at Morrinho, we spotted our first example of date palms on Maio. Here, a handful of *Phoenix* grow in the blistering white sand dunes, impressive in their stature and isolation, accompanied by an occasional *Tamarix* bush and creeping *Cyperus maritimus*. The dunes are bordered on one side by Praia de Santana, a stunning, but desolate beach, and on the other by the salinãs (salt pans) of Terras Salgadas. The salt pan at Morrinho is one of the few relatively undisturbed ecosystems left on the Cape Verdes and is therefore under protection. The vegetation consists of an expanse of salt-tolerant plants such as *Arthrocnemum glaucum* (Chenopodiaceae), *Zygophyllum fontanesii*, the Cape Verde endemic *Asparagus squarrosus* (dead but recognisable) and the leafless, spiny *Launaea melanostigma*, resembling chicken-wire. Birds abound in the salt pan and on the adjacent savanna-like plains; zebra finches chirp en masse in *Prosopis* scrub and guinea-fowl scuttle around in great flocks.

At the village of Pedro Vaz, to the east of the island, we came across a large and ancient grove of *Phoenix*. The palms were majestic, despite some being so old they had lost their crowns. There was no sign of any *Phoenix* seedlings or juveniles here, an indication that the population is not regenerating, hardly surprising as the pressure from goat grazing is intense. One of the most striking palms at this site possessed around 15 stems and reached around 30 m in height, suggesting that it might be very old indeed. After making some collections, we drove through the village of Alcatraz towards Monte Penoso, a mountain, which, at 436 m, dominates the otherwise flat landscape. Monte Penoso is an eroded volcano that is green in the rainy season, hard to believe when the landscape appeared so infinitely barren at the time of our visit.

At Lagoa, to the south of the island, we clambered down the sides of the cultivated and relatively lush ribeira to sample a number of clustering *Phoenix*. Scattered everywhere were rocks encrusted with Gastropod fossils, evidence that Maio, while primarily volcanic, also has sedimentary uplifts. Our search for *Phoenix* continued along the coast by Praia da Lagoa, where we were presented with yet more stretches of sparkling seas and shimmering sands. This walk was not to be blessed with *Phoenix* discoveries, but we did make some other, serendipitous finds; a mass of bifurcating, hollow, stony tubes poking out of the dunes – later identified as fossil carbonate casts of tree roots – and remnants of a hammerhead shark, sea turtles and whales strewn around the high tide mark.

### Boavista

We were greeted at the airport by an array of staff from the local Agricultural Ministry, two of whom, Sonia Ramos Barros and Mario Spencer, accompanied us on our fieldwork. Boavista is composed largely of immense dunes stretching endlessly along the coast and inland. As our Twin-Otter came in to land, we were treated with an astonishing early morning view of the epic white sand dunes at Praia de Chave. Most striking of all though was the glimpse of vast numbers of date palms extending throughout great inland dunes beyond Chave. Around Sal Rei, thousands of *Phoenix* form what appears to be a dynamic population of even age structure, with adults, juveniles and even seedlings popping up spontaneously. We realised that we had our work cut out here – a daunting prospect! In some areas, we noticed many moribund *Phoenix* plants growing near to *Prosopis* (Fig. 6), presumably because the latter competes more effectively for water.

Mario drove us south to the pretty village of Rabil where we collected yet more *Phoenix* from what appeared to be a plantation, and then off-road into the Sahara-like interior of the island (Fig. 8). The *Phoenix* “populations” in the desert oases have also been actively managed, sometimes growing with planted coconuts or tamarind trees. They also appear more static than those around Sal Rei and, as on the other islands, are composed of mature individuals only. We visited a small farm adjacent to a *Phoenix* grove where a deep well provided enough water for vegetables to be grown. On the edge of the smallholding, a few magnificent specimens of *Borassus aethiopum* (Fig. 7) were found. The farmer could tell us nothing of the origins of these undoubtedly ancient palms.

The monotony of the barren landscape was broken at intervals by hidden treasures – a remote beach near Praia Santa Monica covered in crab-prints and bordered by yet more *Phoenix*, the abandoned village of Curral Velho, where bread ovens sat ruined and old cooking pots and limpet shells lay scattered about the long-forgotten houses, the cracked salt crust of the salinãs at Curral Velho with date palms towering on high coastal dunes behind and frigate birds at Praia do Curral Velho (the only known breeding site on the eastern Atlantic being the tiny islet found off this beach). Beyond this, the rocky moonscape continued unabated, with blinding sun and sand-blast.

### Sal

Sal is drab from the air and doesn't improve much on the ground. It has all the desolation, but few

of the charms of the other islands. The land is entirely uncultivated; even the goats are few in number. It is the oldest, most eroded and most barren of all the islands. William Dampier, in 1683, arriving on the isle of Sal from Virginia wrote:

“the land is very barren, producing no Tree that I could see, but some small shrubby Bushes by the Seaside. Nor could I discern any Grass, yet there are some poor Goats on it....There are no more than 5 or 6 Men on this Island of Sall [sic], and a poor Governor...who came aboard our Boat, and gave about 3 or 4 Goats for a Present to our Captain, telling him that they were the best that the Island afforded.”

William Dampier (1698)

Today, Sal's main source of income is from tourism, centred on the small town of Santa Maria. The seeds of tourism were sown in the 1960s when the first small guest house was built in Santa Maria by the six mile beach. Today, Santa Maria is a depressing contrast to the other places in which we had stayed, the streets lined with restaurants and shops pandering to European tastes, but the essence of Cape Verde culture still remains. Stray only a few metres from the tourist route at night, to the backstreets of Santa Maria, and the place becomes alive with countless hairdressers, tucked-away bars and grocers, and local people thronging the streets.

Sal may not be the most attractive of the islands visited, but it is critical in terms of *Phoenix*; two of Chevalier's *P. atlantica* syntype localities are found here. The palms are neither as numerous as in Boavista nor as majestic as in Maio. At the first syntype locality, Algodeiro, we collected in the small, dense grove (Fig. 1) adjacent to a beach with a remarkable salt-and-pepper blend of white shell sand and black volcanic dust. The second syntype locality, Palmeira, allegedly named for its abundance of palms, merely boasted a single stand in the middle of a run-down suburb of the town.

One of Chevalier's specimens from Sal (26 June 1934, *Chevalier s.n.*, P!) is annotated with the locality “Pedro Lime” – the most similar place-name today is Pedra de Lume, found about halfway up the eastern coastline. An exploration of the area for *Phoenix* proved fruitless, indeed we could see nowhere that even appeared to offer suitable habitat, but the trip was fascinating for other reasons. High above the village of Pedra de Lume is a salt lake inside the mouth of a long-extinct volcano from which salt has been extracted for many centuries. The architecture of the village serves as a reminder that this sleepy settlement was once a hive of industry; the terraced houses are



8. A clustering adult *Phoenix* growing in the interior of Boavista. Other individuals established in the dry stream-beds, can be seen in the background. *Tamarix canariensis* grows the foreground.

more reminiscent of 19<sup>th</sup> century industrial Britain than of anything we had seen so far on the other islands. The salinās themselves are set within the adjacent crater, reached by a tunnel carved through the crater wall. The tunnel is found by following the cables and wooden pylons of the old tramway that was used at the peak of the production to transport salt from the crater to the port at the village. Today, one passes through the mountain to the salinās to find a surprisingly silent and beautiful place, with regularly-spaced rectangular ponds of pink, blue and white. The rusting machinery and rotting buildings remain, the pulleys and tram-carts still visible, as if the whole industry was stopped short and abandoned suddenly before the end of a day's work.

Here in the salinās we saw seven black-winged stilts, elegant, but absurd-looking birds which appear to have the body of a gull and the legs of a flamingo, and look altogether out of proportion. The redundant saltpans of Pedra de Lume are of great environmental importance as Sal is the only island in the Cape Verdes where these birds breed. Flamingos were also once prevalent here; Dampier wrote about flamingos on Sal's salinās in 1698, saying "Their tongues are large, having a large Knob of Fat at the Root, which is an excellent Bit, a Dish of Flamingos' Tongues being fit for a Prince's Table." The bird of which he writes is the Rosy Flamingo which is now extinct on the islands; their demise was probably encouraged by Dampier's party shooting 14 of them in one go.

We explored the eastern coast of Sal by 4WD from Pedra de Lume, returning to the main road near Santa Maria. Finding yet more startlingly white sand dunes and wind-blasted beaches, we failed completely to locate any more *Phoenix* populations. A quest for another of Chevalier's sites on Sal, "Palha Verde," (Chevalier 45840, 1934, P!) also proved difficult, as it was not evident on any of the maps. After consulting a man selling salt crystals at Pedra de Lume we drove to Fontona, an old settlement in a dry ribeira just north of Palmeira, where we did indeed find a grove of around 200 *Phoenix* interspersed with a few coconut palms and *Terminalia catappa*. Again, nearly all the *Phoenix* palms were clustering adults. Towards the centre of the island, we identified a "new" locality for *Phoenix* (Fig. 9), where around seven individuals grew in a dry ribeira. At Fenjaol, we relocated another grove of around 150 *Phoenix* in a ribeira of blown sand and one of only two sites where naturally-established seedlings were observed. Perhaps the blown sand that covers the seed here and in the population at Sal Rei on Boavista encourages germination by protecting the seed from dessication?

### Discussion and Conclusions

We observed some very striking populations of *Phoenix* in the Cape Verde Islands, but through the course of the field trip we began to appreciate how little the palms differed, if at all, from *P. dactylifera*. What is intriguing about Chevalier's

observations is that he was able to distinguish between *Phoenix atlantica* and *P. dactylifera* in the field. Furthermore, of the islands we visited, he recorded *P. dactylifera* from Santiago alone, from a palm grove near Praia (Chevalier 1935a, b), suggesting that all other palms that we saw would have been *P. atlantica* in Chevalier's eyes. Not only this, in addition to "pure" *P. dactylifera* and *P. atlantica*, he was able to identify hybrids of the two near Praia in Santiago (Chevalier 1935a, b). There is no indication as to how he determined these; certainly he made specimens neither of the putative hybrids nor of *P. dactylifera*. We were unable to distinguish the two species, let alone a hybrid.

Throughout the trip, we considered the distinguishing features specified by Chevalier and subsequent authors discussed above. Nearly all the date palms that we saw were multiple-stemmed, but this is a weak character, given that *P. dactylifera* is inclined to cluster if unmanaged. None of the *Phoenix* sampled bore fruit and therefore it was impossible to evaluate fruit characters, though anecdotal evidence suggests that Cape Verde *Phoenix* fruit is small, pink (to red) and often inedible. However, as *P. dactylifera* cultivars display a vast range of fruit in terms of colour, size, sweetness and shape (see for example Rhouma 1994), the distinction in fruit size outlined by Brochmann et al. (1997) is probably too simplistic.

Any difference in leaf colour is also observed with difficulty; it even seems to vary within the same individual (the wax coating on leaves may vary with age). However, the new collections will make possible a more thorough investigation of the comparative leaf and floral morphologies in the herbarium.

Whilst all species of *Phoenix* intercross freely (Wrigley 1995), the suggestion that Cape Verde *Phoenix* may be a hybrid between *P. dactylifera* and *P. canariensis* (Barrow 1998) now seems unlikely. Chevalier (1935b) noted that *Phoenix canariensis* was occasionally planted on Cape Verde and recorded it from the island of Sao Vicente, to the west of the islands we visited. Despite our best efforts we failed to find this species on Maio, Boavista, Sal or Santiago; perhaps it is cultivated on some of the wetter islands to the west.

Until the taxonomy is resolved, the conservation status of this palm cannot be assessed; for this very reason, *Phoenix atlantica* was omitted from the most recent Cape Verde Red List (Leyens & Lobin 1996). This study is further complicated by the claim that the species has been said to exist further afield. Chevalier (1952) and Kunkel and Kunkel (1974) reported it from the Canaries and Madeira (but see also Morici 1998) and Chevalier (1952) described it from Senegal and Morocco (see also Munier 1973: 20). In the same paper, Chevalier also described *P. atlantica* var. *maroccana* A. Chev.

9. A number of clustering *Phoenix* specimens growing in a dry ribeira next to an abandoned settlement north of Murdeira, Sal. Most *Phoenix* populations in the Cape Verdes are found in close proximity to settlements; did the settlements grow up around the naturally occurring palms, or were the palms planted by the villagers?



which Barrow (1998) placed in synonymy with *P. dactylifera*. These records are not particularly important in solving the taxonomic conundrum of *Phoenix* in Cape Verde, but they do suggest that a detailed, broad-scale assessment of the morphological and genetic variation in *P. dactylifera* and its relatives across their range is long overdue.

The need for a clarification of the taxonomy and conservation status of *Phoenix atlantica* is obvious. Potentially, it is one of only two endemic tree species in the Cape Verde Islands and one of only four palm species native to Europe and Macaronesia. However, whether or not the Cape Verde *Phoenix* proves to be distinct from the date palm *P. dactylifera*, our observations suggest that it is of prime importance to the people of the islands in terms of providing shade, food for livestock and materials for building shelters. It also provides welcome relief for the eyes in an otherwise highly degraded and seemingly endless, barren landscape.

#### Acknowledgments

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## Onaney Muñiz 1937–2002

On June 7, 2002, Onaney Muñiz-Gutiérrez, passed away of a heart attack in Havana, Cuba. Muñiz was born in the city of Bayamo, the former province of Oriente, Cuba on August 17, 1937. He received his BSc degree from Havana University in 1968.

Onaney Muñiz was director of Havana's Botanical Garden from 1959 to 1967 and the first director of the Institute of Botany of the Cuban Academy of Sciences from 1967 to 1980. From 1981 to his retirement in 1999, he moved to the Institute of Tropical Geography in Havana, where he was senior researcher.

Muñiz was a fine, respected and devoted scientist who made an important contributions to phytogeography, taxonomy and ecology of Cuba and the greater Caribbean region as well. In particular, he established a high profile within the botanical community with the description of nearly 150 new species – including new palms – often with co-author A. Borhidi of Hungary. He will be best remembered by IPS members for *Coccothrinax munizii*, named in his honor by Borhidi.

Having an incredibly versatile personality, Muñiz was also committed to preserve and protect the remains of Cuba's many landscapes. He studied the endemism of the Cuban flora and proposed schemes of species' migration routes through the Caribbean. He worked diligently on a theoretical reconstruction of Cuba's original 16<sup>th</sup> century vegetation. He introduced the commercial-scale mushroom cultivation in caves.

His colleagues witnessed his incredible devotion to botanical research, his meticulous mapping methods, and his commitment to reach the most inaccessible places in search of clues to understand the extraordinary endemism of Cuban flora. Onaney Muñiz felt a singular urgency for passing his knowledge on to others and for developing a genuine appreciation of nature in his country.

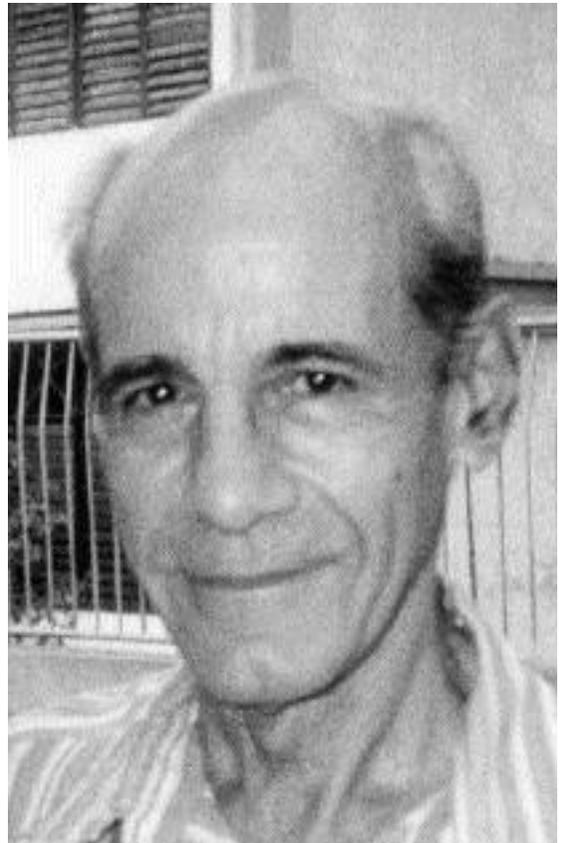
In his final days, Onaney Muñiz was enthusiastically working on establishing Havana's Metropolitan Park, an effort done, he said, to save the last relics of a rainforest within the city limits. He was also digging in the alluvial plain of Almendares River to find evidence of the Quaternary environment. He was organizing an

expedition to collect in the southern slope of the Turquino Peak (the highest in Cuba), a place he thought might yield some new species.

Although his health was not good in his retirement years, he remained committed to an active research agenda and he maintained a high profile within the geographical and botanical communities in his homeland. He died a few hours after reading his latest paper on landscaping and conservation of the royal palm in Havana to a group of planners and developers of the Cuban capital.

Onaney Muñiz was a productive colleague, a warm and generous friend, a strong force in scientific research and, above all, an ethical scientist. He is survived by his wife, Elsa.

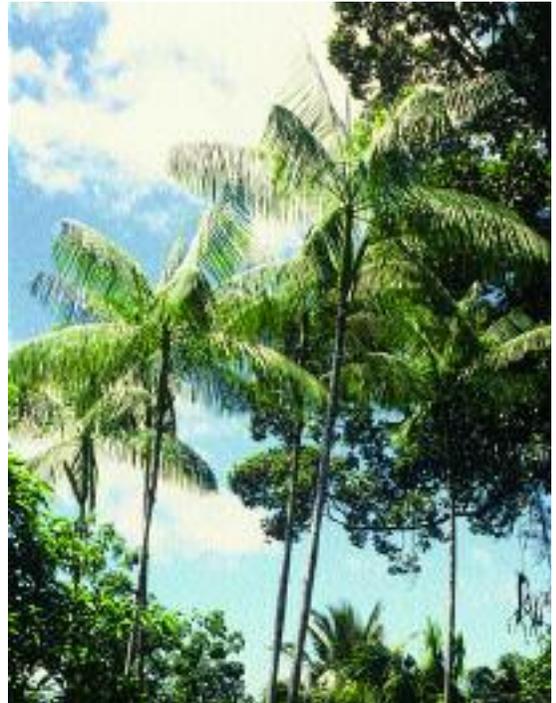
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# The Functions of Hooked Fibers on *Euterpe* Endocarps

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1. *Euterpe oleracea*  
cultivated in Thailand,  
(Photo: S. Zona)

In this paper, the endocarps of *Euterpe oleracea* are shown to be covered with hooked fibers. The author speculates that these hooks have multiple functions, including dispersal and protection.

A peculiar trait of palm fruits is a layer of vascular or non-vascular fibers that remains attached to the endocarp after the pericarp has been eaten or worn off (Essig & Young 1979, Uhl & Dransfield 1987, Tomlinson 1990, Dransfield 1992). These

fibers remain attached to the endocarp and included seed even after its passage through avian or mammalian guts (Moegenburg pers. obs.). After mesocarp removal, the free ends of the fibers often loosen from the seed, giving it a fuzzy or hairy

appearance (Fig. 1; Dransfield 1992). While the cellular structure of these fibers has been well-studied, little is known of their function or adaptive significance (Tomlinson 1990, Dransfield 1992).

A number of authors have suggested possible functions of these fibers. Several posit the fibers serve a protective function for the seed and germinating embryo (Essig & Young 1979, Uhl & Dransfield 1987). Others hypothesize that fibers aid in dispersal, particularly water dispersal (Uhl & Dransfield 1987), a function ascribed to hairiness or pubescence of seeds of other hydrochorous plant species (Van der Pijl 1982, Murray 1986, Roth 1987, Kubitzki & Ziburski 1994, Waldhoff et al. 1996, Williamson et al. 1999). Dransfield (1992) suggested that the hooked fibers attached to the endocarps of *Pinanga rivularis*, a rheophytic palm of Borneo, may aid in dispersal by allowing the fruits to function as burrs that cling to the fur of passing vertebrates. A more general function of hairs or fibers attached to seeds may be as anchors on the substrate, allowing seeds to adhere to substrates on the soil and preventing their washing-away into unfavorable sites by water or wind (Esau 1977, Van der Pijl 1982, Dransfield 1992). Finally, Willson (1983) suggested that hairs or pubescence protect seeds from insect predators, which can be a major source of seed mortality (Janzen 1971). To date, there has been no systematic evaluation of these various hypotheses.

Among the palm species with fiber-covered seeds is the well-known and economically important *Euterpe oleracea*, which produces a "hard albuminous seed, with a rather fibrous exterior" (Wallace 1853). According to Uhl and Dransfield (1987), "thin flat fibers" form the inner layer of the otherwise thin mesocarp, which is used by inhabitants of the Amazon River estuary to make a popular, nutritious beverage called "*vinho do açai*" (Bates 1864, Anderson 1988, Strudwick & Sobel 1988). *Euterpe oleracea* is hydrophilic, growing extensively along river margins and in floodplain forests known as "*varzea*" or "*igapó*" (Henderson 1995). However, unlike many other floodplain species (Van der Pijl 1982, Murray 1986, Roth 1987), *E. oleracea* produces non-buoyant fruits and seeds (Roosmalen 1985). The small size of *E. oleracea* fruits (ca. 1 cm diameter) makes them available for consumption by a wide variety of birds and mammals, which may deposit seeds in suitable establishment sites (Moegenburg 2000). The seeds are also consumed by a seed-feeding beetle, *Pachymerus sveni* (Bruchidae), which in some habitats destroys the majority of seeds (Moegenburg 2000).



1. *Euterpe oleracea* endocarps with enclosed seeds with fibers removed (left) and fibers loosened but still attached to the endocarp (right).

I tested the following four non-exclusionary hypotheses about the adaptive function of *E. oleracea* fibers as a way to infer the selective factors maintaining the fibers in populations:

- 1) Fibers allow seeds in water to sink more slowly, which may increase the distance to which they disperse.
- 2) Fibers anchor dispersed seeds, preventing further dispersal by water.
- 3) Fibers protect germinating seeds and growing radicles.
- 4) Fibers protect dispersed seeds from insect predators.

#### Materials and methods

The four hypotheses were tested during June–August of 1997 and 1998 at the Ferreira Penna Scientific Station (1°42'30" S, 51°31'45" W, Lisboa 1997) in Caxiuana National Forest (hypotheses 1 and 4) and at a site near the mouth of the Tocantins River (1°45'56" S, 48°57'41" W, hypotheses 2 and 3), Para State, Brazil.

Seeds within their endocarps used in experiments had been discarded after *E. oleracea* *vinho* preparation, which involves soaking fruits in warm water to soften pulp, before kneading them in a woven fiber sieve (Strudwick & Sobel 1988). Any pulp not separated by this process was removed from the endocarps, which were then rinsed in water and dried. Fibers were manually pulled off from half of the seeds for the "without fibers" treatments, whereas the seeds for the "with fibers" treatments were not further manipulated.

**Experiment 1:**

I used a visual test to determine if seeds with fibers sank more slowly than those without fibers. Twenty seeds of each type were dropped, one at a time, from a height of ca. 1 m above water level into a calm, ca. 4 m deep section of blackwater river. The number of seconds that each seed was visible after submersion was measured with a stopwatch.

**Experiment 2:**

To test if fibers anchor dispersed seeds, I placed 100 seeds "with fibers" and 100 "without fibers" in pairs along a 250 m transect. Seeds were first marked with a small spot of red enamel to aid in re-location. One seed of each type was placed at 5 m intervals along the transect, and the location of each pair was marked with a 3 cm high colored straw inserted into the soil. After one month the sites were re-visited and seed distances from the straws were recorded. Only pairs in which both seeds were relocated were used in analyses.

**Experiment 3:**

Seeds from experiment 2 were also used to test hypothesis 3 – that fibers aid in germination. Relocated seeds were checked for germination and the presence of a living root.

**Experiment 4:**

To test if fibers help protect seeds from post-dispersal insect predators, a population of ca. 20 seed-feeding *P. sveni* beetles was first established. Fifty-one trials were run, in which three seeds of each type were placed in the container housing the beetles at approx. 1800 hrs. Beetles had access to seeds for ca. 12 hrs, after which the seeds were removed, placed in petri dishes, and left undisturbed. After three months, which slightly exceeds the development time of *P. sveni*, the seeds were checked for beetle emergence.

**Results**

Seeds with fibers were more buoyant than those without fibers, sinking 42.4% more slowly into the water column (Table 1;  $z = -5.37$ ,  $p < 0.0001$ ). Seeds with fibers were visible for a mean of 11.16 s, while those without fibers were visible for a mean of 6.43 s.

I relocated 102 dispersed seeds after one month. Seeds with fibers were dispersed by water less frequently than were those without fibers. In addition, the seeds with fibers that did disperse moved a shorter distance than did those without fibers. Eighty-two percent of seeds without fibers were moved by water during the one month period, whereas only 57% of those with fibers moved ( $\chi^2 = 13.55$ ,  $p < 0.0002$ ). Of the seeds that were moved by water, those without fibers moved 31% farther than those with fibers (Table 1;  $z = -3.28$ ,  $p < 0.001$ ).

Of the 102 relocated seeds, only six (three with fibers, three without fibers) had not germinated. Most seeds (94%) had germinated and died. More seeds with fibers (7.8%) had living roots after one month than did seeds without fibers (0%; Table 1;  $\chi^2 = 4.71$ ,  $p < 0.03$ ).

The number of beetles that emerged did not differ between seed types (Table 1;  $z = 0.607$ ,  $p > 0.54$ ). An average of 0.575 beetles emerged from seeds with fibers, whereas an average of 0.529 beetles emerged from seeds without fibers.

**Discussion**

Experimental results supported three of the four hypotheses, suggesting that the fibers covering *E. oleracea* seeds serve multiple functions. In these experiments, fibers made seeds more buoyant in the water column, helped anchor dispersed seeds on the ground, and protected young roots. On the other hand, fibers did not protect dispersed seeds from insect predators.

**Table 1. Results of experimental tests comparing buoyancy, dispersal by water, germination success, and predation by bruchid beetles in *E. oleracea* seeds with and without fibers.**

Comparison	With fibers mean $\pm$ s.e.	Without fibers mean $\pm$ s.e.	Statistical results
Buoyancy (seconds)	11.16 $\pm$ 0.27	6.43 $\pm$ 0.23	***
Dispersal distance (cm)	604 $\pm$ 91.27	1262 $\pm$ 96.56	**
Percent with root	7.8	0	*
No. beetles/3 seeds	1.73 $\pm$ 0.16	1.59 $\pm$ 0.13	NS

\*  $p < 0.05$

\*\*  $p < 0.005$

\*\*\*  $p < 0.0005$

Buoyancy in fruits and seeds of floodplain species is considered an important means of dispersal to suitable establishment sites, particularly sites above the zone of permanent inundation (Kubitzki & Ziburski 1994). Various mechanisms impart buoyancy to floodplain species, including hairs (e.g., *Pseudobombax munguba*), internal air pockets (e.g., *Hevea spruceana*, *Swartzia polyphylla*), and fibrous arils (e.g., *Laetia suaveolens*; Murray 1986, Roth 1987, Waldhoff et al. 1996, Williamson et al. 1999). In palms, however, only fibers are thought to promote water dispersal of seeds, particularly in the cocoid species (Tomlinson 1990, Dransfield 1992). Although *E. oleracea* seeds do not float, fibers do allow seeds to sink more slowly through the water column. This may aid dispersal if water currents carry seeds away from the point at which they entered the water. The slower sinking of *E. oleracea* seeds with fibers may result from fibers increasing drag in the water, or from fibers trapping air bubbles as seeds enter the water.

*Euterpe oleracea* fruits, like those of many palms, contain an oily, nutritious pericarp (Uhl & Dransfield 1987), suggesting adaptation to vertebrate dispersal (Van der Pijl 1982, Murray 1986). The small size of *E. oleracea* fruits (ca. 1 cm diameter) makes them available for consumption by a wide variety of birds and mammals, which may deposit seeds in suitable establishment sites (Moegenburg 2000). In this case, it may be beneficial to have a mechanism to avoid being further dispersed by the floodwaters typical in *E. oleracea* habitat. Indeed, in this study fibers anchored seeds in their original dispersal sites, preventing further dispersal by water. Of the seeds that did move by water, those with fibers moved shorter distances. Fibers may allow seed to "hook" on to substrates on the soil, such as leaf litter, other debris, or *E. oleracea* pneumatic roots (Henderson 1995). A similar mechanism was suggested by Dransfield (1992) for *Pinanga rivularis*, which produces hooked fibers that may become caught on obstacles as seeds are swept along by river currents; such obstacles may leave seeds in suitable establishment sites.

*Euterpe oleracea* seeds with access to water germinate after ca. 6 days (Moegenburg unpubl. data, Waldhoff et al. 1996). Germination begins when seeds imbibe water, after which the radicle begins growth (Fenner 1985). A major threat to seeds at this stage is desiccation (Uhl and Dransfield 1987). My third hypothesis was, therefore, that fibers aid in germination, protecting germinating seeds and growing radicles by trapping moisture. This hypothesis was supported, as only seeds with fibers had growing

roots after 30 days exposure. None of the seeds without fibers had growing roots; most had germinated and died. Desiccation during germination and early establishment is a threat not only to regenerating palms (Uhl and Dransfield 1987), but also to the seeds of many species (Fenner 1985) and may explain the frequency of seed hairiness or pubescence (Willson 1983, Roth 1987).

Another major threat to seeds in the pre-germination phase is predation. Palm seeds generally have two kinds of post-dispersal predators: vertebrates such as caviomorph rodents and insects, especially beetles in the family Bruchidae (Janzen 1971, Johnson et al. 1995). Up to 70% of *E. oleracea* seeds can be lost to *Pachymerus sveni* (Moegenburg, unpublished data). Although hairs and fibers in other species have been suggested to protect seeds from insect predators (Willson 1983), particularly in the development phase (Essig & Young 1979), fibers on *E. oleracea* seeds did not appear to serve this function. I predicted that fibers may simply make it more difficult for beetle larvae to enter seeds, or may actually dislodge beetle eggs and larvae when they loosen from the seed. Unlike the other three hypotheses in this study, this one was not tested *in situ* but rather in the lab, which may have affected the outcome. Alternatively, larval beetles may enter seeds through the basal area that is attached to the perianth, which is not covered by fibers (F. Essig, pers. comm.); this could explain the lack of difference between seeds with and without fibers.

In conclusion, the fibers covering *E. oleracea* seeds appear to serve multiple functions. Another hypothesized function, which was not tested, is that fibers aid in pericarp removal, without which *E. oleracea* seeds fail to germinate (Moegenburg, unpubl. data). Additional functions of fibers in this and other palm species may also exist, such as protecting seeds from insect predators during seed development. Whether multiple functions served as factors selecting for the development of fibers on palm seeds, and continue to serve as selective factors maintaining fibers in populations, also is not known. Alternatively, one function may have been the selective factor, with the others existing as exaptations. Fibers covering palm seeds, as a distinctive and interesting feature of many palm species, are deserving of further study.

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# 2002 Biennial and Post Tour

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1. *Jubaea chilensis* at Parc Olbuis Riquier. (Photo: S. Zona)

**From the French Riviera to Spain and Italy, this biennial and post tour featured the many different palms in cultivation in southern European gardens and nurseries and, of course, *Chamaerops humilis* in the wild.**

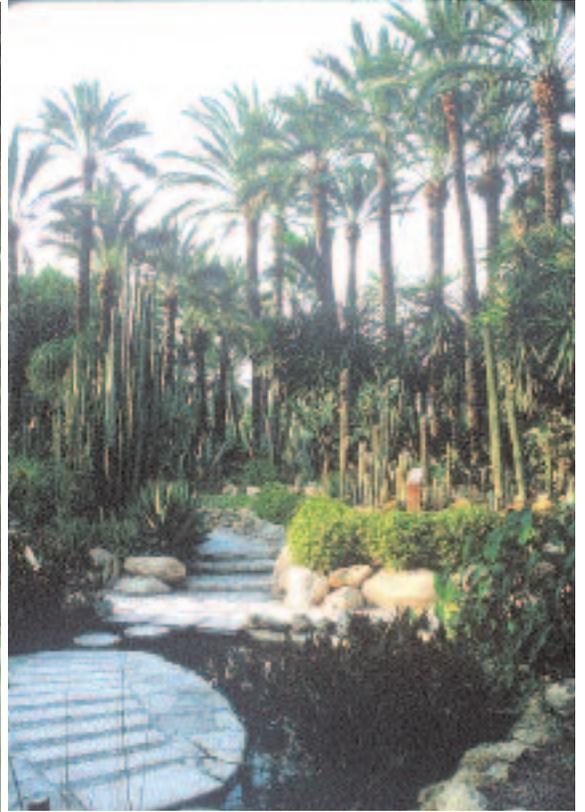
Our hosts for the biennial meeting, the Association Fous de Palmiers, planned an exciting itinerary with lectures from a diverse slate of palm experts. The meeting was based in Hyères les Palmiers, a city renowned for its gardens and parks, and included a visit to Parc Olbuis Riquier. The botanical garden, a former plant introduction site, has a palm collection that includes venerable specimens of *Jubaea chilensis* (Fig. 1) and

*Washingtonia filifera* (Back Cover).

Our group enjoyed seeing familiar palms used in spectacular ways in private and public gardens. The Villa Thuret featured fantastic specimens of *Chamaerops humilis*, which, judging from their large size, must be of great age (Fig. 2). Those people not attending the post tour visited Villa Menton, a stone's throw from the Mediterranean



2 (top). IPS members enjoy the shade of an ancient *Chamaerops*, Villa Thouret, France. 3 (bottom). The group prepares to explore the garden at Villa Menton, France (Photo: S. Zona).



4 (top left). *Rhopalostylis sapida* in a sheltered spot at Jardin du Rayol-Canodel, France. 5 (top right). *Phoenix dactylifera*, in the garden Huerto del Cura in Elche, Spain. 6 (lower left) *Trithrinax campestris* at Huerto del Cura, Elche, Spain. 7 (lower right) IPS members climb a hill to see wild *Chamaerops* in Cartegena, Spain.

Sea. The garden blends collections of palms, conifers and subtropical exotic plants in an charming naturalist way (Fig. 3).

At Jardin du Rayol-Canodel, a garden dedicated to plants of Mediterranean climates worldwide, the group caught glimpses of beautiful *Rhopalostylis sapida* (Fig. 4) growing in a wet, sheltered depression. We also marveled at an ancient cork oak, Australian banksias, and pines overarching a rugged Mediterranean coastline. The group also visited two large palm nurseries and were pleased to see the commercial response to the growing interest in palms in southern France.

Attendees of the post tour went on to Elche, Spain and the Huerto del Cura, a garden in the midst of

Elche's date palm grove intended for contemplation of both plants and works of art (Fig. 5). The palm collection includes *Trithrinax campestris* (Fig. 6) and other species that are well suited to the dry climate of this region. The group hiked to wild *Chamaerops humilis* in the foothills of Parque Regional de Calbanque in Cartagena, Spain (Fig. 7). After Spain, the group continued to Corsica and Sicily, where we toured private and public gardens, and then on to Rome and Naples. The Orto Botanico of Naples was a particularly fascinating garden, as it grows a large number of interesting palms, alongside conifers, cycads and succulents.

While in France, the group visited a botanical garden in the making, the new Jardin du Palmier



IPS President Horace Hobbs plants a *Sabal bermudana* to commemorate the IPS visit to the new Jardin du Palmier, France.

(Garden of the Palm Tree) in development on Porquerolles Island. Horace Hobbs, IPS President gamely undertook the planting of a *Sabal bermudana* to commemorate the IPS visit (Fig. 8). We look forward to watching the developments in this brand new palm collection and to visiting that 2003 Biennial *Sabal* again someday soon.

## PALM LITERATURE

**PALMERAS.** By Jose Antonio del Cañizo. Spanish text. Ediciones Mundiprensa, Madrid. 2002. ISBN: 84-7114-989-3. 68 Euros, hard-bound. 709 pp., 650 pictures and 80 drawings.

There are very few books on palms in Spanish and most of them are small and on specific subjects, and some of them are translated from English. Here, for the first time, is a high quality, hefty, general book on palms produced in Spanish. This new book is not only a great synopsis of the world of palms, valid at the international level, but is also a window into Spain, a palm-growing country of warm Europe, which is surprising the world with its palm potential. There are also many pictures and references about Latin American botanical gardens.

The author is one of the personalities of the Spanish palm world and has fostered the growing interest in palms in his country. He is the director of the botanical gardens Parque de La Concepción, in Malaga, in the warmest part of Spain, and in 2002 was elected to the Board of Directors of the IPS.

His sense of humor is sprinkled all over the pages of this new book, making reading more enjoyable yet still technically useful. To cite an example, his unique page of palm "records" reports, besides the usual records such as the largest seed or the smallest leaf, the record of climbing coconut trees bare-footed, and the record of a man remaining longer than anybody else at the top of a palm.

Pictures are abundant and well-used. Not always spectacular, they still describe well the right palm in the right place, with many photographs taken in natural habitats as well as adult, healthy specimens in great gardens. In many cases, the place where the picture is taken is specified. Besides pictures of living palms and some line drawings, there are also pictures of old paintings, coins and even color covers of the journal PALMS.

The book is thankfully up to date, as is shown by the many references in the text to recent issues of our journal, PALMS. Even the recent palm phylogeny obtained by Lewis, Baker and Asmussen from DNA and its resulting new systematic order are reported. All the scientific names are correctly spelled and written with their authors. The description of each genus always contains a summary of its taxonomic position within the family

The first part of the book (160 pages) gives a broad general view of palms, their uses, landscaping, history, cultivation, morphology and systematics, diseases, pruning, transplanting and other aspects.

The main part of the book consists of species accounts. The 300 species treated are neatly divided in three sections: palms with palmate leaves, palms with pinnate leaves and crownshafts and palms with pinnate leaves without crownshafts. Within each section, genera are arranged alphabetically. There are abundant illustrations.

Each species account usually consists of a list of synonyms and vernacular names followed by various paragraphs on origin, ecology and general aspect. There is a basic and clear paragraph on "Habitat and use in gardens." It may mention a list of places in the world where one can find mature groups or avenues of large size and often gives data about their history and age – this is particularly large in the account of *Jubaea chilensis*. The last paragraph of each species account is a very welcome one. "Morphological Details," printed in smaller font, is the most technical part, which the interested reader will use when the book is used for identifying species. Additional paragraphs are provided in some species accounts, such as is the case of Palm Honey in the large account of *Phoenix canariensis*. The paragraph "Habitat and use in gardens" is maybe too basic. Now we know climatological data for the habitats of many palms. Reading data about rainfall, temperature and soils in habitat would have been a delight for the palm scientist and a powerful hint for the palm grower who would have been able to "learn from the habitat."

The last part of the book is a series of lists "to choose palms," for their resistance to shade, cold, drought, salt and other factors. There is also a glossary, an analytical index, some lists of "useful palm addresses" and a 9-page list of palm bibliography used, which – I have to say – is not always well referenced within text of the book.

I have to advise the readers that not all the 300 species are equally treated. About a third of them have very sparse information. Some species are simply mentioned and only five or six lines are written about *Caryota ochlandra*, *Archontophoenix maxima*, *Pseudophoenix lediniana* and *Calyptronoma plumeriana*. Thankfully some of them are illustrated by pictures. An important genus such as *Ceroxylon* is represented by only one species in this book (*Ceroxylon quindiuense*). On the other hand, we must consider that the book is thick enough (700 pages!) and no more information could be stuffed into it, so these thinner accounts can be intended as a way to make readers beg for more.

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# *Dypsis turkii*

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1. *Dypsis turkii* in the undergrowth of forest, Ambatovaky Reserve, Madagascar.

Another new palm from Madagascar has been discovered. This dwarf palm, *Dypsis turkii*, has extraordinary slender thread-like inflorescences that arch out of the crown with their tips lying among the leaf litter.

Palm novelties continue to be discovered in Madagascar. Some, like the one described here, are local endemics that have come to light when botanists have explored areas previously not thoroughly surveyed. There are also several really interesting undescribed palms that are currently known only from seeds or seedlings in the horticultural trade, and not yet represented by complete herbarium material collected in the wild.

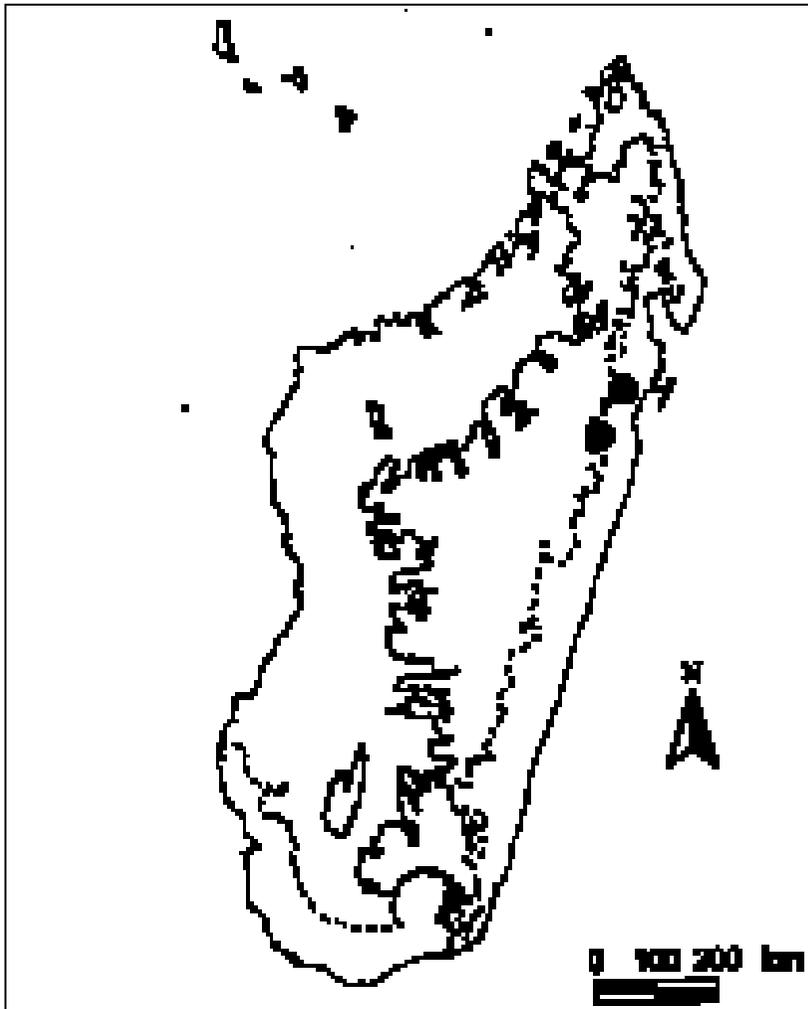
The subject of this paper is an astonishing new species of *Dypsis* with unusual inflorescences unlike those of any other palm in Madagascar. The species is named for Dan Turk, environmental officer of the Fiangonana Jesosy Madagasikara, who recognised it to be undescribed when he collected it on an isolated hill still covered in forest to the northeast of the Betampona reserve in Eastern Madagascar. I examined this specimen in Antananarivo but it has yet to arrive in Kew. The species was also collected by Anja Byg in Zahamena, during fieldwork funded by the International Palm Society. She too was unable to key it out in Palms of Madagascar (Dransfield & Beentje 1995) and suspected it to be undescribed. Finally in 1999 Bill Baker and I discovered it to be locally common in the southern margin of the Ambatovaky reserve and in forest fragments between Ambatovaky and Soanierana Ivongo. It thus has a distribution in upland forest on the eastern escarpment of Madagascar, northwest of Toamasina (Fig. 2).

***Dypsis turkii*** J. Dransf. sp. nov., inter species floribus staminatis triandris staminibus antesepalis inflorescentiis longissimis filiformibus floribus remotis distinctissima. Typus: Madagascar, Toamasina, Soanierana-Ivongo, Ambatovaky Reserve, Baker *et al.* 1013 (Holotypus K; isotypi TAN, MO, P, NY).

Slender, solitary, short-stemmed litter-trapping palm. Stem up to 1 m tall, usually less, often partially buried in leaf-litter and hence the palm appearing acaulescent, c. 8–15 mm diam., internodes 4–20 mm long. Leaves 7–9 in crown, apparently marcescent; sheaths yellow-green, with reddish margins when young, drying rich red-brown, 8–9 cm long, open for  $\pm$  their entire length, tubular in basal 2–3 cm, striate, abaxially bearing numerous reddish brown fimbriate-margined scales distally, scales very sparse proximally, two rounded auricles present, one on each side of the petiole, to 1.5  $\times$  1.5 mm; petiole absent, very short or to 4 cm long, 3.5  $\times$  2 mm in cross section; leaf blade entire-bifid, 29–65 cm long, with 10–14 adaxial ribs diverging at an angle of about 25° from the rachis, the blade divided to one half to two thirds, ca. 9–12 cm wide just below the sinus,

the two apical segments somewhat cucullate at the tips and shallowly toothed, the teeth corresponding to the main folds of the blade, rachis 10–26 cm long bearing scattered reddish brown scales, lamina bearing very sparse, scattered minute grey or reddish scales adaxially, abaxially with scattered punctiform reddish scales along the main ribs. Inflorescences interfoliar, very slender, exceeding the leaves, often greatly so, 72–150 cm long, branching to two orders, all branches diverging at an acute angle of about 20–25°; peduncle 28–ca. 70 cm long, ca. 1.5–2 mm diam.; prophyll tightly sheathing the base of the peduncle, inserted ca. 4 cm above the base, to ca. 8–10 cm long, 4 mm wide, striate and bearing scattered reddish brown scales; peduncular bract similar to the prophyll, ca. 24–26 cm long; rachis 40–80 cm long; rachis bracts triangular, ca. 3  $\times$  1.5 mm; first order branches ca. 6–8, distant, the proximal 2–3 branches branched to the second order, the distal unbranched, each with a conspicuous basal pulvinus and a long basal section devoid of branches or flowers; rachillae very slender, 4–8 cm long, ca. 0.75 mm diam, drying striate, bearing scattered brown scales; triads ca. 5 mm distant near the base of the floriferous portion of the rachilla, ca. 2 mm distant distally; rachilla bracts minute. Staminate flowers globose, ca. 1.5 mm diam.; sepals ca. 0.6  $\times$  0.8 mm, imbricate, broadly triangular with rounded bases, irregularly keeled and apiculate, faintly striate; petals triangular valvate, c. 1.2  $\times$  0.8 mm, striate, glabrous; stamens 3, antesepalous, staminal tube 0.6 mm high, ca. 0.6 mm wide, free portion of filaments ca. 0.2 mm high, ca. 0.4 mm wide, staminodes absent, anthers didymous mostly held within the staminal tube, ca. 0.5 mm high, 0.4 mm wide at base; pistillode minute, 3-lobed. Pistillate flowers globose 2.5  $\times$  2.5 mm; sepals 1  $\times$  1.5 mm, striate, irregularly emarginate and keeled; petals broad triangular 2  $\times$  1.8 mm, imbricate with triangular valvate tips, very thick and fleshy, glabrous; staminodes 6, irregular, tooth-like, sometimes connate laterally, c. 0.4  $\times$  0.2 mm; ovary eccentrically spherical, 1.5  $\times$  2 mm, stigmas 3, eccentrically subapical, 0.6  $\times$  0.1 mm; ovule laterally attached. Fruit ripening glistening bright red, broadly ellipsoid 14  $\times$  8 mm, stigmatic remains subbasal; epicarp smooth; mesocarp 4 mm thick; endocarp striate. Seed ellipsoid, 11  $\times$  4 mm, homogeneous, embryo lateral towards the base. (Fig. 3.)

**SPECIMENS EXAMINED.** Madagascar, Toamasina, Soanierana-Ivongo, Ambatovaky Reserve, ca. 2.2 km southwest of Amberomanitra, near Imangna River, 16°51'.45S, 49°16'.01E, 10 Nov 99, Baker *et al.* 1013 (Holotypus K; isotypes TAN, MO, P, NY);



2. Map showing distribution of *Dypsis turkii*.

Fenoarivo Atsinanana, Vavatenina, ca. 10 km northwest of Manakambahiny, buffer zone of Zahamena Reserve, 17° 32'S, 48° 55'E, 20 Oct 98, *Byg 19* (AAU, K, TAN).

VERNACULAR NAME: Sinkiaramboalavo.

HABITAT. Occurring in rain forest on slopes and near valley bottoms on quartzite, at elevations of 400–800 m above sea level, locally common in the undergrowth.

NOTES. The inflorescences of this species are unlike those of any other taxon in the genus (Figs. 4, 5). The palm is generally short-stemmed, occasionally almost acaulescent. The leaves, usually lacking a long, well-defined petiole tend to trap leaf litter, so that the leaf bases are sometimes entirely obscured. The inflorescences emerge from the crown and arch out between the leaf bases and on to the forest floor; the extremely slender rachillae may be presented over the ground or lie on the surface among the leaf litter. The

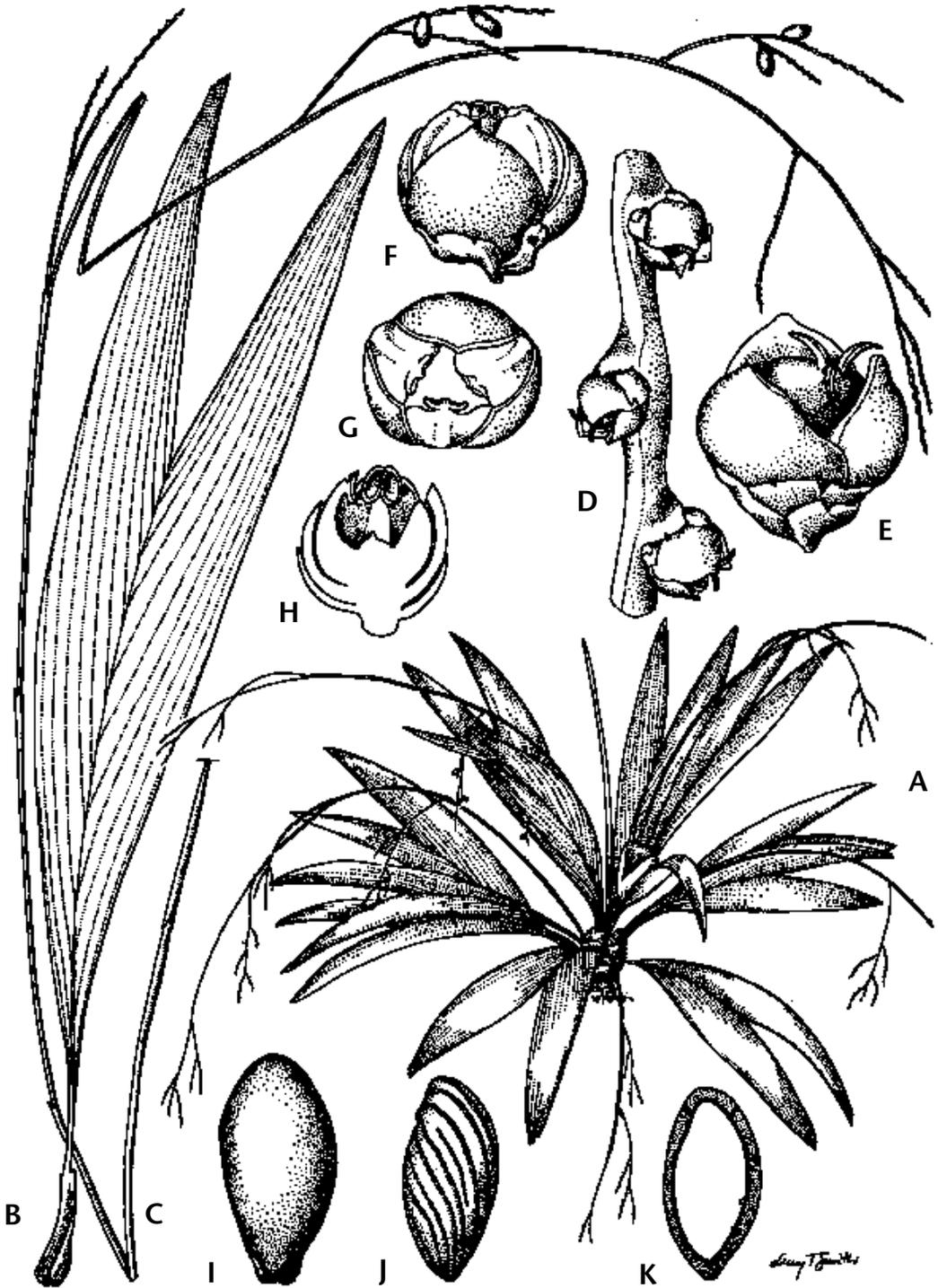
flowers as in so many taxa of *Dypsis* with three-staminate flowers where the anthers are rounded, are extremely small but, unusually, are held on slender, or almost thread-like rachillae. Only in *D. remotiflora* are the rachillae so slender, but here the inflorescence is short, little if any longer than the leaves and quite different from the very long inflorescences of this new species.

#### Acknowledgments

I thank Bill Baker, Aaron Davis, Frank Rakotonasolo and A. Rakotobe for help and companionship in the field. Fieldwork was supported by a grant from the Stevenson Family Charitable Trust. Lucy Smith prepared the line drawing.

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2. *Dypsis turkii*. A Habit; B Leaf  $\times 1/4$ ; C Inflorescence  $\times 1/3$ ; D Portion of rachilla with pistillate flowers  $\times 6$ ; E Pistillate flower  $\times 12$ ; F Staminate flower  $\times 12$ ; G Staminate flower viewed from above  $\times 12$ ; H Staminate flower in longitudinal section  $\times 2$ ; I Fruit  $\times 2$ ; J Endocarp  $\times 2$ ; K Fruit in longitudinal section. All from Baker et al. 1013. Drawn by Lucy T. Smith.



4. *Dypsis turkii*, showing the long thread-like inflorescences.



5. *Dypsis turkii*, detail of infructescence.

# Palm Management for Leaf Harvest: a New Method to Produce White Leaves From the Date Palm

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1. Traditional method of white leaf production: (left to right) two adult palms 2 years after harvest; an encowled adult palm; (an adult) palm 3 years after harvest.



**The traditional method of obtaining white leaves, and the only method used up to the present time, has not changed in hundreds of years (Brotons, 1989). Traditional white leaf production consists of three steps: tying (atado); encowling (encapuruchado) and cutting or harvesting (Picó 1999). This method is described by Gómez and Ferry (1999), but a new, less-damaging method is described herein.**

The date palm grove (*palmeral*) of Elche, designated a World Heritage Site in 2000, is located in southeastern Spain, between 38°9' and 38°21'N latitude and at 01°47' longitude, and covers an area of about 1,800,000 m<sup>2</sup>. Around 200,000 date palms (*Phoenix dactylifera*) occur in Elche; the great majority of the palms are planted in gardens (*huertos*), rectangular-shaped land-holdings each some 900 m<sup>2</sup> in area.

White leaves are the most important product of Elche's date palm grove. The first written references to this production date back more than 500 years (Ramos 1970). Southeastern Spain is, with the exception of the Bordighera region of Italy, the only place in the world where white leaves are produced (Gómez & Ferry 1997). The white leaves are used ceremonially by Roman Catholics on Palm Sunday (Galiana & Agulló 1983). The introduction of the date palm to Latin America has been attributed to missionaries who carried with them date palm seeds to assure a supply of traditional palm leaves for their religious observances (Barreveld 1993).

There is a need to find solutions to the biological stress placed on harvested palms, and the palm landscape degradation brought about by the traditional leaf harvesting practices. Of the 20,000–25,000 adult palms that annually in Elche area are encowled, they have a minimum of 4 m of trunk (adult palms more than 50 years old) and frequently palms having between 10 and 15 m of trunk are encowled (Fig. 1). The vigor of these latter palms decreases notably given that they are more than 100 years old. In addition, there is a higher risk of injury for the *palmereros*, the men who tend the date palms.

It is estimated that at least 10% of the encowled palms die as a result of the harvest of white palm leaves (Galiana & Agulló 1983) (Figs. 2, 3). Municipal legislation specifically protects the palmeral of Elche; among other things, the law stipulates that a 5-year recuperation period be observed after white palm leaves are harvested, the number of palms which can be encowled per huerto is limited, and the encowling of palms is prohibited within the urban area itself (Brotons 1995). It is believed that the legally prescribed 5-year recuperation period is not always respected; therefore the palm mortality rate may be much higher, probably as much as 20%.

Moreover, in recent years the harvest of white palm leaves has facilitated the spread of red date scale insect (*Phoenicococcus marlatii*) that has seriously affected the white leaf industry and the Elche palmeral in general (Generalitat Valenciana 1995).

Finally, Gómez and Ferry (1996) suggested different approaches to solve these various problems, such as to leave a number of fronds free on each palm during the process of tying and encowling, to utilize palms grown for ornamental purposes for white leaf production, to investigate modifications in the white leaf production process, to study the market for white leaves and to find control measures for the red date scale insect that gravely threatens the Elche palmeral.

Based upon the foregoing it was decided to develop a new method of white leaf production with the following basic objectives:

To reduce to zero the mortality of encowled date palms in the post-harvest period.

To make white leaf production more extensive by including those palms destined for ornamental use and to maximize the economic value of date palm cultivation.

To promote new date palm plantings in Elche and the surrounding area and create a new economic resource.

To harvest younger date palms destined for white leaf production, since it is possible to obtain economic harvests from palms having only 80–100 cm of trunk (5–6 years old).

## Description of the new method

### *Tying of palm leaves*

#### Tying schedule

This represents the first operation of the production process. Under the traditional method, tying takes place in January–February, and the white leaves are harvested in January–February of the following year; the palm crown therefore is closed for about 12 months.

Under the new method, it is recommended that the tying operation be delayed until April–May, but the harvest still take place in January–February of the following year, as is the tradition. This change will reduce the period of encowling and light deprivation of the palm by some 20% (2.5 months).

#### Tying method

Tying under the traditional method consists of gathering together the leaves into a tight erect bundle and fastening them together. The lower leaves not in the bundle later are pruned away (Fig. 4).

Under the new method, the leaf tying is the same. The only difference is that before making the leaf bundle, in palms with a trunk height of 80–100

cm, 6–10 of the most external leaves are left in their natural position. In the case of palms having a trunk height greater than 100 cm, a minimum of 12 leaves, two by two, are retained around the palm (e.g., every 60°).

#### Encowling

This practice, characteristic of the Elche palmeral and by which the greatest numbers of first quality white palm leaves are produced, is unchanged. Encowling is done during the summer months from July to September, as is the tradition. This can be accomplished using either cut palm leaves (Fig. 4) or plastic, to form the cowl.

#### Cutting or harvesting white leaves

Traditionally, this operation takes place in January–February, occurring a year after the leaves were tied. This consists of cutting the base of the encowled leaves and extracting from the interior the white leaves that have been produced since the process began. Harvesting practices ultimately leave the palm without a single leaf. (Figs. 2, 3).

The harvesting details are as follows. The *palmerero* cuts the cords on the exterior of the leaf bundle, removes the cowl and then cuts the remaining interior cords binding together the leaves. In this way the white leaves that have grown out into the center of the bundle are exposed. The *palmerero* cuts 4–6 green leaves from the outside of the bundle, on one side only, to gain access to the white leaves. White leaf harvest is selective; cutting only those of sufficient quality so they can be sold, leaving the fronds that cannot be used, which constitute a high percentage of the leaves of the encowling. Thereafter the remaining leaves are also cut.

The white leaves harvested by this method (Fig. 4) are graded depending upon their quality, i.e. the whiteness of the leaf and its length. Six grades are recognized:

Grade 1 – leaf more than 3 m long, completely white and without any blemishes;

Grade 2 – leaf 2-3 m long, completely white and without blemishes;

Grade 3 – leaf 1-2 m long, completely white and without blemishes;

Shoots and Points (*cogollos* and *puntas*) – leaf less than 1 m long, white and without blemishes;

Green Point (*punta verde*) – Grade 1 or 2 leaf with a green tip;

Malformed (*facho*) – leaf 2-3 m long with half the length green and the other white.

#### Experimentation

Two experiments were conducted to study the effects of the new method on four fundamental aspects: mortality rate, postharvest recovery period of the palm, average productivity of white leaves and minimum age for encowling.

Experiment 1. The objective was to study the white leaf productivity of the new method to determine if a relationship existed between trunk height and the number of leaves that should not be harvested. A total of 104 palms were tied and encowled; they had a mean trunk height of  $77.31 \pm 16.99$  cm, and a mean of  $4.67 \pm 2.19$  leaves were left free and intact during the period of tying and encowling. To ascertain if there existed some effect of using a plastic cowl, 75 palms were encowled with plastic and the remaining 29 palms were encowled with other palm leaves. The period of encowling was 10.3 months (309 days).

After the harvest, there were no dead palms detected among the encowled trees. A significant positive statistical correlation  $p < 0,02$  ( $r = 0.256$ ,  $n = 94$ ) was found between the height of the trunk and the total number of white leaves produced; in other words the greater the trunk height the greater the white leaf production. In addition, there was a significant positive statistical correlation  $p < 0,001$  ( $r = 0.3421$ ,  $n = 94$ ) between the number of free uncut leaves and the total number of white leaves produced; that is, the greater number of free uncut leaves the greater the white leaf production.

A median of 13 white palm leaves per tree was obtained. The median production every five years of a palm encowled according to the traditional method is about 18 white leaves. According to Gómez and Ferry (1996) these are broken down into: Grade 1 (5–7 leaves); Grade 2 (3–5); Grade 3 (1 or 2); Shoots and Points (1 or 2); Green Point and Malformed (4–6). Picó (1997) gave the breakdown as: Grade 1 (5 leaves); Grade 2 (2); Grade 3 (3); Shoots and Points (2); Green Point (2) and Malformed (3).

When the white leaf production results of the two methods were compared, we found that the production from the new method is about 25% less than the traditional method. This decrease is logical considering that the traditional method harvests white leaves from mature palms (more than 50 years of age) (Fig. 1) and over a time period of 12 months, whereas under the new method white leaves are harvested from young palms (6–8 years old) (Figs. 5, 6) and in a shorter time period of 9–10 months.

Under the traditional method, a date palm yields a harvest of 18–20 white leaves every 4–5 years,



2. Traditional method of white leaf production: (left) an adult palm that has died after harvest; (right) an adult palm after harvest.

which is the legal time period for recovery. Over that same period of time, the new method permits two harvests, giving a total of 26 white leaves, with a recovery period of 1–2 years. Therefore the productivity of the new method is equal to or superior to the traditional method.

A second aspect of the research was to determine if there existed any difference in white leaf production between palms encowled with plastic and palms encowled with date palm leaves. Of

the 104 palms encowled, plastic was used for 75 and date palm leaves for the remaining 29 palms

The only difference in white leaf production between the use of plastic and palm leaves for encowlement was that with palm leaf encowlement there was a decrease in the number of Grade 2 white leaves and an increase in the number of Green Point leaves on individual palms. The total number of white leaves of all other grades were the same whether plastic or palm leaves were used.

3. Traditional method of white leaf production (left to right) an adult palm 1 year after harvest; an adult palm 2 years after harvest; two adult palms recently harvested; an adult palm dead 6 months after harvest; a recovering adult palm 2 years after harvest; a recently-harvested adult palm.



Of the 104 palms encowled for the experiment, at the time of white leaf harvest, 11 palms were found to be infected with red date scale insect. Of the infected palms, 1 had been encowled with palm leaves and 10 with plastic. Therefore, encowling with palm leaves rather than plastic significantly reduced the incidence of red date scale insect during the encowling period.

Experiment 2. This was a replication of Experiment 1. It consisted of tying and encowling 100 palms with a median trunk height of  $95.7 \pm 21.36$  cm; each palm was left with a median of  $8.14 \pm 2.84$  free intact leaves during the experiment. Also in this experiment an attempt was made to establish the minimum time period necessary for white leaf production. Experiment 2 reduced the total time of tying, encowling and harvesting by 25% (2.4 months or 73 days); the duration of encowling was 7.8 months (236 days).

Not a single palm died during or after the white leaf harvest. Statistical analyses were done to prove a significant positive correlation in the results of Experiment 2:  $p < 0.001$  ( $r = 0.3727$ ,  $n = 91$ ) between the height of the trunk and the total number of white leaves produced; and  $p < 0.01$  ( $r = 0.2797$ ,  $n = 91$ ) between the number of free leaves and the total number of white leaves produced.

Of the 100 palms encowled, at the time of leaf harvest, 9% of the palms were found to be infested with red date scale insect. This level of infestation is comparable to what was found among palms encowled in plastic in Experiment 1.

For Experiment 2 the tying and encowling period was 25% less than in Experiment 1. This reduction brought about a decrease in the production of white leaves, giving a median yield of  $9.51 \pm 2.42$  per palm. It also diminished the number of leaves in Grades 1 and 2, the largest white leaves; and increased the number of Grade 3 and Shoots and Points, the smallest leaves. Based on the experimental results, we estimate that the optimal time period for tying and encowling is 10 months, which represents a reduction of 20% from the traditional method of 12 months. An encowling period of less than 9 months will influence adversely the production of white leaves.

Final conclusions from the experiments carried out on the new method of white leaf production are as follows:

Guarantee the survival of palms by eliminating the mortality caused by the production and harvest of white leaves and in the postharvest period.

Reduction in physiological stress of the encowled palms in two ways:

Decreasing the encowling period of time by some 20% (2.5 months);

Leaving leaf surfaces exposed and uncovered to allow limited photosynthesis to continue during the encowling. The palm is not totally cut off from photosynthesis and is able to continue to produce nutrients for its sustenance and growth.

The recuperation time for harvested palms is reduced from 5 years to 1 year.

There is a considerable increase in the profitability of date palm cultivation.

The risk of injury to the *palmereros* and labor costs are both reduced, because it is possible to tie, encow and harvest the white leaves of palms with a trunk height of 80–100 cm without having to climb the tree.

At the present time, new research is being initiated to study the biological control of the red date scale insect, through the use of entomogenous fungi.

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4 (above left). White leaves: (left to right) two Mal-formed; five Green Point; one Shoot; one Grade 3; three Grade 2 and one Grade 1. 5 (above right). New method of white leaf production: a young palm encowled with palm leaves and five leaves left unencowled. 6 (below). New method of white leaf production: young palm with fully developed crown of leaves one year after harvest.



# Palm Heart Extraction in Zahamena, Eastern Madagascar

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**Palm hearts are still an important food source in rural areas of eastern Madagascar, especially in periods when other vegetables are scarce. Deforestation and extraction of the hearts are, however, leading to the endangerment of many of the endemic species. Some of the species with edible hearts also provide other products such as fibres and thatch leaves, which may be extracted non-destructively. It may therefore be possible to incorporate these species into agroforestry systems and thereby contribute to the conservation of the palms and the livelihood of the rural population.**

Extraction of palm hearts for food has constituted an important traditional food source to many peoples in tropical countries since time immemorial. Economic globalisation and modernisation of agriculture has, however, even in remote areas, led to the substitution of many wild products, such as palm hearts, with a small number of intensively cultivated products (Bates 1988). As a consequence, palm heart extraction has been abandoned in some places, while in other places it has been upgraded to a large scale commercial operation (Orlande et al. 1996). At the same time, natural stands, which serve as the basis for subsistence extraction and/or commercial use, are declining in many places due to overexploitation or habitat degradation (Orlande et al. 1996). It is therefore uncertain how large

the contribution of palm hearts to local and global agriculture will be in the future. This also holds true in Madagascar, which houses an extraordinarily rich palm flora. More than 170 different species of palms are native to the island, mainly to its moist eastern regions. Of these 97% are endemic to Madagascar (Dransfield & Beentje 1995) and many species are found only in very restricted areas. This makes the Malagasy palm flora especially vulnerable to extinction. The main threat stems from the clearing of primary forest for agriculture, a process taking place at an alarming rate (Green & Sussman 1990). At the same time overexploitation of some species is reducing the remaining populations to unsustainably low levels (Dransfield & Beentje 1995). Extraction of palm hearts for food is still

one of the most frequent uses of palms in Madagascar (Byg & Balslev 2001) and may also be responsible for local decline of some species.

To investigate the present day importance and patterns of palm heart extraction with regard to the potential and threat for palm conservation, an ethnobotanical field study was conducted in eastern Madagascar. Through structured interviews the following aspects of palm heart consumption and extraction were investigated: number of species used, fraction of people consuming palm hearts, individual preferences, temporal variation and changes in extraction, trade, and cultivation.

### Study area

The study was conducted in and around the Zahamena Protected Areas in eastern Madagascar, which is characterised by high humidity and moderate to warm temperatures. The natural vegetation that ranges from lowland rainforest to semi-moist montane forest is rich in palms. The Zahamena Protected Areas comprise one of the largest remaining tracts of intact moist submontane forest in Madagascar. The protected areas cover approximately 640 km<sup>2</sup>, located at 200–1500 m altitude, 50 km from the coast. The protected areas are surrounded by a buffer zone where controlled extraction of forest products is taking place. Outside the protected areas and buffer zones primary forest is virtually non-existent.

### Methods

Structured interviews concerning the use of palms by local residents were conducted with 54 persons in three villages east of the Zahamena Protected Areas. Interviewees were asked which species with edible palm hearts they knew, which species they preferred, whether they ever bought or sold palm hearts, whether there was a special season or time for palm heart extraction and consumption, whether they cultivated palms and if so, for what reason, and whether their use of palms had changed over time.

Voucher specimens were collected at two different sites in the Zahamena Protected Areas and surrounding buffer zones: Vatovelona forest (17°40' S, 49°00' E, 550–700 m above sea level), and at Ambinany Namantoana forest (17°39' S, 48°57' E, 600–800 m above sea level). Voucher specimens are deposited at the herbaria of the Parc Botanique et Zoologique de Tsimbazaza, Madagascar, Royal Botanic Gardens of Kew (K), UK, and University of Aarhus (AAU), Denmark. Voucher numbers are cited in Byg and Balslev (2001). Species distinguished are “folk species,” i.e., plant groups regarded as separate entities by

local residents. In most cases these folk species corresponded to scientifically recognised species, but in three cases we know them only by their local names (Table 1).

### Results

#### *Extent of palm heart extraction*

Altogether, 270 reports of palm heart extraction were made by the 54 interviewees. A “report” is here defined as one person mentioning the use of one species. Twenty-one folk species were collectively used by the interviewees for the extraction of hearts (Figs 1, 2). Each person knew on average 4.8 species of palms with edible hearts, but variation in individual knowledge was large ( $s=2.5$ ). The most knowledgeable person knew ten different species with edible hearts while three persons did not know any (Fig. 3).

There were also large differences in how many times each of the species with edible hearts were mentioned. One species (*Dypsis tsaravoasira*) was mentioned 44 times, while a number of other species were mentioned only once.

In addition to consumption of palm hearts for food, ten interviewees stated that they also used palm hearts of certain species for medicinal purposes. Palm hearts used as medicine are prepared and consumed in the same way as when used for food and often the same species were used for food and medicinal purposes at the same time. The main medical application of palm hearts was as treatment for chronic cough, especially in children. Other medicinal applications of palm hearts were consumption as a treatment for digestive disorders and as an anti-poison. In addition, some people said that it was beneficial for pregnant women to eat palm heart.

#### *Preferences*

Most persons had clear preferences regarding what species they liked and reasons for their choice of preference were mainly sweetness or other taste attributes. Other reasons which were also mentioned by some persons were the texture of the prepared palm heart, or that certain species could be eaten without needing salt to go with the meal. The most popular palm heart species of all, the Tsaravoasira palm (*Dypsis tsaravoasira*), was the favourite of 20 out of 54 interviewees. There was a significant positive relation between popularity of a species and the number of times it was mentioned (Kendall Tau=0.53,  $P<0.005$ ; Spearman Rho=0.59,  $P<0.005$ ) so that the palm heart species mentioned as the most preferred species by individual interviewees were also the species altogether mentioned by most persons.

**Table 1. Conservation status (according to Dransfield & Beentje 1996), popularity (as indicated by no. of people mentioning a species) and other uses of edible palm species in East Madagascar.**

Conservation status	Species	No. of people eating heart	Other major uses
Endangered	<i>Dypsis tsaravoasira</i>	44	Stem: irrigation pipes
	<i>Ravenea lakatra</i>	18	Leaves: weaving
	<i>Ravenea albicans</i>	11	Stem: irrigation pipes
	<i>Dypsis tokoravina</i>	7	Leaves: weaving
Vulnerable	<i>Ravenea sambiranensis</i>	20	Stem: irrigation pipes, house construction
	<i>Marojejya insignis</i>	17	Leaves: thatch
	<i>Dypsis pilulifera</i>	16	Pith: rice trays
			Leaves: thatch
	<i>Dypsis perrieri</i>	10	Leaves: thatch, weaving
			Leaves: thatch
		Leaf sheath tomentum or Prophyll tomentum: mattress stuffing	
	<i>Ravenea dransfieldii</i>	7	none
	<i>Dypsis prestoniana</i>	6	none
Rare	<i>Ravenea robustior</i>	22	Leaves: weaving
Not threatened	<i>Dypsis pinnatifrons</i>	3	Stem or Inflorescence: broom
	<i>Dypsis fibrosa</i>	2	Leaf sheath fibres: mattress stuffing, rope
			Inflorescence: broom
			Leaves: thatch
Status Unknown	"Mangitranana"	40	Stem: house construction, irrigation pipes
	<i>Ravenea</i> sp.	24	Leaves: weaving
	"Bireso"	1	Stem: house construction
	<i>Dypsis ?canaliculata</i>	1	none
	"Hovopariaka"	1	none
Cultivated	<i>Cocos nucifera</i>	2	
	<i>Raphia farinifera</i>	1	



1. Some of the most popular sources of edible palm hearts: A (upper left). *Ravenea sambiranensis*; B (upper right) *Ravenea robustior*; C (lower left). *Ravenea robustior*; D (lower right). *Ravenea lakatra* (photographs by J. Dransfield).



2. A (top). Fibres extracted from *Ravenea lakatra*; one of the species renowned for its delicious palm heart. The fibres are used for weaving and are popular due to their light colour. B (bottom) *Dypsis tsaravoasira*, the species producing the most popular of all edible palm hearts (photographs by J. Dransfield).

### Temporal variation

The consumption of palm hearts varied through the year, but there were also marked differences between persons (Fig. 4). A majority of the interviewees (27 out of 54) said there was no special season for the extraction and consumption of palm hearts. There was, however, also a large number of people (21 persons) who stated that palm hearts were mostly consumed during the period when the fields are cleared and prepared for planting rice (October through December). During this time people venture into the forest and encounter edible palms. In addition, other vegetables are scarce during this period and palm hearts are a good supplement to rice, which is the Malagasy staple food. A smaller minority of people (7 persons) said that palm hearts were mostly eaten in the period of rice harvest (April through May), as palm hearts are especially good to eat together with new rice. These people also stated that consumption of palm hearts leads to an increased appetite and accordingly should only be eaten when plenty of rice is available, i.e., in the post harvest period.

### Changes

Many people mentioned that palm hearts were formerly much more prominent in their diet and that the decline was due to the increasing scarcity of the preferred species. Five interviewees said that they had totally abandoned palm heart consumption.

### Trade

In the lowland areas along the coast palm hearts are a regular feature at local markets. One palm heart cost between \$US 0.20 and \$US 1.00 at the

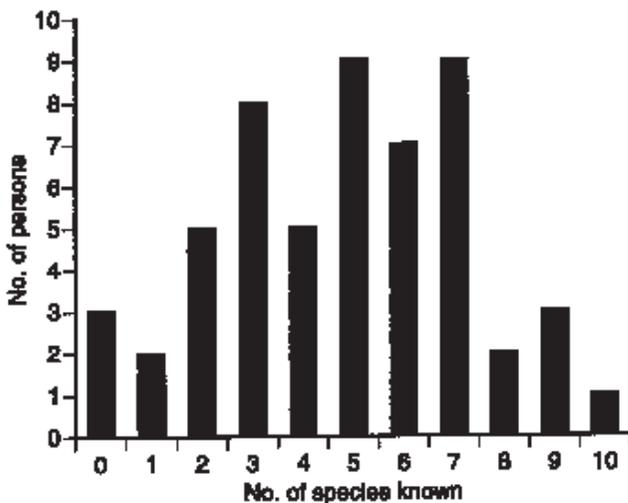
time of study depending on the species and size of the heart.

### Cultivation

Only three palm species were cultivated in the area: the African oil palm (*Elaeis guineensis*), the Raphia palm (*Raphia farinifera*), and the Coconut palm (*Cocos nucifera*). Even though they have edible hearts, only few people cultivate them with the specific purpose of extracting the heart. Nine interviewees said, however, that they would like to grow some of the wild palms with delicious edible hearts, but they were not certain whether this would be possible. None of them had yet ventured to undertake any trials in this respect.

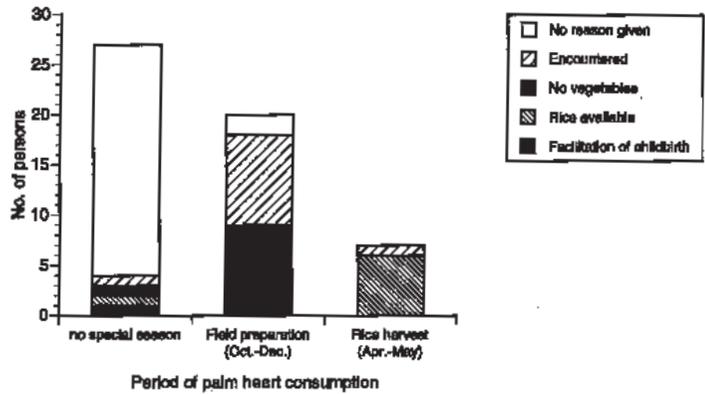
### Discussion

Even though a number of interviewees claimed that their palm heart consumption had declined, palm hearts are still a popular food source in villages in rural eastern Madagascar. Especially at times when other vegetables are scarce or inaccessible palm hearts are important in the diet of many families. The diminishing consumption seems mainly to be a consequence of the declining availability of palm hearts in the area. Although many edible species are found along large parts of the east coast, most of them are endangered or vulnerable due to their low population numbers (Table 1) (Dransfield & Beentje 1995). Reasons for the decline in palm heart species are probably a combination of overexploitation and habitat destruction due to shifting cultivation. Over-exploitation is especially a threat to certain species, which are popular due to their sweet taste, and the most eaten species are generally also among the most threatened (Table 1). Sweetness and quantity are also the characteristics determining the trading



3. Distribution of knowledge of edible palms among rural inhabitants of three villages in eastern Madagascar. The graph shows how many interviewees knew a certain number of palm species with edible hearts. On average each interviewee knew 4.8 species of palms with edible hearts ( $s = 2.5$ ).

4. Periodic variation in palm heart consumption in eastern Madagascar. Interviewees were asked if there were special periods of the year for the harvest and consumption of palm hearts. Categories are: no special season, during rice field preparation, or at the time of rice harvest. For each type of answer the reasons (if any) given by the interviewees for their answer are provided.



prize of palm hearts. Many of the interviewees remarked that they would like to buy and/or cultivate palm hearts. Accordingly there seems to be a large potential for systematic extraction or cultivation of palm hearts. However, examples from other countries such as Brazil show that neither of these are unproblematic. Profit maximisation will often lead to “boom and bust cycles” due to overexploitation or the establishment of monoculture plantations (Orlande et al. 1996, Richards 1997). In order to find sustainable extraction levels more research about growth and reproductive rates of the different species is needed. Palms which have a clustering habit will generally be easier to manage sustainably as their multiples stems may act as buffer against overexploitation (Borgtoft Pedersen & Balslev 1990). Unfortunately, only one of the edible species (*Dypsis fibrosa*) in this study is clustering and this species is one of the least popular. Apart from growth form, the possibility of non-destructive extraction of other palm products is an important factor with regard to evaluating species’ potential for cultivation. The most promising candidates for cultivation are species, which apart from their use for palm hearts, are also used for a multiplicity of other purposes and which can be incorporated in mixed cultivation systems such as agroforestry. Examples of edible species which can be exploited non-destructively for other purposes are *Dypsis perrieri*, *D. pilulifera*, *Marojejya insignis*, *Ravenea albicans*, *R. lakatra*, *R. sambiranensis*, and *R. robustior* (Fig. 2). The leaves of these species are to some degree already used for thatching and weaving. The use of a few species for many different purposes may, however, be impeded by local people’s preferences for certain species. Such preferences not only exist in the case of palm hearts, but also for most other applications according to the use purpose and the characteristics of the materials derived from different species. Thus although a species with a

popular edible heart may also have leaves that can be used as thatch, it is far from certain that it will be considered attractive to cultivate the species with the dual purpose of extracting palm hearts and thatch leaves, if the leaves of other palm species are considered to be superior for thatch. Preferences for certain species may therefore work against the cultivation and use of a few species for many purposes. Only if the convenience of having things close at hand weighs more than material attributes (Adu-Tutu et al. 1979) will the cultivation of a few multi-purpose palms be attractive. The probability that this will be the case is, unfortunately, increasing as the number of wild palms is diminishing rapidly and it becomes increasingly difficult to find the preferred wild species. On a more optimistic note, comparative studies of plant uses in different communities in the species-rich Amazon region have shown that the full use potential of wild plants is often not realised by the inhabitants in any one community. Thus, plants may often be used for many more purposes than the uses that actually take place at a given site (Gentry 1992). If the same holds true for the species-rich Malagasy palm flora it may be hoped that further investigations and experimentation will reveal the suitability of some of the popular edible species for many other purposes than those shown in this study. This may increase the incentive for cultivation or sustainable extraction, and hence increase the probability of the continued survival of these species and contribution to the diet and livelihoods of rural people.

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# Germination Characteristics of Fresh and Dried *Hyophorbe lagenicaulis* Seeds

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Germination of two seed lots of the bottle palm (*Hyophorbe lagenicaulis*) was investigated before and after drying. Seed desiccation tolerance was observed in this endangered species, suggesting possibilities for *ex situ* conservation, which would complement current *in situ* programmes.

*Hyophorbe lagenicaulis* (L.H. Bailey) H.E. Moore, the bottle palm, is relatively easy to grow, generously fruiting and flowering within the glasshouse environment (Ellison & Ellison 2001). Cultivated specimens have been easily obtainable from commercial sources for about the last 20 years (Dransfield 1996). As a consequence, it is used extensively in civic areas, particularly for the aesthetic shape of its trunk. However, its cultivated abundance is in stark contrast to its restricted natural distribution in the Mascarene Islands (Moore & Guého 1984).

The Mascarenes contain five native species of *Hyophorbe*, all of which are either rare or on the verge of extinction (Dransfield 1996). The geographical spread of *H. lagenicaulis* is now limited to Round Island, off the north coast of Mauritius. In the 1980s only eight adult

individuals were known in the wild (Uhl & Dransfield 1987). However, since the eradication of exotic herbivores in 1986 the native population has been recovering. Furthermore, in 1998 about 300 young specimens were planted to further enhance this population (CPDU 2000). Nonetheless, much needs to be done to ensure the conservation of this and other endangered palm species.

More effective world-wide policies guiding the protection of palm species are highly desirable, particularly concerning the complementary use of *in situ* and *ex situ* approaches. Seeds are arguably the most convenient and practical part of the plant to store *ex situ*, consuming relatively small volumes of space compared to the parent plant (Smith et al. 1998). Moreover, the application of suitable collecting methods can result in an

appropriate representation of the genetic diversity found within the species.

A recent review of seed storage behaviour has revealed that the majority of higher plants produce seed which may be stored long-term in the dry state (Hong et al. 1998). Such seeds are described as 'orthodox' in their storage response (Roberts 1973). In contrast, 'recalcitrant' seeds are desiccation sensitive and tend not to be storable for more than a few months (King & Roberts 1979; Black & Pritchard 2002).

Detailed seed storage characteristics of the palms have been examined for only 102 species (ca. 5% of the family; Hong et al. 1998), and only about one quarter of these are thought to have seeds suitable for conventional storage (i.e. dry and cold). The seed storage response of *H. lagenicaulis* remains unknown. Numerous features of the seed biology of *H. lagenicaulis* are investigated here: the characteristics of seed germination, including the role of light, and the effects of desiccation and storage on seed viability and vigour.

## Materials and Methods

### *Seed Procurement and Processing*

Two lots of *H. lagenicaulis* fruits were received from the Sir Seewoosagar Ramgoolum Botanic Garden in Mauritius, arriving at Wakehurst Place on 31 March (seed lot 1) and 8 August 2000 (seed lot 2), respectively. Immediately after receipt, a description of the fruit and seed characteristics were recorded for five individuals per seed lot.

The fruit tissue was removed from the seed by gently rubbing between the thumb and forefinger under running tap-water. The seeds were then rinsed three times in distilled water and blotted between paper towels to remove any excess water.

For temporary storage, each cleaned seed lot was individually wrapped in a loosely tied black plastic bag and placed at 15°C. The bags were frequently opened (every 2 to 3 days) for ventilation and the fresh seeds mixed well to avoid fermentation. For experimentation, each seed lot was split into two. These served as duplicates for the desiccation and germination studies.

### *Seed Germination Assessment*

In a preliminary experiment, seed germination was assessed at 25°C in the light (12 h/day). For germination, seeds were sown on 1% agar water in Perspex 'sandwich' boxes (175 × 115 × 60 mm). However, only ca. 5% of seeds germinated. Thereafter, seeds were incubated at 30°C in the light, which proved to be a more suitable temperature regime for germination. A separate comparison was made with dark germination, achieved by wrapping boxes in aluminium foil to

exclude light. All germination tests were based on 2 × 10 seeds per treatment. The effects of environment on germination were statistically tested by two-way ANOVA following arc-sine transformation of the data.

Seeds were scored as germinated when the operculum was lifted by a coleorhiza-like organ. Mean time to germinate (MTG), at 30°C, was assessed in days as:  $\sum(Dn)/\sum n$  where  $n$  was the number of seeds that germinated on day  $D$ , and  $D$  was the number of days from the beginning of the germination test. The germination test lasted ca. 80 days. From the germination progress curves (see Figs 2A and B) a maximum rate of germination (%/day) was estimated, based on the linear increase in germination from 10 to 60%.

Seed weight for 10 individual seeds per seed lot was recorded weekly in the germination test. This estimate of water uptake by the seeds was used ultimately to determine the seed moisture content during imbibition and at the point of germination.

Each stage of germinative growth was recorded and photographed using a Nikon Coolpix 995 digital camera (Nikon Corporation, Tokyo, Japan).

### *Seed Drying and Moisture Content Determination*

Moisture contents were determined gravimetrically before and after drying using a 103 ± 1°C oven for 17 ± 1 h (ISTA 1999). Determinations were made on seven individual embryos and endosperms per treatment sample.

For each batch of seeds, duplicate determinations of seed equilibrium relative humidity (eRH) were made on sub-lots of five seeds over a 1 h period at 20°C using a Rollog Agent-HT1 unit (Rotronic Ltd, Crawley, UK).

For drying, 50 seeds per batch (i.e. 2 × 25 per seed lot) were placed as a mono-layer, on a slatted-tray and left in a dry-room operating at ca. 15% RH and 15°C, until a constant weight (two decimal places) was reached over two consecutive days.

### *Storage Longevity Assessment*

To assess storage longevity, dried seeds (at moisture contents of ca. 14% and ca. 8% embryo and rest of seed respectively) were hermetically sealed in aluminium foil laminate bags (to maintain their low levels of humidity), and held at 15°C for 18 months. After storage, the seeds were placed for germination as described above.

## Results

### *Fruit and Seed Characteristics*

Fruits had a smooth epicarp, thin mesocarp and a thin fleshy endocarp. The fruit was one-seeded and the seeds were generally black in colour,

indicating physiological maturity (Dransfield 1996). For the two seed lots, fruit length and width were ca. 22 mm and ca. 18 mm on average. The initial weight of the fruits (containing seed) varied from  $4.8 \pm 0.6$  g (seed lot 1) to  $3.7 \pm 0.3$  g (seed lot 2), which was significantly different ( $P > 0.05$ ). Seeds were ellipsoid and varied in length between 15.5 and 15.7 mm and in width between 11.8 and 13.2 mm (Table 1). On dissection, the endosperm appeared homogeneous and the embryos were ca. 1.8 mm long and 1 mm wide (Table 1), lateral, but located close to the seed apex.

After cleaning, the initial moisture content for both seed lots was ca. 54% for the embryo and ca. 30% for the rest of seed material (Table 2). Seed equilibrium relative humidity of freshly cleaned seeds was 94.7% and 95.5% for seed lot 1 and 2, respectively.

#### *Seed Imbibition and Germination of Fresh Seeds*

For both lots, the mean moisture content of the seed increased from ca. 24% to 30% over the first 15 days of the germination test (Figs 2A and B). Thereafter, seed moisture content remained at 30% until the end of the test. Germination started ca. 25 days after sowing and reached ca. 75% after approximately 80 days (Figs 2A and B). The MTG was ca. 44 days. A maximum germination rate, of 1.5%/day, was observed over the period ca. 20–60 days (Figs 2A and B).

#### *Germination Morphology*

Germination occurred when the operculum was forced open (Fig. 1A). Five days after the initiation of germination (DAI), a coleorrhiza-like organ was clearly evident. At 8 DAI, the epiblast and primary root began to elongate (Fig. 1B). Secondary roots started to appear by 11 DAI as did the coleoptile and leaf tip (Fig. 1C), demonstrating an adjacent-

ligular growth pattern. The first leaf had emerged 20 DAI (Fig. 1D). The roots and the first leaf developed rapidly through 26 DAI (Fig. 1E) and 30 DAI (Fig. 1F).

#### *Effects of Desiccation and Storage on Germination*

Drying typically took 14 days and reduced the average tissue moisture contents across the seed lots to  $14.3 \pm 2.0\%$  and  $8.0 \pm 0.1\%$  for the embryo and rest of seed material respectively (Table 2). Seed equilibrium relative humidity of dried seeds was 35.2% and 32.7% for seed lot 1 and 2, respectively.

Drying, and drying plus storage, had no effect on the final level of germination, being about 75% in both treatments (Figs 2A and B). Moreover, post-imbibition, maximum germination rates were similar for freshly cleaned, dried and dry-stored seeds (1.5%/day). However, the starting point for this phase of growth was typically 20 days later for the dried material compared to the fresh material. In addition, dried and dry-stored seeds had an extended MTG of ca. 64 days (cf. un-dried seeds at ca. 44 days). The increase in moisture content of dried seeds was tri-phasic (Figs 2A and B). Initially, there was a sharp increase in moisture content from ca. 8 to 25% over the first 20 days, then a more gradual increase to ca. 30% by 40–45 days beyond which moisture content remained the same. The achievement of this seed moisture content coincided approximately with the onset of germination (Figs 2A and B).

#### *The Effects of Light on Seed Germination*

The effects of light on seed germination in both seed lots before and after drying are shown in Table 2. In the presence of light, germination reached 65–75% irrespective of treatment. In contrast, dark germination was  $\leq 10\%$ . Two-way ANOVA revealed neither an effect of drying on germination ( $P = 0.753$ ) nor an interaction between light and drying ( $P = 0.43$ ). The impact of light on germination was, however, statistically significant ( $P = 0.002$ ).

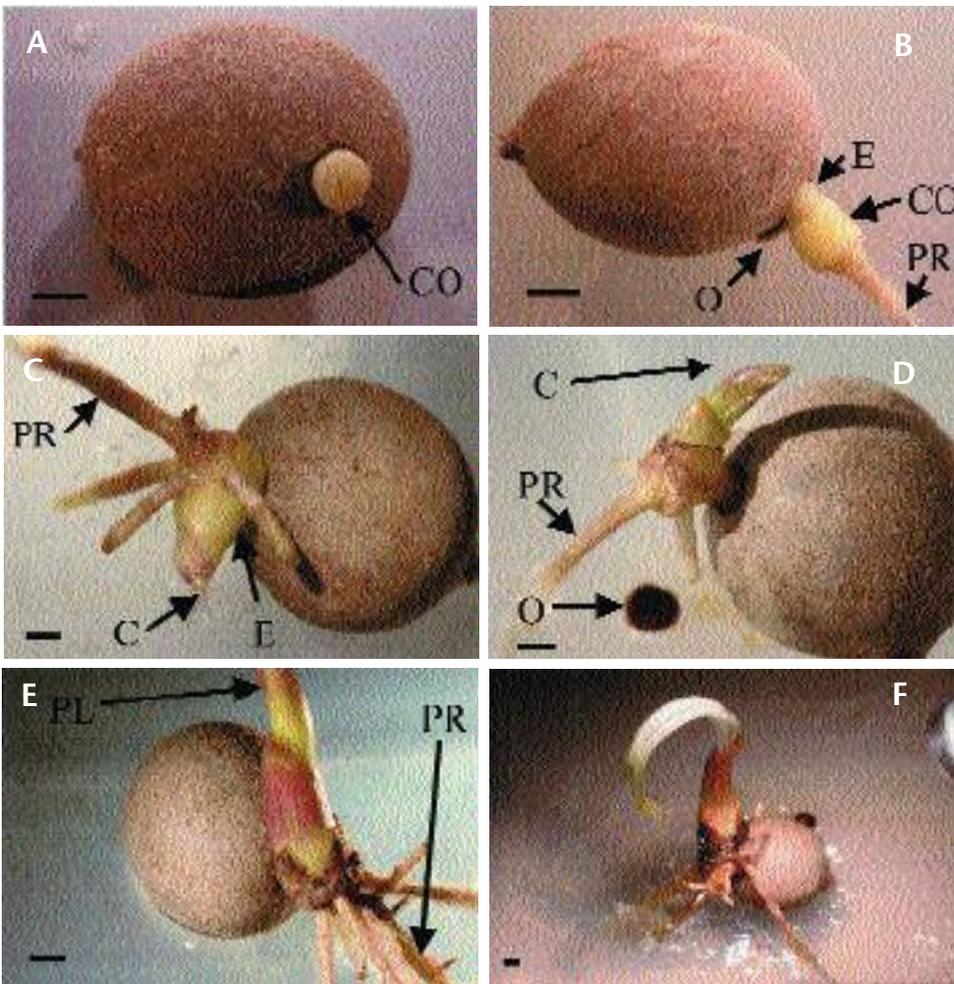
#### **Discussion**

The general appearance of the seeds following cleaning (Table 1) and the similar pattern of imbibition and germination (time and rate) for fresh seeds of both lots (Figs 1A and B) supports the suggestion that seeds of both harvests were of comparable maturity. Nonetheless, there were some differences in fruit and seed size between lots, although these were minor (Table 1).

Germinated *H. lagenicaulis* seeds have an adjacent-ligular growth pattern (Fig. 1), which is thought to be an adaptation for growth in moist environments (Uhl & Dransfield 1987). However,

**Table 1. Seed lot characteristics of *H. lagenicaulis*. All measurements are means based on five individual seeds per batch. Data are significantly different (paired t-test;  $P > 0.05$ ) when followed by different letters.**

Seed characteristic	Seed lot 1	Seed lot 2
Fruit color	3 Black/ 2 Dark Green	5 Black
Fruit weight (g)	$4.8 \pm 0.6^a$	$3.7 \pm 0.3^b$
Embryo length (mm)	$1.6 \pm 0.5^a$	$2.0 \pm 0.6^a$
Embryo width (mm)	$1.0 \pm 0.0^a$	$1.0 \pm 0.0^a$
Seed length (mm)	$15.5 \pm 0.4^a$	$15.7 \pm 0.9^a$
Seed width (mm)	$13.2 \pm 1.1^a$	$11.8 \pm 0.2^b$



1. Stages of seed germination, rooting and shoot emergence. A. 5 days after the initiation of germination (DAI) i.e. after first signs of the operculum lifting, B. 8 DAI, C. 11 DAI, D. 20 DAI, E. 26 DAI, F. 30 DAI. (O) operculum, (CO) coleorhiza-like organ, (E) epiblast, (C) coleoptile, (PR) primary root and (PL) primary leaf. Scale bars represent 5 mm.

*H. lagenicaulis* is typically associated with open and drier habitats (Moore and Guého 1984). These two observations are not necessarily in conflict. Both the light requirement for germination (Table 2) and their tolerance of dehydration (Figs 2A and B) suggest adaptations for a relatively open environment. Nonetheless, selection pressures away from the adjacent ligular form of growth would not be strong if seed shedding and germination closely coincided with seasonal rains.

Seed imbibition was either bi- or tri-phasic depending on the initial seed moisture content. These patterns can be related to the physiology of the germinating seeds. For dried seeds, initial re-hydration is rapid up to ca. 25% moisture content (Figs 2A and B). This is driven by the low matric potential of the seed endosperm. The rate of imbibition then slows as the seed water potential nears that of its surroundings. In this phase, major

metabolic events are initiated prior to coleorhiza emergence / germination (Bewley & Black 1994). These events continue during the third phase of hydration when water uptake appears to stop (Figs 2A and B). This represents the point at which water saturation within the endosperm has been reached, similar to that observed in other endospermic seeds (Bewley & Black 1994). Moreover, the start of germination early in this hydration phase (i.e. a few days at most) suggests that the seeds are non-dormant. For fresh seeds, only two hydration phases were seen, as the seed moisture content was already close to that observed at full hydration. Thus, the seeds were already in the second phase of hydration. Overall, the observations support the proposition that chemical reactions associated with, and providing the driving forces for germination occur at discrete water thresholds (Bewley 1997; Obroucheva & Antipova 1997).

**Table 2. The combined effects of desiccation and light on the seed germination of *H. lagenicaulis* seed lots. Germination results show the standard error of the mean based on duplicate sowings of 2 x 10 per treatment.**

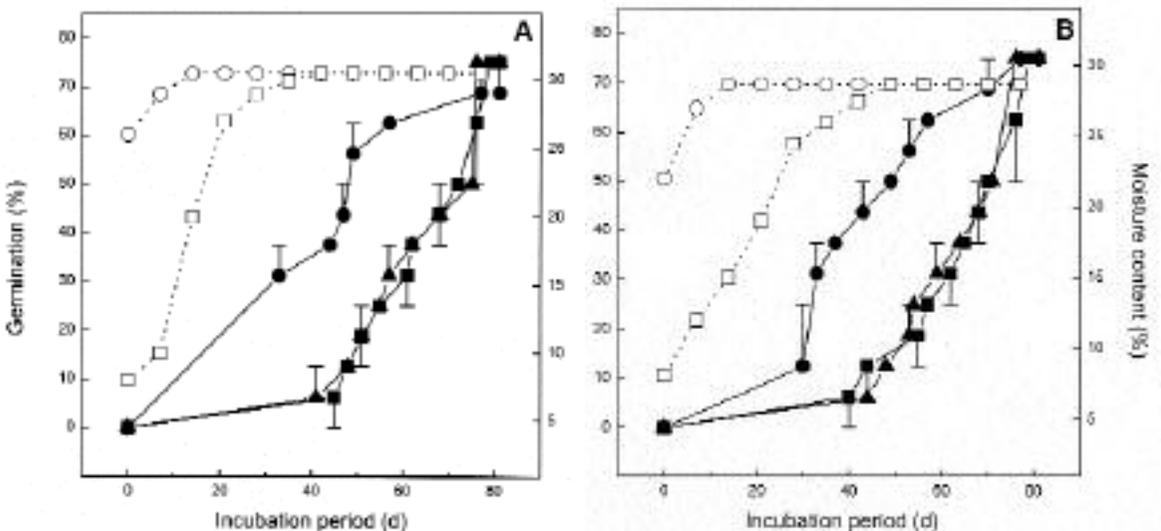
Seed lot	Treatment	Moisture content (%)	Light (+/-)	Germination (%)
1	Undried	56.3 ± 3.5 (Embryo)	+	75 ± 25
		30.5 ± 9.2 (Rest of Seed)	-	0 ± 0
1	Dried	12.3 ± 4.4 (Embryo)	+	70 ± 10
		8.0 ± 0.1 (Rest of Seed)	-	10 ± 10
2	Undried	51.4 ± 4.5 (Embryo)	+	70 ± 15
		28.7 ± 3.2 (Rest of Seed)	-	15 ± 5
2	Dried	16.2 ± 5.3 (Embryo)	+	65 ± 15
		8.1 ± 1.2 (Rest of Seed)	-	10 ± 10

The speed of germination (a measure of vigour), as determined by MTG, was lengthened by seed drying (Figs 2A and B). However, MTG was not affected by storage, post-desiccation. Consequently, it appears that drying *per se* simply extends the time taken to reach the critical seed moisture content for germination. Presumably, shortening the imbibition period, e.g. through pre-soaking, would enhance the germination speed of dried *H. lagenicaulis* seeds. This approach has worked previously for *Sabal palmetto* and *Serenoa repens* seeds, resulting in a 25% increase in germination rate (Carpenter 1987). Similarly, pre-soaking of *Hyphaene thebaica* seeds also resulted in enhanced germination rates (Karschon 1962). In

contrast, Davies and Pritchard (1998) germinated seeds of *Hyphaene thebaica*, *H. petersiana* and *Medemia argun* in water, with a reduction in mean emergence time from ca. 24–50 days to 17–22 days across the three species.

In addition to light and seed moisture content, germination in *H. lagenicaulis* is governed by temperature, 30°C being better than 25°C. Similarly, 30°C has also been shown to be optimal for germination in *Archontophoenix alexandrae*, *Butia capitata*, *Caryota mitis*, *Livistona chinensis*, *Phoenix canariensis*, *P. humilis*, *P. sylvestris* and *Washingtonia filifera* (Sento 1976; Chatty & Tissaoui 1999). However, a large degree of variation

2. Germination progress curves for seed lots 1 (A) and 2 (B): fresh/un-dried (solid circles), dried to 8% moisture content (solid squares) and dried seed stored for 18 months at 15°C (solid triangles). Increases in moisture contents are also shown for freshly isolated seeds (open circles) and dried seed (open squares). Mean time to germinate (MTG) was 43.8 ± 4.8, 64.3 ± 1.0 and 63.5 ± 0.7 respectively for treatments of seed lot 1 (A) and 44.5 ± 1.3, 64.3 ± 0.1 and 64.1 ± 0.8 respectively for treatments of seed lot 2 (B). Bars, where shown, are larger than the symbols and represent one standard error of the mean.



in optimal germination temperatures has also been demonstrated for seeds of the Arecaceae (Sento 1976).

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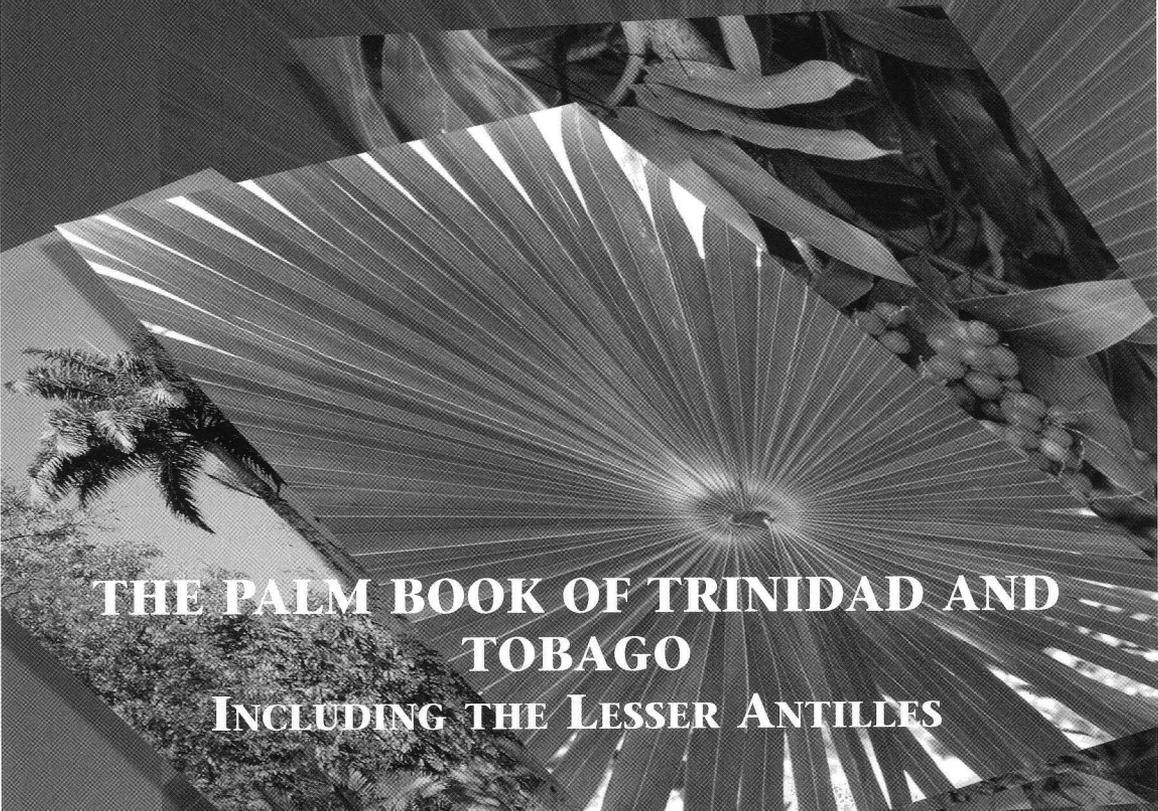
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