

# Palms

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# THE INTERNATIONAL PALM SOCIETY, INC.

## The International Palm Society

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### FRONT COVER

A young female *Medemia arguta* in Dungul Oasis, Egypt. Photo by W.J. Baker. See article p. 9.

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## BACK COVER

*Medemia argun* in Wadi Neigit, Egypt. A close-up of the crown showing the glaucous leaf lacking a hastula, the yellow petioles with scattered marginal spines and a male inflorescence. See story page 9. Photo by Haitham Ibrahim.

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The colorful crownshaft and infructescences of *Pinanga speciosa*, Makiling Botanic Gardens. See article by Fernando et al. page 31. Photo by S. Zona.



# NEWS FROM THE WORLD OF PALMS

Two botanical institutions with significant palm collections celebrate important anniversaries in 2009. Montgomery Botanical Center in Miami celebrates 50 years since its founding in 1959 (as the Montgomery Foundation). The original planting of its estate by Colonel Robert Montgomery began in 1932. After Col. Montgomery died in 1953, his wife remarried, taking as her husband Mr. Al Jennings. Nell Montgomery Jennings died in 1990 and left her estate and fortune to Montgomery Botanical Center that now houses one of the most important palm and cycad collections in the whole world, a collection not only of immense research interest but also of great beauty. A celebratory symposium is planned for later this year (watch the pages of PALMS for further details).

Over the other side of the Atlantic, in 1759, Princess Augusta, the mother of Britain's King George III, established her royal gardens on the banks of the river Thames in the village of Kew to the west of London. The Royal Botanic Gardens Kew has thus reached the venerable age of 250. The gardens house in the celebrated Palm House one of the most diverse indoor collections of palms anywhere in the world, but also has custody of perhaps the most significant dried reference collections of palms in its Herbarium, a collection not only rich in historic and type collections, but also in modern collections from throughout the tropics. This year also sees the 200<sup>th</sup> anniversary of the birth of Charles Darwin on 12 February 1809, an anniversary to be

celebrated at Kew with an exhibition on the life of the great evolutionist to be housed in the Nash Conservatory, one of the most elegant glasshouses at Kew.

From Fairchild Tropical Botanical Garden comes news of a new director whose name will be familiar to readers of PALMS. He is Dr. Carl E. Lewis, and he is a co-author of the new, second edition of *Genera Palmarum*. He is also creator of FTBG's on-line Guide to Palms. Carl has been associated with FTBG for a number of years, first as a visitor to the garden while completing his PhD at Cornell University, then as a post-doctoral researcher, later as a senior curator in the horticulture department and most recently as a palm biologist in the research department. At 35 years old, he is the youngest director in the history of FTBG. His enthusiasm for palms, palm exploration and innovative technology can only mean good things for the future of FTBG.

Another *Genera Palmarum* co-author, Dr. William Baker, of the Royal Botanic Gardens Kew has recently accepted the chairmanship of the Palm Specialist Group of the World Conservation Union and Species Survival Commission. In addition to heading the palm research program at Kew, Bill is charged with overseeing the assessment of the conservation status of the world's palm species and raising awareness for the critical need for palm conservation throughout the world.

THE EDITORS





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THE EDITORS

# GROWING PALMS

Horticultural and practical advice for the enthusiast

by Randal J. Moore

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## Growing Palms in Containers

We all attempt to achieve the ideal conditions for container-grown palms. We want a potting mix that provides good aeration. At the same time, the mix should not dry out too quickly and should maintain a relatively even moisture level. We wish there were one ideal mix that could be used in all pot sizes, from small plugs to large containers, and from short to tall pots. It would also be good if the perfect mix contained the necessary nutrients needed by palms. A single perfect mix would work for all species of palms. And, finally, it can be stored indefinitely without deterioration.

These ideal conditions are very difficult, if not impossible, to achieve. This would mean that the container mix is not affected by other environmental factors. It also implies that the substrate used does not change with horticultural practices. This article will discuss the over-reliance on the potting mix as the main factor that determines good aeration and moisture level in container-grown palms.

We tend to make errors to the detriment of our palms when we consider the composition of the container mix as an over-riding and isolated factor. Importantly, the potting mix is not totally responsible for meeting the air, water and nutritional needs of the palm. We should take an integrated approach to the four main factors associated with the container growing of palms in order to properly balance aeration, saturation and nutrition needs.

Balancing the aeration and moisture levels is a considerable problem when palms are grown in containers. When growing seedlings in small pots or cells as plugs, they are often too wet and die (often from fungal infections called "damping off"). As palms mature and grow and container size increases, they can dry out too quickly. Growers must compensate for changing demands as the palm matures. The aeration and moisture level is not a fixed property of the container mix.

Four major integrated factors discussed below will determine the combined air and water levels in palm containers. They are: the growing medium composition, the container size and shape, handling practices when filling containers and irrigation practices.

### **Factor 1: Growing Medium**

Experienced palm growers know that the potting mix can greatly influence the air and water levels within the container. Different commercially available pre-blended mixes differ in porosity. Most commercial mixes used for containers containing a 50/50 blend of peat/perlite have a porosity of 80–90%. By contrast the porosity of unamended mineral soil is about 50%.

The peat used in the container mix will determine aeration and drainage. Sphagnum peat is preferred over other types (such as root-sedge peats) because of its beneficial fiber structure. Avoid peat that has been milled too much since the fibers will be crushed excessively causing the quality to be reduced. Coir dust is an acceptable substitute for peat. If a bark is used instead, it should be well composted. If the bark is not composted it will absorb nutrients during decomposition making them unavailable to the palms.

An aggregate is generally added to the container mix to improve aeration and drainage. Most commonly used are vermiculite, perlite or polystyrene beads. The aggregate is usually added in

a ratio of 20–60% by volume. The size of the aggregate is very important. Horticultural grade #2 vermiculite or perlite is the most commonly used. The coarser grade is appropriate for all containers except very small cells used for growing plugs. Plug mixes use a #3 aggregate that is finer making it easier to fill the small cells. However, #3 grade aggregate is inferior for aeration and drainage since it is more easily compacted.

The proper growing medium is based on the size of the container to be filled. If the container is small, the type of peat used is very important (and less so if the container is large). The aggregate used will determine aeration and drainage based on the size and shape of the particles. Small particle aggregates can actually be detrimental to good drainage.

### Factor 2: Container Height/Shape.

Air and water content is of less concern in larger containers but is accentuated for smaller containers. From this perspective, growing a small plug is more difficult than growing a large container palm.

Small containers suffer from two problems: they are too short and too small. Since they are short, they do not drain well or do not drain at all. Airspace is reduced as a function of volume. A sample of one-part peat/one-part perlite contains: 0.5–2.5% air space by volume in a plug tray, 13% in a 4 × 4 inch pot, and 20% in a 6 × 6 inch pot.

A normal plug tray is 1 inch tall and provides between 1% and 3% air content. If the cell is



1. Container shape affects total volume. A square container has about 33% more volume than a round container of the same height and diameter.

increased to 2 inches tall, the air content increases to 5–10%. Therefore, increasing the plug cell height cuts production problems measurably. In smaller cells there is a much greater chance of under-watering or over-watering the small palm. This relates to a condition known as the “Perched Water Table Effect.” After receiving irrigation, there is a portion of the medium at the bottom that does not drain. These pores remain saturated with water. This saturation zone is a greater portion of the total volume in shorter containers. The effect holds true for different height containers filled with the same



substrate. The height of the container determines the air space left in the substrate after the drainage of excess water.

Container shape is also important. Smaller palms can be grown in both round and square containers. A round container is actually a portion of a squared conical container. Square tapered containers are somewhat pyramid shaped. They may be preferred because they have greater volume. Comparing the volumes of each, a squared container will have a 33% larger volume than a rounded one (Fig. 1). This extra volume allows more water to be available to the palm with less chance of drying out. Extra volume does not necessarily increase the air space percentage. As long as the height remains the same for both (square and round) there is no decrease in drainage.

### **Factor 3: Growing Medium Handling.**

The grower's handling of the potting mix impacts its air and moisture levels. Much of the benefits from using the best materials, thorough blending in the correct proportions and careful packaging and shipping can be undone by poor handling practices.

Containers should be lightly filled and any excess removed. The mix should not be packed down into the container. One way compaction occurs is when the pots or trays are stacked onto one another. Air space can be reduced by one-half or more through such compaction.

Attain the proper moisture content of the mix prior to filling the container. After adding water to the potting mixture the mix hydrates and swells. The particles do not nest within each other as much. This process helps to create more aeration. The effect is not so dramatic when using larger containers but is important for smaller containers.

Not properly hydrating the container mix prior to use is a common mistake. Most growers immediately use a pre-blended commercial mix right out of the bag. However, water should be added prior to use. To assure proper absorption, it is best if the substrate is moistened, blended and stored overnight prior to use. However, even a few hours wait time is beneficial.

There are some general guidelines for hydrating the potting mix. When filling larger containers, use one part water to one part dry mix. This will yield a moisture level of 50%. For smaller containers, use a ratio of two parts water to one part dry mix. This produces a moisture content of 67%. Surprisingly, increasing moisture levels from 50% to 67% will double or triple the air space. This resultant mix may appear to be too wet based on standard practices; however, it will greatly improve aeration.

The calculation of how much water to add will be based on the initial water content level of the mix. The initial water content is the difference between the dry weight (measured by baking in an oven and weighed, if necessary) and the initial moist weight of the substrate. The calculation is also based on the dry bulk density (measured in pounds per cubic foot). Less dense mixes will require less water to produce a certain moisture level. The reverse also true for mixes of greater density where more water is needed. (For reference, a mix of 50% peat and 50% perlite has a dry bulk density of 6.25 lb/cu ft.)

Adding the correct amount of water to the mix before use will reduce the amount of watering needed afterwards. Light misting may be all that is required as opposed to heavy watering if the moisture content is properly attained prior to filling the container.

Allowing the potting mix to dry out during handling will require remoistening before use. This is detrimental. Of course, this frequently happens when the entire amount of mix is not used at a single time and is allowed to set out overnight.

### **Factor 4: Irrigation Practices.**

Watering practices influence the air content in the root zone. As discussed above, small containers are especially susceptible to over-watering because they do not drain well. Therefore, knowing when to apply water is a very important consideration, especially when watering small containers.

The amount of irrigation water provided is the product of the amount of water applied by the frequency of application. For the optimal levels of aeration and water content, the general rule

is that as the container size decreases the volume of water should be reduced and the irrigation frequency increased.

Also, the smaller the container size the smaller the droplet size and water pressure to reduce the amount of planting mix that will be pushed out of the container when watering. Use special gentle heads on the end of water wands. If overhead irrigation is used in the greenhouse, the spray heads should produce a finer mist.

### **Conclusions**

Understanding the four main factors described above will improve the quality of all container grown palms, from seedlings to larger sizes. The four factors are integrated and must be considered together when attempting to optimize air and water levels. One of the four factors cannot be changed without affecting the other three.

### **Acknowledgment**

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# *Medemia argun* – Past, Present and Future

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1. Two of the larger individuals of *Medemia argun* in the Dungul Oasis population in Egypt.

The genus *Medemia* has attracted the curiosity of palm experts for two centuries because of its romantic history and elusiveness in the wild. Its discovery is rooted in the tombs of ancient Egypt and the adventures of great 19<sup>th</sup> century explorers, and yet for much of the 20<sup>th</sup> century, living specimens were not seen in the wild. Here, we present the story of *Medemia*, from its 5<sup>th</sup> Dynasty past (2500 BC) to its 21<sup>st</sup> century present as an important yet threatened part of the modern Nubian Desert flora.



*Medemia* (Coryphoideae: Borasseae: Hyphaeniaceae) is a mysterious and little known monotypic genus of fan palm from the Nubian Desert oases of southern Egypt and northern Sudan (Fig. 1). The sole species, *M. argun*, resembles *Hyphaene*, to which it is closely related, especially in inflorescence, flower and leaf morphology. However, it is easily distinguished from *Hyphaene* by its supple leaves lacking a hastula, bright yellow petiole, lighter petiole armament, plum-like fruit with ruminant endosperm (Figs. 2 & 3) and, unlike co-occurring *H. thebaica*, an unbranched stem.

### *Medemia argun* – a palm of ancient Egypt

The story of *Medemia* begins with Giuseppe Passalacqua, an Italian fortune seeker who went to Egypt in the early 1800s, initially trading horses, but later turning to something more lucrative: the excavation of ancient tombs for antiquities (David & Tapp 1992, Pain 2006). He succeeded in discovering many treasures but made his name with the discovery of the mummy of Natsef-Amun, a priest at the temple of Karnak, which was among the first to be investigated in scientific detail. In his excavations, Passalacqua found many fruits among the offerings to the dead. When he left Egypt he took up a good position as conservator of Egyptian Collections in the Berlin Museum. The famous German botanist, Karl Kunth, worked on Passalacqua's botanical treasures, among which he recognized fruits from three palms, *Phoenix dactylifera*, *Hyphaene thebaica* and a third species that was not known to science, which he named *Areca passalacquae* (Kunth 1826). Thus, *Medemia* was discovered, not as a living palm, but as an archaeological relic from the ancient tombs of Egypt.

*Medemia* fruits have been found in tombs from the 5th Dynasty (ca. 2500 BC) to Roman times (6–7th century AD) including the celebrated tomb of Tutankhamun (Täckholm & Drar 1950, Laurent-Täckholm 1951, Germer 1985, Schoske et al. 1992, Newton 2001). Archaeological specimens can be found in various collections including the Agriculture Museum in Cairo, the Economic Botany collections at the Royal Botanic Gardens, Kew (Fig. 4) and at the Natural History Museum in London. It seems that *Medemia* fruits were valued highly in ancient Egypt, though it is not known what that value may have been. Authors vary on the edibility of the fruit, Martius (1845) claiming that they are bitter and inedible, while others suggest that the

thin fruit flesh is sweet (Gibbons & Spanner 1996) and may have been acceptable to ancient tastes, especially to those living in the desert where fruit is scarce (Boulos 1968). It is also said that Nubian people processed *Medemia* fruits by burying them in the ground for some time to increase palatability (Täckholm & Drar 1950). The leaves are used for making mats and ropes (Täckholm & Drar 1950, Grant 1872, Boulos 1968). A tentative record of matting fragments in a predynastic tomb in Adaima in Upper Egypt has been reported (Newton 2001), which, if confirmed, would pre-date even the oldest fruit record. Of course, besides practical uses, *Medemia* may have held spiritual or ritualistic significance. It was cultivated in Thebes (Luxor) during the 18th Dynasty; in a list of 20 different trees grown in the garden of Enneni, an official of Thebes, 10 *Medemia* trees are recorded, along with 170 specimens of *Phoenix dactylifera* and 120 of *Hyphaene thebaica* (Täckholm & Drar 1950). *Medemia* also has a hieroglyphic name, *Mama-n-Khanen* (or *Mama-n-Xanin*), which differentiates it from *Mama*, the name for *Hyphaene thebaica* (Loret 1887).

### The living palm

The discovery of *Medemia* as a living palm came just eleven years after Kunth's study of Passalacqua's material was published. In 1837, the German Prince Friedrich Paul Wilhelm von Württemberg and the botanist Theodor Kotschy came upon the palm in Wadi Delah while exploring the Nubian Desert in northern Sudan. Material reached palm authority Carl von Martius who described it as *Hyphaene argun* in the third volume (second edition) of his monumental treatise *Historia Naturalis Palmarum* (1845). Martius states that von Württemberg referred to it in correspondence as *Medemia argun* and reported that Bedouin of the Ababda and Bisharian tribes call the palm *Argun*. The basis of von Württemberg's proposed generic name remains obscure to this day. The link between the living palm and Kunth's *Areca passalacquae* was made later by Unger (1859).

It was not until the German palm authority Hermann Wendland (1881) re-evaluated the borassoid palms that the genus *Medemia* was formally erected. Wendland also recognized two species, *M. argun* and *M. abiadensis*, based on minor fruit size differences, though subsequent authorities have not accepted this distinction and recognize only one species (Beccari 1908, 1924, Govaerts & Dransfield



2. An inflorescence with ripening fruit. Note also the bright yellow leaf petioles.





3. A fruit in section displaying the striking red ruminations and apical embryo.

2005). We have examined type material of *M. abiadensis* from the Paris herbarium (*d'Arnaud s.n.*, Sudan, 1843), which comprises fruits only. The fruits are unripe, which most likely accounts for the minor fruit difference, and based on this limited material no distinction between the species can be made. More importantly *d'Arnaud's* collection was allegedly made far to the south of all other records, although the accuracy of the locality information, which is reported ambiguously in the archive in Paris and in the literature, is questionable. Gibbons and Spanner searched extensively for *Medemia* in these reported areas but found only *H. thebaica* and *Borassus aethiopum* (Gibbons & Spanner 1999).

Throughout the 19<sup>th</sup> and early 20<sup>th</sup> century, sporadic sightings of *Medemia* were reported by explorers active in northern Sudan, and some specimens were also collected. Archived correspondence at the Royal Botanic Gardens, Kew indicates that *Medemia* was as mysterious and intriguing to botanists then as it is now. Among the most famous of explorers to come across *Medemia* were Captains John Speke and Augustus Grant, who found the palm in Sudan in May 1863 during their expedition to discover the source of the Nile. On their way northwards to Egypt, they took a short cut across the Nubian Desert from Abu Hamad until they met the Nile again at Koresko. They chanced upon *Medemia* at the isolated Wadi Soofur near the Egyptian border (Grant 1872).

### *Medemia* – alive in Egypt

The chance discoveries of *Medemia* in Sudan came to an abrupt halt shortly after the end of the 19<sup>th</sup> century, the last published record being that of *d'Albertis* who collected for *Beccari* in 1907 (*Beccari* 1908). However, the first evidence of living *Medemia* in Egypt began to surface at this time. The earliest mention was given by *Ernest Sickenberger* in 1901 who was informed by the *Ma'mur* (police chief) of El Kharga that an unbranched fan palm with small fruits, called *doleib*, occurs at Nakhila near to Kurkur Oasis in the Nubian Desert of Egypt. The record was considered uncertain because *doleib* applies to *Borassus* in Sudan, a genus that does not occur in Egypt. However, it was subsequently proved authentic by *Bahay Issawy*, an Egyptian geologist who visited Nakhila in 1964, taking both photographs and fruit specimens which support the record unequivocally (*Boulos* 1968, *Langlois* 1976). *Issawy* found just one adult female *Medemia* at Nakhila, which is figured in the account of *Langlois*, but noted the remains of five others that had been felled, perhaps by nomads collecting leaves or fruits.

The renowned Egyptian botanist *Loutfy Boulos* (1968) was the first to champion *Medemia* as "a member of the modern Egyptian flora." With *Vivi Täckholm* and *Mahmoud Zahran*, *Boulos* visited *Dungul Oasis* in November 1963, a remote and uninhabited site in the





4. Archaeological specimens of fruit from a Pharaonic tomb in Egypt held in the archaeological collections at Kew.

Nubian Desert west of the Nile, 160 km south-west of Aswan. The group discovered one tall female tree and seven juveniles (Boulos 1968, Zaharan 1968). The paper written by Boulos put *Medemia* on the map in Egypt and contained the first published images of the palm alive in the wild. However, earlier in the same year, though not reported until a decade later (Abdallah et al. 1972), three Egyptian sites to the east of the Nile were discovered at Wadi Difeit, Wadi Murra and Wadi Koresko by a team surveying the flora of Egyptian Nubia prior to the construction of the high dam at Aswan. Though many areas visited by this team were subsequently inundated by Lake Nasser, it seems that only the last of the three

*Medemia* sites, Wadi Koresko, would have been affected.

The frequent occurrence of *Medemia* fruits in offerings in the ancient tombs may indicate that the palm was more widely distributed in Egypt at that time. It has been stated that the ancient Egyptians imported *Medemia* from Upper Nubia, i.e. northern Sudan (Täckholm & Drar 1950), although we have not seen evidence to support this claim. Gibbons & Spanner (1996) suggested that trading routes through Dungul and Nakhila account for its presence as a cultivated introduction at these sites, implying that *Medemia* is not a native of Egypt (they were not aware of the sites

reported by Abdallah et al. (1972)). They appear to misinterpret the ancient road discussed by Täckholm and Drar (1950), which we understand to be a major route connecting upper and lower Nubia (i.e. northern Sudan and southern Egypt). We are not aware of trading routes at either Dungul or Nakhila. Evidence of human habitation has been found in Dungul, dating from a wet period in the Paleolithic (>20,000 BC; Hester & Hobler 1968). We accept that palms in general have been moved around desert oases by man and that the Egyptian *Medemia* sites have certainly been visited by nomadic people. However, given the relative proximity and similarity of these sites to those in northern Sudan (ca. 150–500 km), all of which fall within the Nubian Desert region that spans the political border, it seems more justifiable to assume that *Medemia* occurs naturally in Egypt until proven otherwise.

#### Recent exploration for *Medemia*

After the discoveries in Egypt, *Medemia* lapsed into obscurity once again, remaining unreported for more than three decades. Suspicions were raised that it might even have become extinct altogether (Uhl & Dransfield 1987), prompting the adventurous palm

enthusiasts and nurserymen Martin Gibbons and Tobias Spanner to resolve to rediscover the genus. They chose to hunt for *Medemia* in northern Sudan, rather than Egypt, aiming for the most frequently mentioned locality, Wadi Delah. In October 1995, they mounted a successful expedition to this site; their find of a *Medemia* population close to Murrat Wells was triumphantly reported in the pages of this journal (Gibbons & Spanner 1996). New scientific specimens as well as seeds were collected, facilitating the clarification of the morphology of *Medemia* as well as its introduction to cultivation. They also reported that mature trees are cut down by local people to harvest leaves for making rope. A year later, they found larger numbers of *Medemia* in Wadi Shagrib and estimated the population in that area to comprise around 1000 individuals (Gibbons & Spanner 1999).

Shortly after the rediscovery in Sudan, a team led by Irina Springuel of South Valley University, Aswan and Reinhard Bornkamm of the Technical University of Berlin surveyed Dungul Oasis in 1998 (Bornkamm et al. 2000). They found that the tall mother tree that had been so handsomely illustrated by Boulos (1968) was dead, its crown blown off and its

5. The entire Dungul Oasis population of *Medemia argun* viewed from the rim of the wadi. Note the tyre tracks indicating significant human activity in this fragile location. The dead trunk of the female palm reported by Boulos (1968) can be seen in the center of the population.







6. Majestic stands of *Hyphaene thebaica* also occur in Dungul Oasis. *Phoenix dactylifera* occurs in the distance.

trunk still standing to 10 m. However, the juveniles that Boulos had reported were healthy and had grown to more than 3 m with one reproductive female and four reproductive males. Moreover, 29 new juveniles of various sizes were found. In about 35 years, the *Medemia* population size in Dungul had grown from eight to 36.

#### Research on *Medemia* today

*Medemia argun* is a palm with a rich history, and yet it faces an uncertain future. Numerous reports, dating back to the late 19<sup>th</sup> century, suggest that *Medemia* is at risk of over-exploitation for its leaves in both Sudanese and Egyptian sites (Wright 1901, Täckholm & Drar 1950, Boulos 1968, Gibbons & Spanner 1996). Correspondence with the Royal Botanic Gardens, Kew in January 1897 indicates that the botanist Georg Schweinfurth feared that the species would be exterminated, while subsequent communications in March of that year relate that the Sirdar of the Egyptian army had ordered that the population near to Murrat Wells should be preserved. The observations made by Issawy in 1964 and Gibbons and Spanner in 1995 indicate that the felling of trees for leaf collection is a serious threat to *Medemia* even now. Although *Medemia* has survived, population size appears to be limited in Sudan and highly restricted in

Egypt. Moreover, the likely impact of climate change on *Medemia* in these critical sites is unknown.

Here we pick up the story. *Medemia* is an important piece of Egypt's cultural and biodiversity heritage, although few Egyptians are aware of this or of the extreme threat faced by the palm in Egypt and its habitat. In response to this, a project was initiated at the Unit of Environmental Studies and Development (South Valley University, Aswan) that aims to survey the Egyptian Nubian Desert for *Medemia*, to monitor its populations and work towards its conservation. The project began as research work for the first author's Masters degree, but has grown to involve collaboration with the Egyptian Environmental Affairs Agency (EEAA) and the Royal Botanic Gardens, Kew. Recently, the International Palm Society has provided generous funding for the initial exploration for Egyptian *Medemia* populations, and we report on that fieldwork here.

#### Dungul Oasis

Our first priority has been to revisit the site at Dungul and monitor the status of the *Medemia* population there (Fig. 5). Following on from the expedition of Springuel and Bornkamm's team in 1998, we visited Dungul again in 2001, 2002, 2005 and 2007. To reach the oasis, we drive 180 km on paved road from Aswan





7. A group of *Medemia* individuals of different stages, suggestive of multiple phases of recruitment.

towards Abu Simbel before turning off the road at an unmarked point and heading straight across the desert for 50 km. There are no tracks or wadis to follow. We navigate by major landmarks and trust in the skill of our experienced Nubian drivers but always carry GPS, compass and satellite phone. The desert is treacherous in places, changing suddenly from stable sand to deep silt as fine as wheat flour. In a single wheel spin, a vehicle can be bogged down to the axles. It is vital to take two vehicles in case of a breakdown, but this does not guarantee an easy ride. When the second author visited Dungul in 2005, we lost our first vehicle to clutch failure and, shortly after, nearly lost the second in the sand. We were saved only by the skill of Awad, our driver, who extricated us after some nerve-racking moments and then mended the damage to the engine. Exploring any remote desert site safely requires extremely careful planning and proper logistical support. A recent tragedy, in which the lives of two EEAA staff were lost in the Nubian Desert following a vehicle breakdown, reminded us how costly any mistake can be.

We do not drive to Dungul itself, but make a camp at the foot of the Sinn El Kadab plateau, some 3.5 km south of the oasis. The desert here lacks vegetation entirely but is not lifeless. Our camp is usually visited at night by Ruppell's sand foxes hoping to pick up food

scraps. Early the following morning, we climb the scarp and start our walk to Dungul. It is a different world on top of the plateau. At the very edge, just above our camp lies Dineigil Oasis, the southern part of the Dungul Oasis complex. It extends for about 1.5 km in a narrow strip only 200 m wide along a limestone ledge. The vegetation is dominated by the low, spiny legume shrub *Alhagi graecorum*, which here grows in remarkable parallel lines, following faults in the underlying rock. The site is dotted with a few acacias (*Acacia raddiana*, *A. ehrenbergiana*) as well as some large *Hyphaene thebaica* stands. Evidence of gazelles and invertebrates can easily be found showing how important these small vegetated areas are to desert animals.

To reach Wadi Dungul itself, we walk for the remaining 3 km across a spectacular landscape of sandy plains and blasted limestone canyons, with rock outcrops weathered by wind into remarkable shapes. We see no further plant life until we reach Little Dungul, a small area of vegetation close to Wadi Dungul occupied by a tamarisk hillock, some grass (*Imperata cylindrica*) and a lonely *Phoenix dactylifera*.

Shortly after Little Dungul, we come to the edge of Wadi Dungul, a beautiful view of the entire *Medemia* population opening up below us, with the trunk of the old dead mother tree

still standing in the middle. The population is separated from other palms in the valley. Farther to the east, some magnificent specimens of *Hyphaene thebaica* (Fig. 6) can be found along with more date palms.

At the last survey in 2007, 32 living *Medemia* palms were found growing in Dungul, comprising seven fertile adults (three females, four males) and 25 palms of varying sizes that have not yet flowered (Fig. 7). This represents a decline of four individuals since the visit of Springuel and Bornkamm in 1998 but an increase in the number of flowering females by two. In morphology, the palms match very well the description provided by Gibbons and Spanner (1996). The dead leaves are persistent on all of the palms, lending a shaggy appearance to the taller specimens in particular; clearly *Medemia* leaves are not harvested here. Carpets of fruits lie baking in the sun below the females. We have found evidence that gazelles and rodents feed on the fibrous fruit pulp. Even though some seeds become buried by blowing sand, it seems unlikely that any will be dispersed and germinate until significant rain falls. With at least 10 years between major rains, opportunities for recruiting juveniles are few and far between.

Our surveys at Dungul have resolved an outstanding mystery linked to the account of Boulos (1968) that was first raised by Langlois (1976). How could a lonely adult female have produced a cluster of juveniles? After 45 years, we found the answer; the remains of a male *Medemia* lie on the ground about 70 m from the famous old female reported by Boulos. From its weathered condition, it is clear that the palm fell many years ago, but it would once have stood about 9 m tall and bore many inflorescences which are still visible today.

During our visits to Dungul, we have monitored changes to the *Medemia* population, measured growth rates, gathered phenological data, collected seed for germination experiments and recorded human impacts on the site. The details of this work will be written up elsewhere. In summary, it is clear that despite a small loss of individuals over the past decade, the *Medemia* population at Dungul is currently healthy and has shown a dramatic increase in size since its first discovery by Boulos, Täckholm and Zahran in 1963. There is no evidence of these palms being exploited by man for their leaves or fruits. However, we have observed an intensification of human

activity in the Wadi. While we gain access to Wadi Dungul on foot, vehicle tracks are now widespread in the valley, especially around the *Medemia* population. Although this human activity in itself may not constitute a threat to the palms, it does place the palms at risk of accidental or malicious damage, by burning for example.

### Other sites in Egypt

In conducting a survey for *Medemia*, we aimed to revisit all known Egyptian sites, although to date we have been unable to locate guides who know a route to Nakhila Oasis. We also selected other potential *Medemia* localities in the Nubian Desert mostly to the south of Aswan based on their similarity in vegetation type to the known sites. We have now visited Kurkur Oasis, Kharga Oasis, parts of the Toshka Depression, and some small sites on the Sinn El Kadab Plateau, all locations to the west of the Nile. Except for Kharga, these remote sites can be reached only by four wheel drive vehicle. It is disappointing, then, to report that despite considerable efforts they yielded no sign of *Medemia*.

However, we have received reports from Bedouin in Wadi Allaqi of single palms that produce leaves that are good for making ropes. Wadi Allaqi, in the Nubian Desert to the east of the Nile, is close to the border with Sudan and to a reported Sudanese site of *Medemia* in Wadi Gabgaba, a main tributary of Wadi Allaqi. In April 2006, a group from South Valley University and EEAA led by Irina Springuel found a single unbranched palm in Wadi Neigit in the upstream part of Wadi Allaqi, ca. 50 km from the border with Sudan, which the first author later confirmed as a male *Medemia*. A juvenile some 2.5 m in height has also been located by the first author in another tributary of Wadi Allaqi known as Wadi Umm Gir (Fig. 8). In addition, a single juvenile palm has been found in Wadi Quleep, downstream of Wadi Allaqi, ca. 30 km from Lake Nasser. The Bedouin in this area call the palm *Elsaafa*, which means palm leaves in Arabic. We have also surveyed Wadi Gabgaba as far as the Sudanese border, but found no further *Medemia* palms.

### The future of *Medemia* in Egypt

The Nubian Desert ecosystems in which *Medemia* occurs are rare, fragile and of extreme importance not only to *Medemia* but also to the unique plant and animal communities that depend on them for resources in this harsh



environment. Clearly the future of *Medemia* in Egypt depends on the security of each site as a whole. Dungul Oasis has been proposed as a protected area, along with Kurkur, but this status has not yet been confirmed by Egyptian law. In a new phase of our work, we aim to conduct broad biodiversity surveys in the Egyptian Nubian Desert Oases that will provide essential baseline data to underpin the case for their protection and will draw public attention to their national and international importance. In addition, we aim to establish a program to increase public awareness of *Medemia*, its cultural significance and Nubian Desert biodiversity. As part of this, we have established an *ex situ Medemia* garden in 2003 that now contains 21 juvenile palms and has been used to supply local schools with *Medemia* seedlings. We intend to use the *Medemia* garden as a key part of community outreach work in the new project phase.

Finally, with the larger part of the world *Medemia* population being found over the border, it is vital to build links with Sudan if conservation is to be effective on a global scale. With the help of robust field knowledge and public awareness, *Medemia* has an important role to play in the region as a flagship species for conservation, which ultimately may bring long-term security not only to the mysterious

palm itself, but also to the critical Nubian Desert ecosystems that it inhabits.

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8. A lone, non-reproductive *Medemia argun* individual found in Wadi Umm Gir, Egypt. Leaves have been pruned by Bedouins for making ropes. Inexplicably, this palm also appears to have been burnt.



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# Population Structure and Reproductive Strategy of Two Multiple-Stemmed Rattans of Côte d'Ivoire

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Life history evolution is an important field of modern ecology (Stearns 1992, Begon et al. 2006). A useful approach is to compare the life histories of related organisms to determine how evolution has shaped the relation between different life history traits. In this context palms are suitable models to study perennial plant demography and life history (Barot & Gignoux 1999), because they are monocotyledonous that generally do not branch aerially. Consequently, it is easy to define, observe, and record stages based on morphological traits for palm trees. However, some palm species are able to generate several ramets (stems) from the same rhizome (De Granville 1977). So far this type of clonal behavior has not been frequently studied.

Three rattan genera endemic to Africa belong to this category (Sunderland 2003): *Eremospatha*, *Laccosperma* and *Oncocalamus*. Rattans constitute a large and diverse group of climbing palms, comprising an important assemblage of non-wood forest products that are extensively collected for household uses and cash income throughout the humid Old World tropics (Sastry 2002). Their exploitation generates important income either through industrial or handicraft activities (Siebert 2004, Zoro Bi & Kouakou 2004). In Côte d'Ivoire, Zoro Bi and Kouakou (2004) pointed out an increasing number of industrial and handicraft companies using rattan in Abidjan (capital of Côte d'Ivoire) and its suburbs. This trade is based on the exploitation of wild rattans, which could in the long-term result in the natural populations of these species becoming exhausted (Dransfield 2001). This risk is particularly serious for *Eremospatha macrocarpa* (G. Mann & H. Wendl.) H. Wendl. and *Laccosperma secundiflorum* (P. Beauv.) Kuntze, the two most exploited species (Zoro Bi & Kouassi 2004).

Despite their social and economic importance and the necessary development of sustainable practices of exploitation, very little is known about the ecology and population demography of these species. In this work, we focused our analyses on the population structure and the reproductive strategy of two species: *E. macrocarpa* and *L. secundiflorum*. The two species have distinct flowering types. *E. macrocarpa* is pleoanthic. Inflorescences develop from axillary buds. Consequently, ramets continue their growth after flowering (Sunderland 2003) with multiple flowering.

*Laccosperma secundiflorum* is hapaxanthic. Inflorescences are produced simultaneously towards the stem tip, and ramets (individual shoots of a clustering plant) die after flowering (Tomlinson 1990, Baker et al. 2000, Sunderland 2002). This suggests that the reproductive and demographic traits of these two species have co-evolved in relation to their flowering types (Stearns 1992, Begon et al. 2006). The two species are thus likely to have developed different demographic strategies, and these strategies should lead to different population structures. To test this hypothesis, we describe and compare some demographic traits of the two rattan species as well as their population structure. This is a prerequisite to analyze the demography of the two rattan species and in the long term to implement reliable management strategies to optimize harvesting practices. Such practices should be sustainable and guarantee an income to local populations. They would be usefully implemented in the whole geographic area where our two rattan species grow, but have to be based on solid knowledge about their life-histories. Our study is a first step in that direction.

## Materials and Methods

**Study site.** The study was conducted in the N'zodji forest (1086 ha) in South-Eastern Ivory Coast. This forest is located between 5°33'N and 5°43'N and between 3°49'W and 3°56'W. N'zodji forest is dense, wet and evergreen. The climate is wet and subequatorial, with an annual mean precipitation of 1350 mm and an annual mean temperature of about 25°C. Soils are ferrallitic and are derived from schist rocks (Dabin et al. 1960). For the last 11 years, the

**Table 1. Descriptions of the five stages used in the study**

Stages <sup>1</sup>	Leaves <sup>2</sup>	Ramet <sup>3</sup>	Sexual reproduction	Harvestable
Shoots (S)	No (arrowhead)	No	No	No
Rosette (R)	Yes < 15	No	No	No
Juvenile 1 (J1)	Yes	Yes < 6 m	No	No
Juvenile 2 (J2)	Yes	Yes > 6 m	No	Yes/No <sup>4</sup>
Adult (A)	Yes	Yes > 6 m	Yes	Yes

<sup>1</sup> J2 and A genets are found only in clumps while the three other stages can be in the two biological forms (solitary or clump).

<sup>2</sup> Leaves of the J2 and A stages are longer than those of the J1 and R stages

<sup>3</sup> J2 ramets are green; A ramets are brown

<sup>4</sup> Peasants harvest J2 ramets when A ramets become scarce

area of the N'zodji forest has been opened by the SODEFOR (the main institution involved in the monitoring and management of forests in Côte d'Ivoire) to the public for timber and other forest products. The site is covered by an evergreen forest dominated by *Musanga cecropioides*, *Tarrietia utilis* and *Diospyros gabunensis*. Forest canopy height averages 20–30 m.

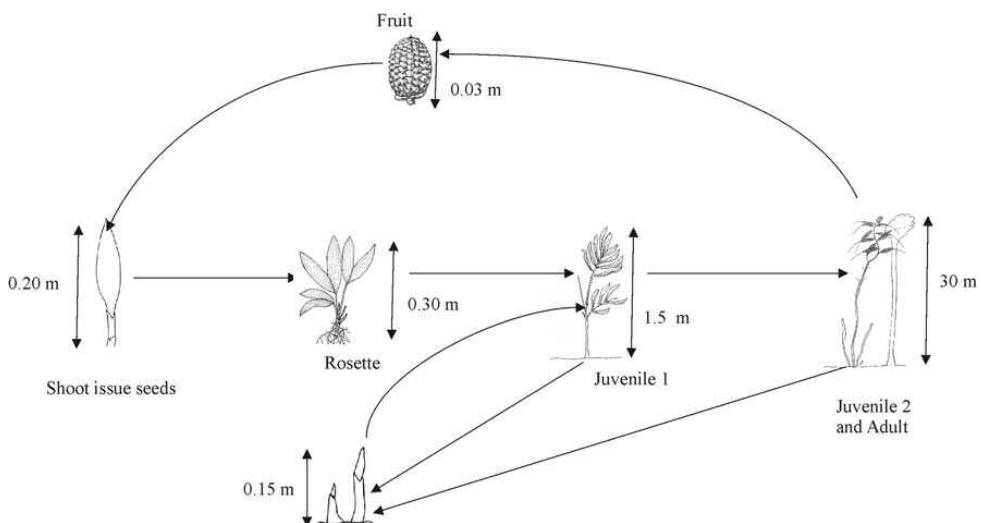
Three 200 × 200 m (4 ha) plots were established in the northern part of N'zodji forest. The first plot (Plot 1: 5°42'N, 3°52'W) is located on the outskirts of the forest. It corresponds to a secondary forest growing on well drained soils (mean soil moisture of 21%). In this plot, canopy trees have moderate heights (20 m). The second plot (plot 2: 5°41'N, 3°52'W) is located 3 km inside the forest. It is a semi-secondary forest growing on well drained soils (mean soil moisture of 17%). Canopy trees are of variable heights (20–30 m). The last plot (plot 3: 5°41'N, 3°51'W) is located 7 km inside the forest. It is a primary forest, less drained (mean soil moisture of 44%), with high canopy trees (30 m). The average altitude of the plots is 122 m. In this forest, five rattan species have been identified: *Calamus deerratus* (G. Mann & H. Wendl.), *E. macrocarpa*, *E. hookeri* (G. Mann & H. Wendl.) Wendl., *L. laeve* (G. Mann & H. Wendl.) Drude and *L. secundiflorum* (Zoro Bi & Kouassi 2004). The plots are representative of the whole forest as far as rattan densities are concerned.

**Study species.** In Africa, *L. secundiflorum* and *E. macrocarpa* are distributed from Liberia to

Angola. *Eremospatha macrocarpa* is an example of multiple-stemmed rattan with as many as 50 ramets (stems) per genet (genetically distinct individual) (Sunderland 2007). The climbing stem, with sheaths devoid of spines, can reach up to 30 m and have a small diameter (1–1.8 cm). Flowering is pleoanthic (Sunderland 2003). *Laccosperma secundiflorum* is also a multiple-stemmed climbing palm. Here, although the different ramets from a genet remain attached to the same rhizome we consider the production of new ramets as a form of vegetative reproduction (Tomlinson 1990). The climbing stems have spiny sheaths and can reach up to 30 m. They have a larger diameter than *E. macrocarpa* stems (3–5 cm diameter). Flowering is hapaxanthic. The fruits of these rattans are ellipsoidal and one-seeded. Those of *E. macrocarpa* are larger (2.5 cm in diameter, 2 cm in height and 15–20 rings of scales) while those of *L. secundiflorum* are relatively smaller (1.5 cm in diameter, 1 cm in height and 12 spiral rings of scales). These species are found in secondary or primary forest and often grow in canopy gaps (Sunderland 2003). Here, the harvest rate, defined as the number of ramets collected every six months per harvestable ramet (juvenile 2 and adult stages), varied according to the plot and the species. These estimates were 18–23% and 8–42% for *E. macrocarpa* and *L. secundiflorum*, respectively. The harvest rate was on the average higher in *L. secundiflorum* (Gore Bi 2004).

**Data collection and statistical analysis.** We defined five development stages for the two

#### 1. Life cycle of *Eremospatha macrocarpa* and *Laccosperma secundiflorum*.



species (Fig. 1): (i) shoot (S); (ii) rosette (R); (iii) juvenile 1 (J1), (iv) juvenile 2 (J2) and (v) adult (A). These stages were described using criteria traditionally (Tab. 1) used for palms (Bullock 1980, Chazdon 1992, Bernal 1998, Barot & Gignoux 1999). Shoots (S) are buds with undeveloped leaves. Rosettes (R) are plantlets bearing fully-developed leaves (< 15 leaves). It is worth noting that shoots quickly grow into rosettes (in less than 6 months). Juveniles 1 (J1) are individual ramets with green-colored stems, up to 6 m long. Juveniles 2 (J2) are individual ramets with harvestable green-colored stems. Adults (A) are sexually reproductive genets, characterized by brown ramets. In this study, clumps were considered as a single genet. Indeed, it has been shown from preliminary studies (Zoro Bi & Kouassi 2004) that ramets growing at more than 25 cm from each other belong to different genets, and those growing closer are always linked by a common rhizome. The stage of a genet was considered to be the stage of its more developed ramet.

The study was conducted in January 2004. A total of 1856 ramets of *E. macrocarpa* and 1277 ramets of *L. secundiflorum* were counted and described in all the plots.

To assess the effect of soil humidity on the abundance of rattans, each plot was divided in 25 (40 × 40 m) quadrats. In each quadrat, we assessed the percentage of moisture (H) on one soil sample collected in June, i.e. during the rainy season, between 0 and 15 cm, P1 being the weight of the fresh sample and P2 being the weight of the dried sample, H was calculated as follows:  $H = (P1 - P2) / P1$ . In each

quadrat, the abundance of the genets and ramets of the two species was also measured.

Fecundity by sexual reproduction was estimated during three successive six-month periods as the number of newly germinated shoots and rosettes. These shoots were attributed to the adults of the considered plot to assess the number of newly produced individuals by adult genet (Menges 1990).

Statistical analyses were implemented with the SAS statistical package (SAS 1999). We described the genet and ramet stage distributions, the ramet number by genet in each stage or all stages pooled together. Distributions were compared using log-likelihood tests. The effect of soil moisture on the abundance of the two rattan species was tested using PROC GLM procedure and the 25 quadrats of each plot as repetitions. The fecundities of the two species were compared through a GLM Repeated measured model using the three plots as repetitions (SAS 1999).

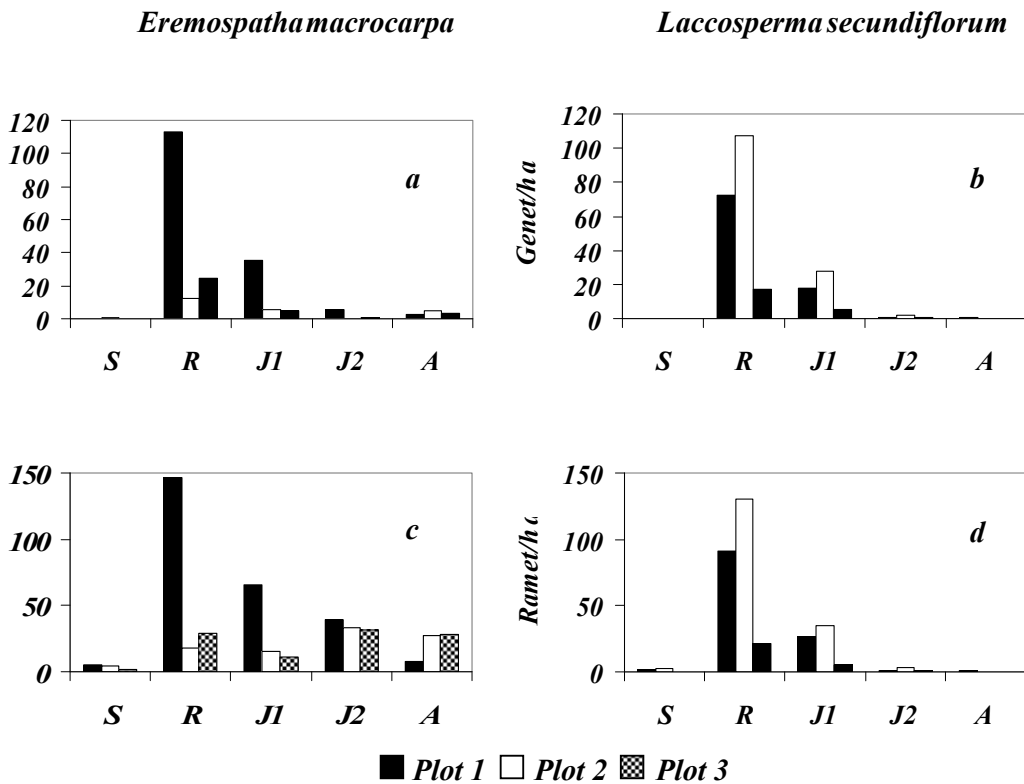
## Results

*Genet and ramet density.* An average of  $154.5 \pm 94.42$  and  $106.08 \pm 72.46$  ramets per hectare was found respectively for *E. macrocarpa* and *L. secundiflorum*. Ramet densities vary from 98 (plot 2) to 263.5 (plot 1) for *E. macrocarpa*, and from 27.50 (plot 3) to 170.25 (plot 2) for *L. secundiflorum*. An average density of  $71.17 \pm 74.26$  and  $83.92 \pm 57.85$  genets per hectare was found respectively for *E. macrocarpa* and for *L. secundiflorum*. Genet densities also vary from 33 (plot 3) to 156.75 (plot 1) for *E. macrocarpa*, and from 22.75 (plot 3) to 137.15 (plot 2) for *L. secundiflorum*. There was no

**Table 2. Log-likelihood ratio test (G) to compare the population structures of the two rattan species**

Structures	Plots	df	G	P
Genet distribution	Plot 1	3	16.67	0.003
	Plot 2	4	85.13	< 0.001
	Plot 3	3	17.20	< 0.001
Ramet distribution	Plot 1	4	125.87	< 0.001
	Plot 2	4	591.01	< 0.001
	Plot 3	4	145.11	< 0.001
Percentage of genets with more than one ramet	Plot 1	1	7.51	0.006
	Plot 2	1	50.70	< 0.001
	Plot 3	1	5.82	0.016





2. Genet and stem distribution by stage (S: shoots; R: rosette; J1: juvenile; J2: juvenile 2; A: adults) for the two rattan species and the three studied plots.

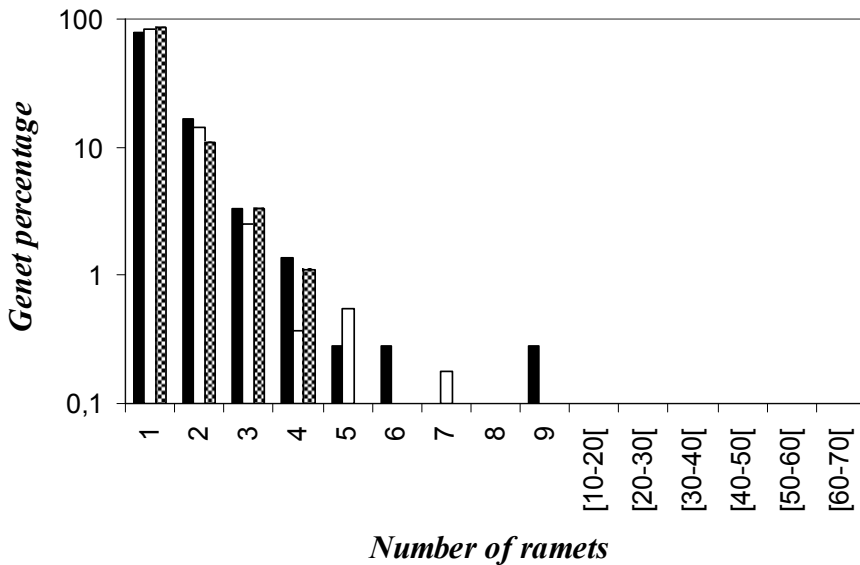
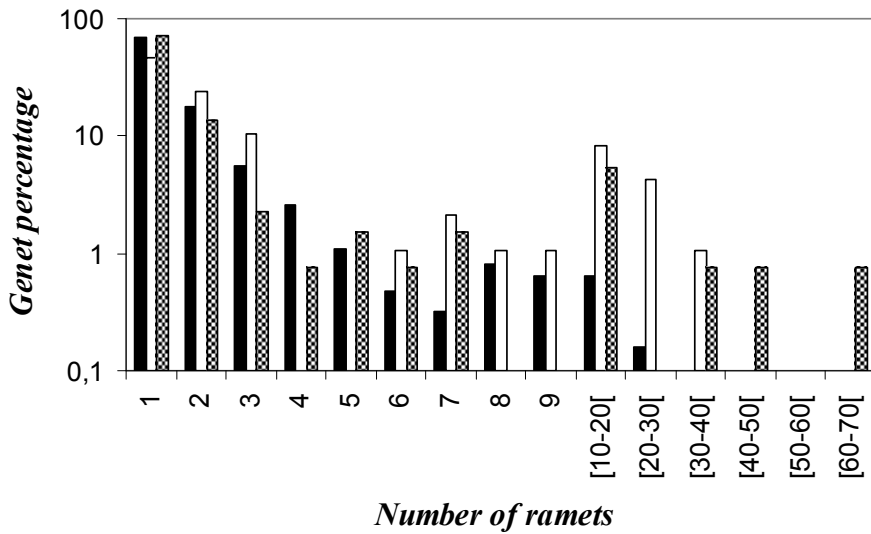
significant effect of soil moisture on the abundance of ramets and genets of the two rattan species (ANCOVA including both a plot and a moisture effect and the interactions between the two factors).

**Genet stage distribution.** For *E. macrocarpa*, the rosette stage was the most abundant and genet proportion gradually decreased from the rosette to the juvenile 2 stage and slightly increased at the adult stage in the plots 2 and 3 (Fig. 2a). *Laccosperma secundiflorum* (Fig. 2b) presented the same pattern, but the frequency of genets did not increase from the juvenile 2 to the adult stage. For each plot, the genet stage distributions of the two species were significantly different (Tab. 2).

**Ramet stage distribution.** For the two rattan species the percentage of genets and ramets in the shoot stage is very low, probably due to a low residence time of ramets in this shoot stage. Genet and ramet stage distributions were very similar for *L. secundiflorum* and *E. macrocarpa* (Fig. 2). For this species, the ramet percentage per stage decreased from the rosette to the adult stage less than the genet

percentage. While the ramet stage distributions of the two species were significantly different ( $P < 0.001$ ) in all plots (Tab. 2) percentages of genets and ramets per stage are highly variable between plots.

**Number of ramets per genet.** The percentage of genets in the different classes of ramet number was a decreasing function of the ramet number (Fig. 3). It decreased respectively from 71.96 to 0.76% and from 82.2 to 0.18% for *E. macrocarpa* and *L. secundiflorum*. Approximately 63 and 82% of genets has only one ramet for *E. macrocarpa* and *L. secundiflorum* respectively. The maximum numbers of ramets per genet were respectively 70 and 9 for *E. macrocarpa* and *L. secundiflorum*. The mean number of ramets per genet of the adult stage is much higher for *E. macrocarpa* (2.17 ramets) than for *L. secundiflorum* (1.26 ramets). Log-likelihood test showed that in two plots (1 and 2) the distributions of the number of ramets per genet of the two species were significantly different (plot 1:  $G = 7.02$ ,  $P = 0.009$ ; plot 2:  $G = 34.81$ ,  $P < 0.001$ ; plot 3:  $G = 2.91$ ,  $P = 0.094$ ).



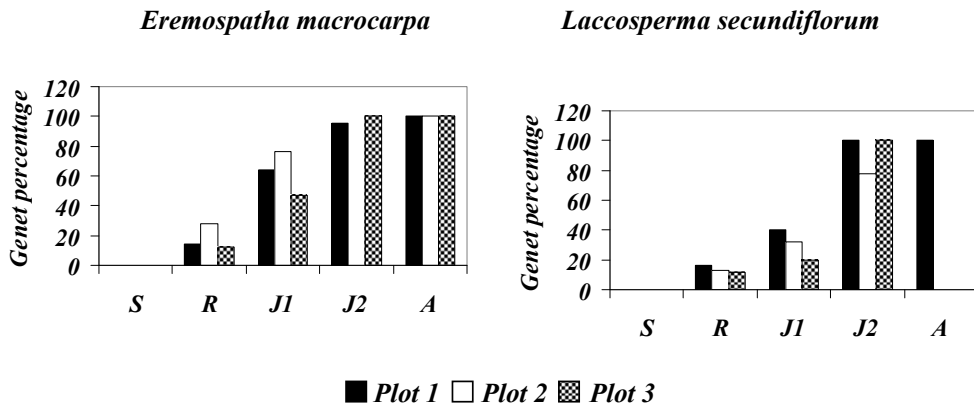
■ Plot 1 □ Plot 2 ▨ Plot 3

3. Distribution of the number of ramets per genet for the two rattan species in the three studied plots. Upper graph shows data for *Eremospatha macrocarpa*; lower graph shows data for *Laccosperma secundiflorum*. The y-axis has a logarithmic scale.

*Percentage of genets in clump.* For the two species and in all the plots, the percentage of genets in clump, i.e. having already started vegetative reproduction, increased from the rosette to the adult stage where it reached 100% (Fig. 4). For each plot, the percentage of genets in clump by stage was significantly higher for *E. macrocarpa* than for *L. secundiflorum* (Tab. 2). This percentage increased more quickly along

the successive stages for *E. macrocarpa* than for *L. secundiflorum*. This suggests that vegetative reproduction starts earlier in *E. macrocarpa* than in *L. secundiflorum*.

*Sexual fecundity.* The average fecundity was  $0.12 \pm 0.09$  new individuals (shoots and rosettes) per year per adult genet for *E. macrocarpa* and  $0.89 \pm 0.92$  for *L. secundiflorum*.



4. Percentage of genets growing in clumps per genet stage for the two rattan species in the three studied plots (S: shoots; R: rosette; J1: juvenile; J2: juvenile 2; A: adults).

The difference between the two species for this parameter was significant (repeated-measures ANOVA,  $F = 14.13$ ,  $P = 0.023$ ).

### Discussion

**Genet and ramet densities.** We did not find a clear relationship between harvest rates and ramet or genet densities. This could be due to a weak effect of ramet harvesting on survival and growth of rattan genets (Siebert 2004).

Siebert (2004) showed that ramet harvesting seems to stimulate the production of new ramets and that a repeated harvest only reduces the average ramet length. The harvest rate of *L. secundiflorum* ramets was higher in plot 2 (43%). For *E. macrocarpa*, this rate was higher in plot 1 (23%). The high densities of *L. secundiflorum* and *E. macrocarpa*, in plots 1 and 2 respectively, are likely to make harvesting more attractive and efficient in these plots and could also lead to the high harvesting rates of these plots. This suggests that human exploitation does not threaten the studied population of the two rattan species, at least for the moment, after 11 years of exploitation.

Differences observed between species abundances can be explained by their reproductive biology and/or their growth requirements (Siebert 1993). For many rattan species, higher light intensities generally result in higher growth rates (Bøgh 1996, Siebert 2005, Sunderland 2007). According to Sunderland (2007) *E. macrocarpa* is extremely light demanding, occurring naturally in forest gaps and forest margins. *L. secundiflorum* is more shade tolerant and is present as slender

climbers under the canopy of mature forests. Thus, the paucity of genets and stems of *E. macrocarpa* in plot 3 might be related to its high light requirement, given that tree density and canopy height are higher in this plot than in the two others. Besides, rattans are generally more abundant on well drained soils (Bøgh 1996, Siebert 2000, Siebert 2004). However, no effect of soil moisture on the abundance of the two rattan species was found. This suggests that the level of drainage in our plots is sufficient to provide suitable conditions to the two rattan species. Other differences observed between the abundances of the two rattan species in the three plots remain difficult to explain. Of course, censuses of the two rattan species in many plots of different forests are necessary to determine with certainty the factors influencing their densities. It would also be useful to study rattan abundance at a lower spatial scale (10 × 10 m), i.e. the scale at which the local structure of the forest determines the availability of light and the presence of suitable trees to support the climbing rattan ramets.

**Demographic strategies of the two species.** Genet and ramet distributions of many palm species have been reported (Bernal 1998, Barot & Gignoux 1999, Siebert 2000, Escalante et al. 2004, Barot et al. 2005, Widyatmoko et al. 2005). Authors showed that genet densities and frequencies by stage decrease overall from the juvenile to the adult stage. This general pattern in plants is due to the high mortality rates usually found in the first stages. Such a high mortality could be explained by the effect of environmental stress and intraspecific competition that should be higher for less

**Table 3. Various demographic characteristics of *Eremospatha macrocarpa* and *Laccosperma secundiflorum***

	<i>E. macrocarpa</i>	<i>L. secundiflorum</i>
Flowering mode	Pleioanthic	Hapaxanthic
Stem diameter	Thin (1.0–1.8 cm)	Large (3–5 cm)
Fecundity by sexual reproduction	Lower	Higher
Vegetative reproduction	Higher	Lower
Fruit size	2.5 cm long x 2 cm diam.	1.5 cm long x 1 cm diam

developed stages characterized by smaller genets storing less resources.

*Eremospatha macrocarpa* has more ramets per genet (individual) than *L. secundiflorum*. This explains why the ramet and genet stage distributions are different for *E. macrocarpa* but identical for *L. secundiflorum*. Genet stage distribution is slightly bimodal for *E. macrocarpa* in plot 2 and 3, i.e. more adults than juveniles 2, but not for *L. secundiflorum*. A bimodal distribution was already mentioned for several solitary and clumping palms (Enright 1985, De Steven 1986, De Steven 1989, Eguiarte et al. 1993, Bernal 1998, Barot & Gignoux 1999, Siebert 2000, Escalante et al. 2004, Widyatmoko et al. 2005). Enright (1985) showed that the accumulation of slow-growing individuals in the larger stages was the cause of size bimodality in *Rhopalostylis sapida*. This structure would be due to relatively high genet survival rates in larger size classes (here the adult stage) and relatively high recruitment rates to the adult stage. In the case of *E. macrocarpa*, adults having survived in the first stages grow quickly and accumulate in the multi-stemmed adult stage. The unimodal stage distribution for *L. secundiflorum* genets could be due to a higher mortality rate at the adult stage. This high death rate could be due to the hapaxanthic flowering of this species, if a higher ramet mortality leads to a high genet mortality. Similarly, *E. macrocarpa* has a bimodal ramet distribution (more adults and juveniles 2 than juveniles 1 in plot 2 and 3) while *L. secundiflorum* has a unimodal ramet distribution. This suggests that ramet survival is higher for *E. macrocarpa* than for *L. secundiflorum*. This should again be due to their different flowering modes.

The average number of ramets per genet varies between plots but is higher for *E. macrocarpa* than for *L. secundiflorum*. Such an interspecific variation in the number of ramets by genets

has already been highlighted (De Steven 1989, Siebert 2000, Escalante et al. 2004, Widyatmoko et al. 2005). Using these published studies, we have tried to test whether high or low numbers of ramets per genet could be respectively associated with pleioanthic and hapaxanthic palms. However, no general rule was found. Nevertheless, the difference observed between *E. macrocarpa* and *L. secundiflorum* should be explained by a higher ramet survival (pleioanthic flowering vs. hapaxanthic) and/or by a more intense vegetative reproduction (higher rate of stem production) of *E. macrocarpa* compared to *L. secundiflorum*.

Although *L. secundiflorum* and *E. macrocarpa* are two multiple-stemmed palms growing in the same environment they have different life history characteristics (Tab. 3). Ramet diameter ranges between 1 and 1.8 cm for *E. macrocarpa* and 3 and 5 cm for *L. secundiflorum*. Moreover, according to Sunderland (2007), the relatively higher proportion of thick-walled fibers and narrower diameter of metaxylem vessels in the ramets of the *Laccosperma* genus suggests they have a greater density and hence are mechanically more resistant than the ramets of *Eremospatha*. Together with their smaller diameter, this suggests that *E. macrocarpa* ramets are less costly to be produced than *L. secundiflorum* ramets but are probably more fragile. Indeed, increasing stem diameter and producing physically resistant structures decreases the risk of stem bending or breaking (through branch and tree falls) for understory palms (Svenning, 2000).

Genets must distribute their resources between the basic biological functions (growth, maintenance, reproduction). If they increase the resource allocation to a function, they must decrease the resource allocated to the other functions. This leads to the concept of trade-off (Stearns & Hoekstra 2000, Saenz &



Guariguata 2001) and obliges species to adopt different allocation strategies and thus different demographic strategies. The ramet diameter of *E. macrocarpa* is thin and corresponds to a lower resource investment than for *L. secundiflorum*. For this reason, *E. macrocarpa* ramets probably grow more quickly than *L. secundiflorum* ramets, and *E. macrocarpa* starts reproducing vegetatively earlier in its life-cycle. This would be a hint of a trade-off between the ramet diameter and the number of produced ramets. Such a trade-off would be the equivalent for vegetative reproduction of the classical trade-off between offspring size and fecundity (Stearns & Hoekstra 2000). Of course, complementary data would be necessary to support further the hypothesis of such a trade-off. It would for example be useful to be able to assess the biomass of whole ramets to measure more accurately the resource investment in each ramet.

Our results suggest that there is a low fecundity by sexual reproduction for both *E. macrocarpa* and *L. secundiflorum* (numbers of new individuals in the shoots stage). However, this fecundity seems to be lower for *E. macrocarpa* than for *L. secundiflorum*. This suggests that there is a trade-off between vegetative and sexual reproduction. Besides, the fruits of the two species contain 1–3 seeds, but the fruits of *E. macrocarpa* are larger than those of *L. secundiflorum* (Sunderland 2003). The lower fruit size and the higher fecundity of *L. secundiflorum* push this species towards the *r* pole in the continuum between *r* and *K* demographic strategies. On the contrary, the lower potential for vegetative reproduction of *L. secundiflorum* seems to push this species towards the *K* pole. This apparent contradiction could result from the suggested trade-off between sexual reproduction and vegetative reproduction. These results cast some doubts on the applicability of a theory classifying demographic strategies on a unique *r*–*K* axis, especially for species with both sexual and vegetative reproductions. However, it can be argued that the production of new ramets in the two rattan species does not correspond to vegetative reproduction: it does not increase the number of genets. Moreover, a high potential for new ramet production, as in *E. macrocarpa*, can be considered as a strategy to increase individual size and longevity. It allows colonizing local canopy gaps but does not directly help colonizing a whole forest. Moreover, pleonanthly is likely to increase further the longevity of ramets and genets of

this species. In this way, *L. secundiflorum* (lower longevity and individual size, higher fecundity by sexual reproduction) would be closer to the *r* pole than *E. macrocarpa*.

Finally, the different life history strategies observed for our two rattan species are probably linked evolutionarily to their different flowering types. However, the life-cycle of other multi-stemmed palms should be studied to test whether pleonanthic and hapaxanthic palms are characterized by the same demographic syndromes as *E. macrocarpa* and *L. secundiflorum* and to study the precise nature of underlying trade-offs. As a test of these hypotheses, it remains to compare directly the quantity of seeds produced by the genets of the two species, as well as the rate of germination of their seeds. It also remains to estimate the ramet and genet survivals in the different stages. This would also help construct population matrix models. These models would allow us to describe in a synthetic way the demographic strategies of the two rattan species and to evaluate better the relative importance of the sexual and vegetative reproductions of these two species for the growth rate of their populations (Caswell 2001). In the long term, constructing and parameterizing these models should also help in designing sustainable harvesting practices optimized for the demographic strategies of the two rattan species.

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# The Palms of the Makiling Botanic Gardens, Philippines



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1. *Heterospathe califrons* (in the lower right) welcomes visitors to the gardens and hints at the palms within.

The native palms of the Philippines are featured in a botanical garden operated by the University of the Philippines, Los Baños. It is the best place to see the country's unique palms.

Along the slopes of Mt. Makiling, less than two hours from the bustling sprawl of Manila, lies the Makiling Botanic Gardens, in Los Baños, Laguna. The 300-hectare area now occupied by the garden was first recognized by the Americans during the colonial times as the Makiling National Botanic Garden by virtue of Executive Order No. 47 issued on 4 December 1920 by Francis Burton Harrison, then Governor-General of the Philippine Islands (McLean 1921). However, it was not until 20 June 1963 that the garden was formally established by Republic Act No. 3523 by then President Diosdado Macapagal and placed under the jurisdiction of the University of the Philippines. In the past four decades, the Makiling Botanic Gardens has amassed a significant collection of palms, most of which are native Philippine species.

A massive stone marker and the entrance gate provide tastes of the palms therein. The entrance gate (Fig. 1) boasts *H. califrons*, while the marker (Fig. 2) is planted with *Heterospathes scitula*. Both species are endemic to the Philippines. *Heterospathes scitula* is small, thin-stemmed palm with narrow leaflets. *Heterospathes califrons* (Fig. 3) is a short-stemmed, solitary palm with sturdy, undivided leaves. It is endemic to ultramafic soils on the island of Mindanao but is growing well in the volcanic soils of Mt. Makiling. This species was described relatively recently (Fernando & Sotalbo 2001), but already it is proving to be a valuable ornamental in both sun and shade.

Just beyond the entrance gate lies a collection of several native palms including *Pinanga copelandii* (Fig. 4), *Pinanga bicolorana* and *P. heterophylla*. *Pinanga copelandii* is a single-trunked species with a stem ca. 10 cm in diameter and a purplish crownshaft. Like *P. bicolorana*, its broad, multi-nerved segments are mottled on young plants (Fernando 1988). *Pinanga bicolorana* is restricted to the Bicol National Park in southeastern Luzon, hence its name. *Pinanga heterophylla* (Fig. 5) has clusters of slender stems and graceful leaves. It is used as an elegant and effective screen. *Heterospathes intermedia* is a single-stemmed palm, which like so many species in this genus has great – but largely untapped – horticultural potential. Also in this area are several tall specimens of *Livistona saribus*, *L. rotundifolia* and a towering *Orania palindan*.

Adjacent to the visitor center are the clustering *Licuala spinosa*, a solitary *Pinanga maculata* and a group of *Areca catechu*. Slightly down the

slope of the Molawin creek valley, lies a clustering palm of great interest. The palm is *Oncosperma gracilipes* (Fig. 6), a poorly-known species endemic to Luzon and Biliran Islands. The stems are about 6 m tall and spiny, but the crownshafts are a distinctive orange, a color not seen in other species of *Oncosperma*. Like so many of the palms here, *O. gracilipes* is not cultivated outside this botanical garden. Cultivation may be the only way to save this palm, which is threatened in its native habitat by deforestation.

A series of concrete paths and steps makes a steep descent to the creek, where small plants of *Arenga pinnata* are the most common palm of the forest understory. *Caryota rumphiana* is also common along the creek, although one rarely finds specimens whose leaves have not been broken by falling branches from the towering hardwood trees that make up the forest. A specimen near the bridge, growing away from its taller neighbors, bears a crown of leaves in good condition (Fig. 7).

2. A stone marker for the gardens displays *Heterospathes scitula*.





### Checklist of the Native Philippine palms cultivated at the Makiling Botanic Gardens

*Adonidia merrilli* Becc.  
*Areca camarinensis* Becc.  
*Areca catechu* L.  
*Areca costulata* Becc.  
*Areca parens* Becc.  
*Areca ipot* Becc.  
*Arenga pinnata* (Wurmb) Merr.  
*Arenga tremula* (Blanco) Merr.  
*Arenga undulatifolia* Becc.  
*Caryota cumingii* Lodd. ex Mart.  
*Caryota mitis* Lour.  
*Caryota rumphiana* Mart. var. *philippinensis* Becc.  
*Corypha utan* Lamk.  
*Calamus aidaae* Fernando  
*Calamus caesius* Blume  
*Calamus discolor* Mart.  
*Calamus merrillii* Becc.  
*Calamus ornatus* Blume  
*Daemonorops mollis* (Blanco) Merr.  
*Heterospathe elata* Scheff.  
*Heterospathe califrons* Fernando  
*Heterospathe cagayanensis* Becc.  
*Heterospathe scitula* Fernando  
*Heterospathe intermedia* (Becc.) Fernando  
*Heterospathe philippinensis* (Becc.) Becc.  
*Korthalsia laciniosa* Mart.  
*Licuala spinosa* Wurmb.  
*Livistona merrillii* Becc.  
*Livistona robinsoniana* Becc.  
*Livistona rotundifolia* (Lam.) Mart.  
*Livistona saribus* (Lour.) Merr. ex A. Chev.  
*Oncosperma gracilipes* Becc.  
*Orania palindan* (Blanco) Merr.  
*Pinanga bicolorana* Fernando  
*Pinanga copelandii* Becc.  
*Pinanga curranii* Becc.  
*Pinanga egregia* Fernando  
*Pinanga geomiformis* Becc.  
*Pinanga glaucifolia* Fernando  
*Pinanga heterophylla* Becc.  
*Pinanga insignis* Becc.  
*Pinanga maculata* Porte ex Lem.  
*Pinanga modesta* Becc.  
*Pinanga philippinensis* Becc.  
*Pinanga speciosa* Becc.  
*Pinanga urosperma* Becc.



3 (top). *Heterospathe califrons* has undivided leaves.  
 4. (bottom) *Pinanga copelandii* is an attractive solitary palm with a purplish crownshaft.





5. *Pinanga heterophylla* is a clustering species.

The road leading to the gardens' nursery is lined with Philippine endemic trees, most of which bear the species epithet "philippinensis." Here visitors can see a mature planting of the most widely grown Philippine palm in the world, *Adonidia merrillii*. The palm is so commonly planted in the capital city, that its local common name is Manila Palm. The golden variety of *A. merrillii* can be found just outside the main gate, across from the entrance kiosk. This variety, which bears yellowish-green leaves, is popular in Thailand and is increasingly grown in other places in the world wherever *A. merrillii* thrives.

Across the creek and up a series of steps lies the Palmetum. Here, one can find a selection of climbing palms or rattans notably *Calamus merrillii* and *Korthalsia laciniosa*. A careful inspection of *C. merrillii* reveals that it forms branches that appear to emerge from the internodes. This phenomenon has earlier been described in detail (Fernando 1987). These branches produce roots and have the potential, if the cane on which they form touches the ground, of rooting and growing out as new plants.

Also found here are native understory species including *Heterospatha cagayanensis*, *H. scitula*,

*H. elata*, *Pinanga insignis*, *P. glaucifolia*, *P. speciosa*, *Caryota cumingii*, *C. mitis*, *Areca camarinensis*, *A. catechu*, *A. costulata*, *A. parens* and *A. ipot*. The specimens of *A. ipot* are still young and are just beginning to flower. Several *Livistona robinsoniana* and *L. merrillii* stand gallantly near the pathway.

An especially large palm, *Corypha utan*, grows along the road in the nursery area, although none of the specimens is fruiting at this time. It is native to NE India to N Australia, including the Philippines and, although it makes a handsome landscape accent, it is rarely planted as an ornamental in the Philippines. Nevertheless, this species is widely cultivated in rural areas as source of materials for making bags, hats and mats.

Also within the nursery area are other native palms, including *Arenga undulatifolia* *Heterospatha philippinensis*, *Pinanga curranii*, *P. egregia*, *P. geomorformis*, *P. modesta*, *P. philippinensis* and *P. uosperma*.

Landscapers and homeowners in the Philippines are demanding exotic palms, such as *Dypsis madagascariensis* and *Wodyetia bifurcata*, while snubbing native species (with the exception of the Manila Palm). It is a great





6. *Oncosperma gracilipes* is a spiny, clustering palm with an orange crownshaft.

pity that local gardeners and landscapers do not embrace the native palms. As the Makiling Botanical Gardens so readily demonstrate, the palms of the Philippines are a diverse and beautiful group.

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7. *Caryota rumphiana* grows throughout the forested areas of the gardens.

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# Discovering Africa's Newest Palm

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1. *Borassus akeassii*, Africa's newest palm. This fruiting specimen was found outside Banfora.

In 1996, a paper was published discussing the identity of a palm in the genus *Borassus*, occurring only in West Africa. It was identified as *B. flabellifer*, the Asian palmyrah palm, previously unknown in Africa. This paper recounts the story of an expedition to find and document these palms, resulting in the description of *Borassus akeassii*, Africa's newest palm species.



The palm flora of mainland Africa is famous for its lack of diversity. Compared with the other tropical regions in the Americas and Southeast Asia, Africa hosts only a fraction of the number of palm species and genera (Dransfield 1988). Indeed the island of Madagascar, off Africa's east coast, holds three times the number of palm species as does the whole African continent, despite being only a fraction of the size (Dransfield & Beentje 1995).

*Borassus* is widely distributed across sub-Saharan Africa, and in West Africa is a familiar part of the landscape. It is known by the name *rônier* in Francophone Africa, a name derived from the Wolof word *rôn*. *Borassus aethiopum*, previously the only species recognized in mainland Africa (Tuley 1995), is widely utilized by the local populace and did not seem to offer any difficulties of identification. It was therefore surprising when Aké Assi and Guinko (1996) published a description of a *Borassus* palm in West Africa (Fig. 1), which differed significantly from *B. aethiopum*. They were of the opinion that it most resembled *B. flabellifer*, the palmyrah palm of Southeast Asia.

In 2001, RPB began a project to revise the genus *Borassus*, as part of his Ph.D. studies. The taxonomic revision is now published (Bayton 2007). Two years earlier, AO (1999) completed a Masters thesis investigating *Borassus* in the West African state of Burkina Faso. Subsequently, he published a brief account of his work (Ouédraogo et al. 2002).

In 2004, a joint fieldtrip to Burkina Faso was organized, during which the palm described by Aké Assi and Guinko (1996) was collected and later identified.

### Burkina Faso

Burkina Faso is a landlocked country in West Africa, on the southern edge of the Sahara. The climate is characterized by two contrasting seasons: a rainy season lasting 3–6 months and a dry season lasting between six months (in the south) and nine months (in the north). The northern third of the country occupies part of the Sahel zone, a semi-arid region with typically under 600 mm precipitation annually. In the southwest corner of the country, precipitation reaches its maximum at about 1300 mm per year. Consequently, the vegetation in the southwest (mainly dry forest and riparian forest) is the most diverse.

Our expedition began in Burkina Faso's capital, Ouagadougou (pronounced 'Wagga-doo-goo'), situated in the heart of the country. Ouagadougou is home to many mature *Borassus* palms (they are often planted as street trees), including several within the grounds of the Presidential Palace. While these were not accessible, the numerous immature specimens in the grounds of the Université de Ouagadougou provided us with our first opportunity to assess the differences between the two *Borassus* taxa. The university is the home institute of AO, and most of the palms in its grounds were planted by him in 1998.

2. Semi-managed population of *B. aethiopum* near Pama. Note the watermelons growing below the palms.



The *Borassus* palms of Burkina Faso can be divided into two groups. Those with yellow fruits, presumably *B. aethiopum*, which occur in the eastern provinces of Boulgou, Ganzourgou, Gourma, Kompienga, Koulpélogo, Kouritenga and Tapoa. Those with green fruits at maturity, the putative *B. flabellifer*, occur in the western provinces of Houet, Kéné Dougou, Léraba and Comoé. Therefore two excursions, one to the eastern provinces and one to the western provinces, were arranged. The primary purpose of the fieldwork was to gather herbarium specimens, pollen, DNA samples and other data from the *Borassus* palms.

### The Palms of the Eastern Provinces

Our first excursion took us to the village of Pama in Kompienga Province. Pama borders a vast population of the yellow-fruited *Borassus*. The palms appear to be a wild, naturally-occurring population, though they are much influenced by man. The ground beneath the palms is used to grow crops, particularly watermelons (Fig. 2). The leaves are harvested (Fig. 3) for use in construction (the rigid petioles) and thatching (the lamina), while the hypocotyls (swollen base of seedlings) are consumed. When eaten raw, they have a flavor that is intermediate between peanuts and coconut flesh. A second population was examined in Arly National Park in Tapoa Province (Fig. 4). These palms line the banks of the Pendjari River, which forms the natural boundary between Burkina Faso and Benin. They are protected from human interference, but were recently damaged by a wildfire. The amazing resilience to fire demonstrated by *Borassus* is impressive. Even though the ground was still dry and blackened, *Borassus* seedlings stood out as their fresh, green growth erupted from below ground, despite the fact that all their older leaves had been destroyed. The collections made in Pama and Arly confirmed the identity of the yellow-fruited palm as *B. aethiopum*. The leaves had the distinctive large, rose spines on the margins of the petiole and the stem was prominently ventricose. In other populations of *B. aethiopum* visited by RPB (e.g. Kenya, Malawi), the mature fruits were orange. However, there is variation in this character as the fruits in Burkina Faso were yellow (Fig. 5), while a population in Cameroon had red fruits (J. Dransfield pers. comm.).

On our journey back to Ouaga, we visited the village of Tambarga (between Arly and Pama). Along the River Karbonga was a small grove of

*Raphia sudanica*, numbering several dozen trees. They were taking advantage of a permanent water source and were growing with the base of their stems submerged in the somewhat stagnant water. Within the grove, the air was cool and provided respite from the oppressive heat. The respite was however short-lived as we had to collect herbarium specimens and seeds from these large and rather spiny palms. Each palm was approximately 15 meters tall and each individual leaf had over 120 pairs of leaflets. The massive, almost woody midrib is used in construction of furniture, wall paneling and fencing. After getting very wet, we managed to gather the required material, including several of the orange, scaly fruits.

### The Palms of the Western Provinces

On our second expedition, Dr. Paulin Ouôba joined us. We traveled via Burkina Faso's

3. *Borassus aethiopum* near Pama; the lower leaves have been harvested by local people. Note the distinctive spiral arrangement of the leaf bases and the inflorescences emerging from the upper leaf axils.







4 (left). Mature *Borassus aethiopum* survives fire unscathed in Arly National Park. 5 (right). Female yellow-fruited *Borassus aethiopum*, growing near Pama, Burkina Faso.

second city of Bobo-Dioulasso to the city of Banfora in Comoé Province. While *Borassus aethiopum* forms discontinuous populations in the east of the country, after leaving Bobo, stands of *Borassus* become increasingly common. In Comoé Province, they can stretch as far as the eye can see. This, the wettest part of Burkina Faso, is a major cotton-growing region, providing considerable wealth for the country. Maize, sorghum and rice are the main food plants and these crops cover large areas underneath the ever-present *Borassus* palms (Fig. 6).

With the abundance of *Borassus* in the vicinity of Banfora, it was not difficult to collect ample specimens, though it was necessary to gain permission from the land owners before proceeding, as the palms are a valuable commodity. Immature fruits are gathered and cut open to expose the endosperm, which is soft and sweet. The leaves are used for weaving and particularly basketry. However, the prime resource extracted from the palm is the sweet sap, which is bottled (often in old red wine bottles) and then fermented by the simple process of leaving the bottle in the sun. Roadside vendors selling 'vin de palmier' are

common in Comoé; their bottles of wine are lined up along the road with the froth of fermentation bubbling out of the open bottle. The alcohol content of these wines is extremely variable, depending on how long the bottle has been sitting outside, but there is a wine to suit every palate, and it is sold by the cup (actually a bottle gourd bowl). Palm sap is harvested by cutting a hole through the upper part of the palm heart (Fig. 7); a bowl is suspended under the cut to collect the sap. The cut is renewed periodically by cutting a further slice out of the heart. This process is eventually fatal, and it is true that there are many dead *Borassus* stems in every population in Comoé. However, harvesting is stopped after several days to ensure the plant's survival. A side effect of this process is that the stems of most adult palms are spindly, pitted and scarred, revealing a history of exploitation (Fig. 8). One young palm had a 50 cm diameter hole transecting the stem.

A number of morphological characters were quickly identified, which distinguished the green-fruited palm from *B. aethiopum*. The leaves were smaller and almost unarmed; they were also somewhat glaucous with green (not



6. *Borassus akeassii* in typical habitat outside Banfora. Note the decapitated palms in the background.

yellow-black) petioles. The fruits were considerably smaller, green and of a slightly different shape. Our first impressions were that this was not *B. flabellifer* (which typically has

black fruits), but to what extent was the intensive harvesting of the palm (particularly the damage to the apical bud) having on its gross morphology? The female inflorescences of all *Borassus* species are almost always spicate (i.e. unbranched), but in this palm, branched female inflorescences were common (Figs. 1 & 8). In a sample of 100 female palms, 47% of individual palms and 31% of inflorescences showed some degree of branching. Was this the result of human-inflicted damage?

#### Analysis

The various materials collected in Burkina Faso were returned to the UK for further analysis. The herbarium material was examined and compared with existing specimens from Africa and Asia. During this process, several specimens from Senegal were located which appeared to match the green-fruited palm of Burkina Faso. Pollen samples were examined using a scanning electron microscope; the resulting images were compared with those from other *Borassus* species. DNA was extracted from leaf material of both the yellow- and green-fruited palms and added to an analysis of DNA variation in *Borassus* and related palms.

The morphology of the green-fruited palms was found to be somewhat intermediate between *B. aethiopum* and *B. flabellifer*. This might suggest that the palm was the product of hybridization between the two species, but *B. flabellifer* does not occur in Africa and so this seems unlikely. Some of the morphological features, such as the branched female

**Table 1. Diagnostic characters for native and cultivated *Borassus* in West Africa.**

Character	<i>B. aethiopum</i>	<i>B. akeassii</i>	<i>B. flabellifer</i>
Stem ventricose?	yes	yes	no
Leaves glaucous?	no	yes	no
Commissural veins	8–15 per cm	5–7 per cm	11–18 per cm
Petiole color	yellow-black	green	yellow-brown
Petiole spines	large	absent or small	small
female inflorescence	spicate	spicate or branched	spicate
female inflorescence flower-bearing portion	53–96 cm	24–39 cm	19–25 cm
Fruit color	yellow-orange-red	green	black
Fruit apex	flat or depressed	pointed	flat
Pollen gemmae	sparse	dense	sparse
Pollen surface	perforate	reticulate	perforate



inflorescences could perhaps be attributed to wine tapping, which damages the apical bud. However, there were other distinctive characters which are independent of such damage, including the pollen. Bayton (2007) found that there is very little variation in the pollen of *Borassus* and it is essentially impossible to identify *Borassus* species from their pollen alone, with one exception. The green-fruited *Borassus* had very distinctive pollen; each grain was so densely covered in small, spherical protuberances (gemmae), that the surface of the grain was almost invisible. In all other species, the gemmae are widely spaced and the grain surface is clearly visible. Where the surface is visible, it is pierced by numerous irregularly shaped holes, forming a net-like (reticulate) pattern. In other *Borassus* species, the pollen surface is pierced by numerous round holes (perforate). DNA data also suggested that this taxon was distinct, and so it was described as a new species (Bayton et al. 2006), the first new *Borassus* species since 1914. The characteristics of African *Borassus*, are compared in Table 1.

***Borassus akeassii*** Bayton, Ouédraogo & Guinko

**Morphology.** Stem to 15 m tall, almost always ventricose, to 80 cm diam.; stem often marked by numerous irregular scars caused by tapping. Leaves glaucous, 8–22 in the crown; petiole and sheath 90–160 cm long, 3.0–7.4 cm wide at midpoint, green, margins with small serrate black teeth, 0.2–0.6 cm long (immature leaves), or teeth largely absent (mature leaves); adaxial hastula conspicuous, to 2.4 cm, abaxial hastula rudimentary; lamina rather flat, radius to 160 cm maximum; leaflets 45–82, 2.8–7.3 cm wide, leaf divided to 60–99 cm. Male inflorescences branched to two orders, branches terminating in 1–3 catkin-like rachillae; rachillae green-brown, 23–36 × 2.3–2.5 cm; rachilla bracts forming pits that contain a cincinnus of 5–10 male flowers. Female inflorescences spicate or branched to one order; rachis ± 80 cm long, flower-bearing portion 24–39 cm long with ± 23 flowers arranged spirally. Male flowers 0.4–0.6 cm long, exerted from the pits individually or in groups of 3–5. Female

7 (left). Palm wine harvesting from *Borassus akeassii*. The upper part of the palm heart has been removed to stimulate the flow of sap. 8 (right). The long-term effects of palm wine harvesting are recorded as notches in the stems of mature *B. akeassii*. Note the branched infrucescences.



flowers  $3.5 \times 3$  cm. Fruits  $\pm 15 \times \pm 12$  cm diameter, ovoid with a somewhat pointed apex, fragrant and yellowish green at maturity; produced inside persistent perianth segments; pyrenes 1–3 per fruit,  $6.8\text{--}9.3 \times 5.4\text{--}7.5$  cm.

A particularly distinctive feature of this species is the pattern of veins on the leaves. The commissural veins, the small cross-linking veins which run at right angles to the major veins in each leaflet, are rather prominent in *Borassus* species, particularly in dried leaves. When the leaves of *B. aethiopum* and *B. flabellifer* are dried, they have a smooth surface. This is as a result of the close spacing of the commissural veins (8–18 veins per cm). When the leaf dries, the surface layers begin to collapse but are supported by the network of veins. In *B. akeassii*, the veins are more widely spaced (5–7 per cm) and so provide less support to the leaf, which collapses into the rectangular spaces (lacunae) formed from surrounding veins. The result is that the dried leaf has a rough surface with easily discernible puckering. This feature is particularly useful for identifying specimens in the herbarium, which may consist of leaf fragments only. For example, a specimen collected in the Democratic Republic of Congo (*Liben 2822*), consisting of a single mature leaflet only, was identified as *B. akeassii*, thus substantially expanding the range of the species.

**Distribution.** West and Central Africa. While this species is probably more widespread, collections exist from only three countries: Burkina Faso, Senegal and the Democratic Republic of Congo.

**Habitat & Ecology.** Savannas with 800–1300 mm annual rainfall. In Burkina Faso, most populations are semi-managed for wine production. Seed is collected and planted and the palms often have crops planted beneath (usually cotton, maize, sorghum or cassava). For this reason, we are uncertain as to the original or 'natural' habitat of this species. In all probability, the areas now exploited for agriculture were once savanna in which *Borassus akeassii* was an important component. However, with their lack of forest cover and relatively high rainfall, they were perfect for conversion to agriculture and these valuable and functional palms are all that has remained. Nothing is known of the pollination and seed dispersal strategies of *B. akeassii*. However, Thione (2002) investigated pollination of *B. aethiopum* in Senegal, and identified over 15 insect species (Diptera, Hymenoptera,

Lepidoptera) that may facilitate pollination. It is possible that these or similar species pollinate *B. akeassii*, or that the *Borassus* palms themselves were incorrectly identified.

**Uses.** Almost every part of the palm can be used, including the stem, leaves, fruits, seeds and sap. A comprehensive account of the uses of *B. aethiopum* in West Africa can be found in Burkill (1997). This of course does not distinguish *B. akeassii*, but it is likely that most if not all of the uses listed are applicable to both species.

**Conservation Status.** Data deficient (IUCN 2001). The actual distribution of *Borassus akeassii* is unknown, and therefore it is impossible to gauge any potential conservation threats. However, in the areas where it is known to occur, it is abundant, and a significant crop for local people. This could lead to over-exploitation, or could enhance its conservation status due to its significant economic value. Sambou et al. (1992, 2002) report that over-exploitation is threatening populations of *B. aethiopum* in Guinea and Senegal, but it is possible that these refer instead to *B. akeassii*. In many cases, it is difficult to determine whether populations of *B. akeassii* are cultivated (i.e. planted) or merely wild plants that are exploited.

**Etymology.** The name *Borassus akeassii* honors Professor Laurent Aké Assi (Centre National de Floristique, Abidjan, Côte d'Ivoire) who, together with Professor Sita Guinko (Université de Ouagadougou, Burkina Faso), first distinguished the palm from *B. aethiopum* (Aké Assi & Guinko 1996).

## Discussion

The palm account for the *Flora of Tropical East Africa* (Dransfield 1986) did not recognize varieties in *B. aethiopum*. Of course, this account did not cover West Africa, but Dransfield's taxonomy of *Borassus*, the only modern treatment in Africa, became a standard that was widely employed (e.g., Tuley 1995). *Borassus aethiopum* was considered the only *Borassus* species in Africa and *B. akeassii* remained unnoticed. For example, an account of the palms of the West African nation of Guinea-Bissau by Johnson (1984) described *B. aethiopum* as having orange-sized fruits that were green in color; this is more suggestive of *B. akeassii*.

The story of the discovery of *Borassus akeassii* began with Aké Assi and Guinko's paper in 1996. Since then, *B. akeassii* has appeared in



9 (left). Germinating *Borassus* seeds at Montgomery Botanical Center. The black plastic column (an Adams pot) allows for the cotyledonary petiole, which rapidly penetrates the soil, effectively burying the embryo. 10 (right). Seedlings of *Borassus aethiopum* (A) and *B. akeassii* (B). The ruler is in centimeters. Photos by Vickie Murphy.

some of the most recent African floras, including Arbonnier (2002, as *Borassus* sp. aff. *flabellifer*) and Aké Assi et al. (2006). Ten years later, *Borassus akeassii* has emerged from obscurity as Africa's newest palm.

#### Burkina Faso Palms in Cultivation

This section was prepared with the assistance of Vickie Murphy (Montgomery Botanical Center) and Ken Neugent (Fairchild Tropical Botanic Garden).

*Borassus* is often considered difficult to grow from seed as the cotyledonary petiole extends rapidly, pulling the embryo plant downwards into the soil, while leaving the woody endocarp at the surface. This mechanism protects the seedling from fire and herbivory in its natural habitat, but provides a challenge for those growing palms in containers. At Montgomery, the solution is to use a long plastic column filled with growing media, known as an Adams pot, placed on top of the normal container (Fig. 9).

The seeds of *B. aethiopum* and *B. akeassii* were initially placed in regular 1-gallon pots in a greenhouse at ambient temperature (heated only when below 18°C/65°F). After 30 days, they were transferred in to the Adams pots, atop regular 2-gallon pots. The growing medium used consists of 40% Canadian peat, 30% composted bark, 20% coarse sand and 10% airlite (ground polystyrene). Sharp drainage is particularly important. Additives to the medium include dolomite, magnesium sulfate and triple super phosphate.

Once the seedlings had established, the Adams pots were removed. The seedlings were fertilized using Florikan Nutricote (N18: P6: K8) timed-release fertilizer. Germination was quicker in *B. aethiopum* than in *B. akeassii*; in the latter, germination took between 5–10 months, with a 73% success rate (a 90% success rate was achieved with *B. aethiopum*). Figure 10 shows a seedling of *B. aethiopum* and one of *B. akeassii*, two years after the seeds were received at Montgomery. The slightly more advanced stage of the *B. aethiopum* seedling is evidenced by the greater number of leaves in its crown.

*Borassus* seeds can be sown directly in the ground, an approach that has proved successful for some growers, and of course the method used by farmers in Africa and Asia. However, the soil must be well-drained but with adequate moisture and some shade in the early years. This replicates natural conditions, where palms establish on moist but sandy soil, under the canopy of riverine forest.

Burkina Faso's native palms are commonly cultivated within that country, and across the campus of the university in Ouaga, numerous specimens of both *Borassus aethiopum* and *B. akeassii* are to be found. Their presence in a collection in the United States will further safeguard their long-term survival and allow their ornamental potential to be assessed. Montgomery holds possibly the most complete sampling of *Borassus* species at any institution in the world, including four of the five recognized species.

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# Mortality of Adult *Livistona* *australis* on Cabbage Tree Island, Australia

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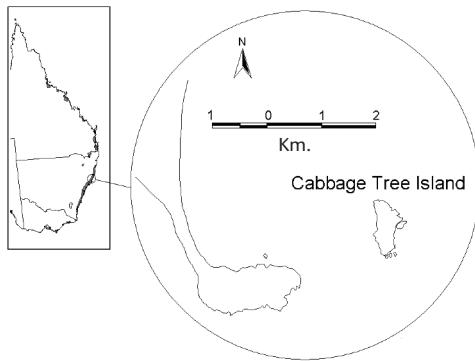
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An isolated population of *Livistona australis* (R. Br.) Mart. has been impacted by almost a century of browsing by European rabbits, *Oryctolagus cuniculus*, on Cabbage Tree Island, Australia. Ongoing adult mortality was documented in this study (n=19) between 1992 and 2001 in addition to a lack of seedling recruitment. Structural failure of the palm trunk or subsidence of the substrate was the prime cause of death in this palm population (63%) with natural senescence of mature palms making up the remainder of the sample. This represents an annual decline of 0.4% per annum and if continued without further recruitment would result in the adult population halving in 125 years. Rabbits were eradicated from the island a decade ago, and the recovery of the vegetation, including palm seedlings, gives hope that the hiatus in recruitment will not negatively impact on the structure of this unique island rain forest.

Cabbage Tree Island (herein abbreviated to CTI), also known as John Gould Island Nature Reserve, is about 1000 m long and 450 m wide reaching an altitude of 123 m (Fig. 1 inset) and is located at 32°41'S, 152°13'E. The island is situated 1 km offshore from the mid north coast of New South Wales, Australia (Fig. 1) and is aligned more or less north-south with a precipitous eastern seaward shore and a more gradual slope of approximately 30° on its sheltered western side. It is predominantly covered in rain forest dominated by *Livistona australis* in the two main gullies that cut into its western side (Fullagar 1976) (Fig. 2).

The CTI rainforest is a form of Dry rain forest Suballiance 23 (*Ficus-Streblus-Dendrocnide-Cassine*) (Floyd 1990). Despite the rock scree, the gullies support mature rain forest that increases in height on deeper soil on the lower reaches of the island's western side. There is evidence of past fire, with some of the taller palms bearing fire scars, but no fires have been recorded within the last century. There are approximately 500 adult *L. australis* palms on CTI, mostly confined within the 3 ha of the two main gullies, and a sample of these were studied between 1998 and 2001 (Carlile 2002). For that research and the present study, adults



1. Study site for adult *Livistona australis* mortality, Cabbage Tree Island, mid-north coast of New South Wales, Australia. The distribution of the species along the east coast of Australia is indicated by shading.

are defined as individuals that have reached or exceeded the point of first reproduction (based on inflorescence scars) at approximately 5.2 m trunk height.

Cause of death of adult palms on CTI was recorded only for individuals previously known to be alive. This encompassed palms with dead crowns still attached or those that underwent structural failure resulting in their still-green canopies found on the forest floor. The observations covered a four-year period during the palm studies and six years previously spent undertaking other full-time research at this site (Carlile et al. 2003). No formal survey of adult palm survivorship was carried out, but the island was visited at least six months out of every twelve during the ten years. Palm canopies were easily observed as the population grows on steep slopes allowing horizontal views out over the forest. The structural failure of palm trunks was evident while carrying out ground-level activities in the gullies.

The mortality of adult palms on CTI needs to be viewed in context of the lack of seedling recruitment at this site. CTI had been infested by rabbits between 1906 and 1997 (Priddel et al. 2000). Rabbits were intentionally introduced in 1906 during the attempted development of a rabbit "pox" on a nearby island for their control on the mainland. The CTI population was eradicated in 1997 (Priddel et al. 2000). While rabbits existed on the island they altered the vegetation structure (Werren & Clough 1991, Carlile 2002) and suppressed seedling establishment of *L. australis* (Priddel et al. 2000, Carlile 2002). A seedling survival study on CTI between 1993 and 1996 showed

survival was low in the presence of rabbits (Carlile 2002, Priddel & Carlile unpub. data). Twelve months after germination less than 24% of uncaged seedlings survived ( $n = 50$ ) compared to 68% of caged seedlings. After 30 months only 6% of uncaged seedlings survived compared to 53% of caged seedlings. Further seedling experiments on CTI following the eradication of rabbits supported the previous caged results with both uncaged and caged seedlings achieving 72% and 68% survival after 30 months (Carlile 2002).

### Observations

Observations revealed that there were different causes that resulted in the premature death of 12 adult palms (Tab. 1). Six incidents were recorded where the subsidence of substrate caused dislodgement of the root mass and for the palm to topple over and die.

Occasionally part of the trunk was partially or completely encased by an arboreal termite nest of *Nasutitermes walkeri* 2–7 m above ground. The nests of this species commonly encase large branches and tree forks (Hadlington 1987). The attachment of a termite nest, a dark and carton-like structure (Watson & Gay 1991), does not lead to the infestation of the inner tissue of the trunk. The pithy core of palms means they are not susceptible to internal attack. On two occasions it appeared that the weight of the termite nest had contributed to the palm toppling over. While the weight of these nests have not been reported elsewhere, on CTI they can be up to 1 m high and encase the trunk of a palm with the bulk of their structure on the down-hill side (mean circumference of adult palms at 1.5 m was 0.71 m, s.e. 0.02 m,  $n = 28$ ). As termite nests are constructed principally of wood derivatives (Emerson 1938), their weight would impact on the stability of some palms. When these nests are abandoned and eventually dislodge the trunk is usually left with an indentation or scalloping of the trunk at the point of attachment. Some palms survived despite termite damage accounting for the loss of more than 75% of the trunk at the original point of nest attachment (Fig. 3). Individual palms surviving termite impact were located among the expansive canopies of Deciduous Figs, *Ficus superba*, where they were protected from winds and the resultant extensive lateral movement. On four occasions palms were observed to snap at this weak point.

Seven crownless adult palm trunks were encountered (Tab. 1). These individuals died



2. The northern of two gullies on Cabbage Tree Island’s western shore dominated by *Livistona australis*.

despite the trunk remaining upright. The apex of the remaining trunk extended to a narrow point just below the crown. While some crowns were at canopy height, others were subcanopy individuals. It is probable that these are cases of natural senescence rather than

3. The trunk of an adult *Livistona australis* showing wear (ca. 1 m above the persons head) associated with the attachment point of a termite nest.



premature death and did not necessitate the individual palm to be older and therefore taller than the surrounding palms.

**Discussion and Conclusions**

The process of senescence and death in natural populations of palms has rarely been thoroughly recorded. Most detailed observations have been restricted to cultivated palms (Dalrymple & Fisher 1994). From studies in these environments the mechanism that leads to thinning, impoverished crowns in the tallest of palms and eventual malfunctioning in vascular bundles that transfer nutrients throughout the plant, has been documented (i.e., Tomlinson 1990). This is natural senescence, and the dead palm is characterized by the remaining trunk tapering to a narrow

**Table 1: Senescence and death by accident of adult *Livistona australis*, on Cabbage Tree Island, Australia from 1992 to 2001.**

No. of Palms	Cause of death
6	Toppled from subsidence
2	Toppled from weight of termite nest
4	Snapped at narrow wear point from old termite nest
7	Death of crown

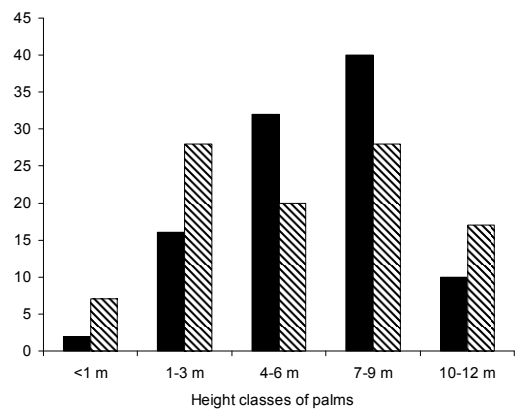


apex, where once the crown grew. From the study on CTI it is known that some *L. australis* in natural populations do survive long enough to reach this critical point.

This study reported several other causes of adult mortality. The sloping rock-scrub on CTI (Fullagar 1976) contributed to several deaths where subsidence of the substrate had occurred. With many of these palms growing in what appears to be pure rock scree, the erosion that leads to subsidence is likely to be water induced. *Livistona mariae* was also found to be prone to death from toppling following scouring of the surrounding soil (Latz 1975) during periods of flooding. The effects of termites on the trunks of *L. australis* led to some adult palm mortality. No sign of arboreal termite nests had been recorded from other palm sites surveyed on the mainland as part of an extensive study into *L. australis* demography (Carlile 2002). It is likely that this feature is unique to CTI, possibly due to reduced host availability brought about by the confinement of *Nasutitermes walkeri* to the island. On CTI the termite also utilized several other tree species. On the Australian mainland *Eucalyptus* species are a common host for these biogenic structures (Hadlington 1987). The persistence of the termite nests on palms on CTI and their negative impact on adult longevity may be causing a higher adult mortality here than in other populations on the Australian mainland. From studies of other palms it appears that structural failure rather than natural senescence (Tomlinson 1979) determines the life span of palms (i.e., Piñero et al. 1984, Enright 1992).

Research into the causes of death in palms is scant. However, for cultivated palms, Dalrymple and Fisher (1994) provided insights into the morphology of certain species after catastrophic death. For naturally occurring palms, Zimmerman and Covich (2007) studied the dynamics of age structure of palm populations after hurricane impact. The survival of storm-damaged palms and their continued growth, quite apart from the mortality, has been used as a feature for aging these destructive events on forest communities (Sarukhán et al. 1985).

The impact of the loss of adult palms on the population structure and future recruitment for the CTI population is of concern. If the 19 palm deaths over 10 years in a population of approximately 500 (0.4% per annum) were maintained then the adult population would



4. A comparison of height classes (after Orschesg & Parsons 1996) of Cabbage Tree Palms ( $n = 50$ ) with exposed trunks on Cabbage Tree Island (black) and the nearby mainland site (18 km NNE), the rainforest remnant of Mungo Brush 32°34'S, 152°16'E (hatched). Mean trunk height at first flowering is 5.2 m for CTI and 5.6 m for Mungo Brush.

be halved in 125 years if no recruitment from subadults occurred. Rabbits had been present on the island since 1906 and were eradicated in 1997, after 90 years (Priddel et al. 2000). In recent years rabbits had caused a marked suppression in the regeneration of *L. australis* (Carlile 2002, Priddel & Carlile unpub. data). The population structure of the CTI palms is markedly different to another studied site on the adjacent mainland, where rabbits are not a threat (Carlile 2002) (Fig. 4). Carlile (2002) determined that a larger proportion of the mainland population was subadult (46% compared to 34% on CTI), indicating a better potential here for recruitment into the reproductive population. On CTI however, the compounded effect of suppressed palm recruitment combined with adult senescence over the last 90 years may see a further decline in the number of adult palms on the island for the foreseeable future. While no premature death of subadult palms were recorded on CTI during this study, any loss within this group could further impact the population here.

The rate of growth and adult life-expectancy for palms on CTI has been approximated by Carlile (2002). The rate of growth of palms on CTI ( $n = 50$ ) was estimated by measuring the change in distance between a fixed point high on the trunk and the point of bifurcation of the oldest leaf from the stem directly above this point. From this it was determined that palms on CTI grow approximately one meter every 25 years (Carlile 2002). The greatest



height and therefore oldest palm in the sample was estimated to be 392 years (14.9 m). From seedlings planted in 1993 and monitored until 2001 it was determined that the maximum pre-emergent stem diameter of *L. australis* in the CTI population could take 60 years to develop. From flower scars on the trunks it was determined that reproductive height was reached at 5.2 m (s.e. 0.19,  $n = 28$ ) or at 185 years of age. Of the palms regularly sampled on CTI, 66% ( $n = 33$ ) of them were reproductive and many will reach senescence before the recently establish cohorts of seedlings become reproductive. This loss will cause a decline in reproductive palms on the island. Recruitment should be unbroken however, as the immature trunked-palms will, by this time, be producing seed. What is not known is how the resultant change in the rainforest canopy structure and height will affect its stability. While good recovery in palm seedlings has been noted since 1997 (Carlile 2002, Carlile & Priddel unpub. data) any large gaps appearing in the canopy will assist establishment of a range of aggressive weed species (including the locally problematic Bitou Bush *Chrysanthemoides monilifera*). The palm population will require further monitoring to track their continued persistence in this unique rainforest locality.

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