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Beccariophoenix madagascariensis. See article by Roberts et al., p. 177. Photo by J. Dransfield.

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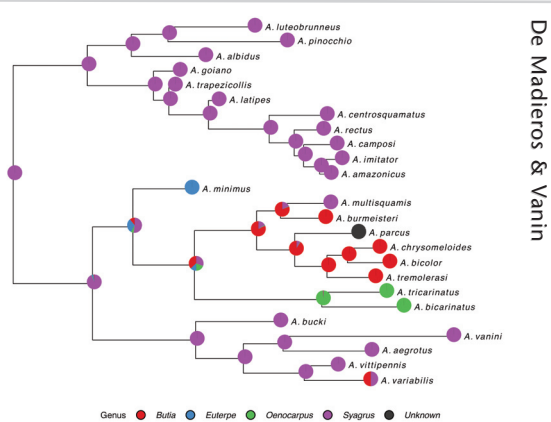
PALM NEWS



Alex Popovkin

A forthcoming article in *Plant Biology* by C.M. Barbosa et al. (<https://doi.org/10.1111/plb.13162>) examines the reproductive biology of *Syagrus coronata*. The pollinators for this species are a diverse assemblage of small beetles in the weevil family. They confirm something long suspected by those familiar with the palm: **The peduncular bract emits a unique scent that is involved in pollinator attraction.** They identified 23 volatile compounds produced by the flowers, but the peduncular bract produced a 24th compound not found in the flowers. In many *Syagrus* species, the pale, reflective inner surface of the peduncular bract may act as a visual signal to pollinators, and we now have evidence that it emits olfactory cues as well.

And speaking of beetles, a new systematic account of palm-specialist weevils of the genus *Anchylorhynchus* has been published by B.A.S. De Madieros and S.A. Vanin (*Zootaxa* 4839: 1–98. <https://doi.org/10.11646/zootaxa.4839.1.1>). These weevils visit palm flowers and are involved in pollination. They mate and lay eggs in the female flowers, and the next generation of adults emerges from aborted and dropped fruits. Of particular interest is how one major lineage of *Anchylorhynchus* shifted hosts from *Syagrus* to other genera of palms. In *Butia* and *Oenocarpus*, there was subsequent speciation of the weevils, but the shift to *Euterpe* was an evolutionary dead end for them and resulted in no further speciation.



New York Botanical Garden has announced **the retirement of our member and prolific palm researcher Dr. Andrew Henderson.** We wish Andrew a long and very productive retirement. In his final year on the staff Andrew has produced two massive and extremely important monographs, published in the journal *Phytotaxa*. **He has revised the problematic New World genus *Attalea*** (Henderson, A.J. 2020. A revision of *Attalea* (Arecaceae, Arecoideae, Cocoseae, Attaleinae) *Phytotaxa* 444: 1–76). The massive size of most species has made their representation in herbaria difficult, and particularly, historic specimens on which names are based are often very tricky to interpret. We now have a clear, modern monograph that should allow much greater understanding of these economically important palms. As if that were not enough, **Andrew has also produced a massive monograph of the whole genus *Calamus*** in its broadest sense (including *Ceratolobus*, *Daemonorops*, *Pogonotium* and *Retispatha*) (Henderson, A.J. 2020. A revision of *Calamus* (Arecaceae, Calamoideae, Calameae, Calaminae) *Phytotaxa* 445: 1–656). Astonishingly thorough, this monograph will be the baseline for all further taxonomic research on the most important genus of rattans. Our congratulations go to Andrew on the appearance of these two milestones.

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Palms and People: *Raphia vinifera* Usage and Cultivation in the Grassfields of Western Cameroon

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Raphia palms are quintessential elements in many sub-Saharan African landscapes. The submontane species, *Raphia vinifera*, mainly grows in the Cameroonian highlands between 1000 and 2000 m. It is a characteristic element of the vegetation of the Grassfields region. In addition, like most *Raphia* species, *R. vinifera* plays a central role in people's daily lives, as well as in the socio-economic and cultural spheres. Yet, little is known about this palm and how people have managed it through time to the present day.

As one ascends from the lowland rain forests into the highlands of western Cameroon, we enter a more open landscape, composed of hilly plateaus, crossed by a chain of high volcanic mountains, stretching from South-West to North-East, whose summits can reach up to 3000 m. This mountainous area, currently overlapping with the West and North-West administrative regions, is well known for its savannah type vegetation referred to as "Grassfields" by European

travellers (first the German then the British) from the colonial period. This landscape is home to countless villages surrounded by farming plots with scattered forest fragments (Fig. 1, Fig. 2). As soon as we reach these plateaus, at around 1000 m in altitude, the palm enthusiast can start to see the submontane species *Raphia vinifera*, known as the "Bamenda raphia" by Anglophone botanists. Compared with its lowland relatives, *R. vinifera* is a rather small palm with a



1 (top). Example of a Grassfields landscape, with villages interspaced with fields, cultivated crops such as banana (forefront), and *Raphia vinifera* occurring in valleys. Near the Sam village, 2016. Photo by Thomas L.P. Couvreur. 2 (bottom). *Raphia vinifera* grove lining a stream (light blueish-green palm). Other palms include *Phoenix reclinata* (darker green cespitose palm) and *Elaeis guineensis* (single stemmed palm at forefront). Fotsem-Lessing, 2017. Photo by Ariane Cosiaux.



3. Habit, note acaulescent habit, with leaves arising from ground. North-West region, 2016. Photo by Ariane Cosiaux.

subterranean stem (Fig. 3). The leaves, reaching up to 10 m tall, rise directly from the ground, forming a large funnel-shaped crown with hanging shaggy-looking leaflets (Fig. 3). It is at the base of these leaves, at around breast height that spectacular large inflorescences appear (Fig. 4), covered with large brown bracts (Fig. 5). This inflorescence will soon become a heavy infructescence, with hundreds of scale-covered fruits (Front Cover), characteristic of the genus *Raphia* and Calamoid palms in

general. In fact, spotting this palm is not hard as it forms dense, nearly monospecific stands clustering along the valleys and water courses that zigzag across the Grassfields (Fig. 2). Beyond the Cameroonian highlands, *R. vinifera* extends to the North-East through the Mambilla Plateau (Nigeria) and in some valleys of the Adamawa (Cameroon). Interestingly, it has also been collected in some localities at lower altitudes in the Central African Republic and South-Sudan towards the east, and



4. Detail of infructescence, note large bracts. Photo by Thomas L.P. Couvreur.



5. Detail of dried partial inflorescence. Photo by Thomas L.P. Couvreur.

towards the west, potentially as far as Mali (Mogue Kamga et al. 2019).

The taxonomic status of this species, “misidentified for far too long”, has recently been clarified by Mogue Kamga et al. (2019). *Raphia vinifera* used to be known in Cameroon and Nigeria under the name *R. mambillensis* Otedoh, but a detailed study of its type material revealed that both names are in fact conspecific (Mogue Kamga et al. 2019). *Raphia*

vinifera actually corresponds to one of the first two *Raphia* species ever described, over 200 years ago by Palisot de Beauvois (1804) after his field trip to Nigeria in 1786.

Besides its characteristic hilly open landscape, the Grassfields region is also known for its high population (3.5 million inhabitants in 2005) and its around 150 chiefdoms (or “fondoms”), under the customary authority of *fons* (ruler/king). The Grassfields are also home



6. Landscape of palms with *Raphia vinifera* stand along the valley bottom, bordering by wild date palms *Phoenix reclinata* and surrounded by oil palms, *Elaeis guineensis*. Fondjomekwet, 2017. Photo by Ariane Cosiaux.

to an impressive 50 languages. Seen from above, the Grassfields landscape appears to be the result of complex interactions between people and nature. Villages characterized by scattered settlements easily identifiable by the

corrugate aluminium roofs (Fig. 1), dot the landscape. Sacred groves are found throughout; a few of them are remnant forests, the others are the result of past human practices and of a complex historical legacy

(Salpeteur 2010). In between, a number of farming plots are cultivated by smallholders containing a panoply of cultivated plants (Figs. 1, 2, 6) such as banana, plantain, yam, maize, groundnut, potatoes, njama-njama (*Solanum nigrum*), cocoyam, coffee and a number of other fruiting tree species like the African plum tree (*Dacryodes edulis*).

Amongst these crops, *R. vinifera* stands out as one of the most important endogenous species of the region. The *fon* (king) of Oku, His Majesty Sentieh II, told us that “*Raphia* [*vinifera*] is a completely important ingredient in our life style, *Raphia* constitutes our livelihood” (Fumtini and Couvreur 2017). Indeed, this species is one of the most versatile and useful of all *Raphia* species (Mogue Kamga et al. 2020), with dozens of uses of all parts of the palm. The long and flexible petioles (referred to as “bamboo” in the region) and leaves are used for construction, house furniture and weaving different types of mats and baskets (Figs. 7 & 8); the sap or palm wine has a major importance in daily life and customary ceremonies (Fig. 9); the leaf sheath is used as firewood; the trunk, when rotting, is the nesting place of the certain beetles of which the large larvae are prepared as a delicacy; the fibers, extracted from leaflets are mainly used for weaving utilitarian bags or

special bags (Fig. 10), for important people (e.g. a dignitary or a member of secret societies) or specific purposes (e.g. going to a funeral celebration) (Knöpfli 1997). Today, some royal palaces are still built using *Raphia* bamboo (Fig. 7), while the world famous “white Oku honey” comes from beehives traditionally built with *Raphia* material (Fig. 11). Finally, the vital role *R. vinifera* played within older Grassfields societies is illustrated by the fact that this resource was the target of organized raids, documented by the German military lieutenant Franz Hutter during his stay in 1891–1892 at Bali-Nyonga (see map Fig. 12). He noted the frequent conflicts between chiefdoms over this resource, due to shortages of *Raphia* bamboo for construction (Hutter 1902). He wrote: “every tribe jealously guards their [*Raphia*] stands within their sphere of influence”, and adds “Among the Bali, as well as the dominant tribes in general, the gathering of [*Raphia*] bamboo generally becomes a “collection by force” because of their inherent rapacity, which attracts them to foreign territory even when it is not necessary”. Although this practice does not continue today, *R. vinifera* still occupies a place of importance amongst Grassfields societies.

Yet the societal importance of *R. vinifera* and its inescapable presence across the Grassfields landscape contrasts with the little knowledge

7. Palace of Oku chiefdom, partly constructed with *Raphia* petioles (bamboo). Elak-Oku, 2016. Photo by Thomas L.P. Couvreur.





8. Detail of a ceiling made with raphia petioles (bamboo), Bamendjinda, 2017. Photo by Ariane Cosiaux.

that scientists have about this palm in almost all respects. Throughout the western highlands of Cameroon, *R. vinifera* stands are very common and botanists from the 1940s to the 1980s reported the species as cultivated

(Letouzey 1985, 1978, Portères 1946; Russell 1965). Staring into this complex landscape one can ask: what is and has been the role of *R. vinifera* in Grassfields societies? How have people influenced its distribution? What consequences has the management of this vitally important palm had on the dynamics of these landscapes since the end of the 19th century? These questions about *R. vinifera* form part of the PhD project of the first author. The observations presented here are a result of several extensive fieldwork periods of the first author in the western highlands of Cameroon and from a preliminary analysis of written historical sources within her doctoral research.

To date, AC undertook four field trips to western Cameroon (Fig. 12) to study how people of Grassfields societies have interacted with *R. vinifera* and how this relationship has been sustained or has evolved over time (i.e. the field of ethnoecology and historical ecology). Ethnoecological research is based on prolonged stays in the field, allowing the researcher to become part of the society as much as possible, enabling the researcher to acquire a more in-depth understanding of the societal context while also building confidence with people to collaborate. In 2016, two preliminary trips (in total three weeks) were

9. Serving *Raphia vinifera* wine during a ceremony between Elak-Oku dignitaries. The wine is kept in a calabash fruit and served in cow horns. Elak-Oku, 2016. Photo by Thomas L.P. Couvreur.





10. Bag woven with raphia fibers. This special bag is used during dowry ceremonies. Bamendjinda, 2017. Photo by Ariane Cosiaux.

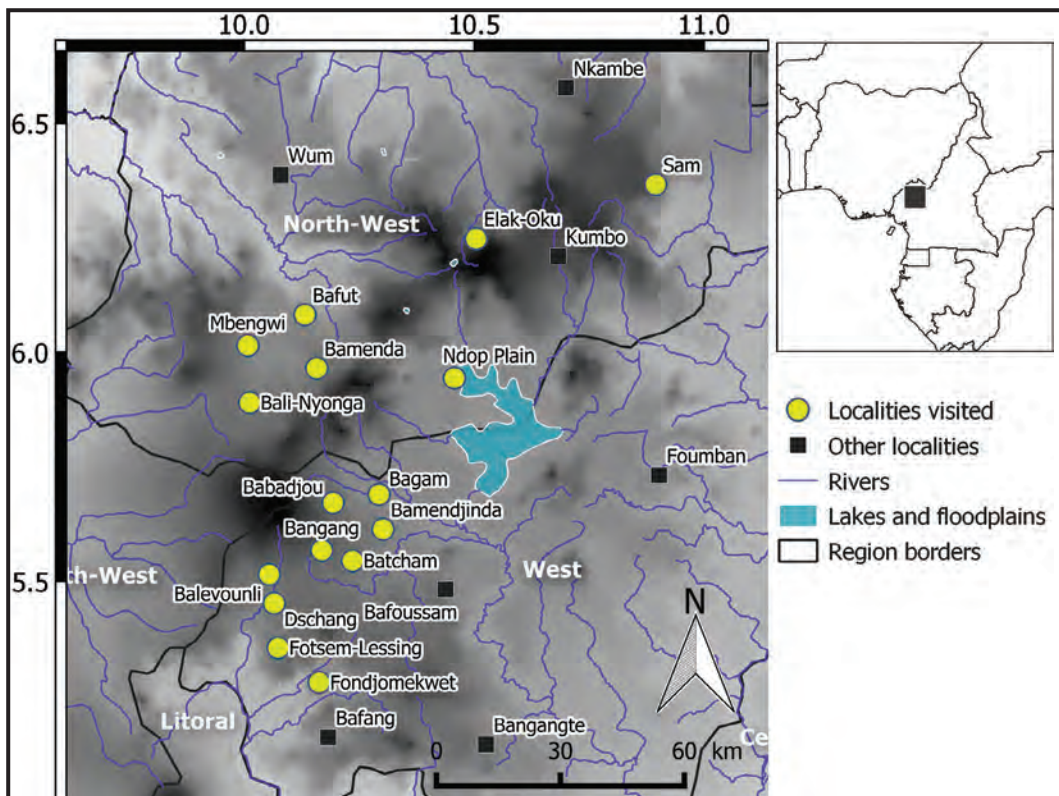
undertaken to the North-West English-speaking region, in particular to the localities of Bamenda, Bafut, Bali-Nyonga, Mbengwi and finally Elak-Oku (of which Mt. Oku (3011 m) is the second highest peak in Cameroon after Mt. Cameroon). These trips resulted in some important preliminary findings such as information on the trade of seedlings between

the Ndop Plain and Elak-Oku (Fig. 12). After this, the first long field trip in the West French speaking region took place from mid-July to mid-August 2017. Seven localities were visited during this trip: Fondjomekwet, Dschang, Balevounli, Bagam, Babadjou, Bamendjinda and Fotsem-Lessing. The last fieldwork, lasting three months, focused on the Bamboutos area of the West region from May to July 2019, around the villages of Batcham, Bangang and Babadjou, the last of which is now the main focus of the first author's doctoral research. Since 2017, it is no longer possible to carry out field research in the English-speaking part of the Grassfields due to an armed conflict in the North-West region. Besides AC's trips, we add observations undertaken by TLPC during his own trips in the region (mainly in 2016).

During these field trips, we observed that *R. vinifera* groves are still very common and abundant along humid valleys, easily recognizable by the metallic glaucous green color of the leaves (e.g. Fig. 2). Nevertheless, its distribution is not homogenous throughout the Grassfields. Within the Fondjomekwet chiefdom, to the South-West of the Grassfields, *R. vinifera* stands are found uniquely in valley bottoms, often bordered by other native palms, such as the beautiful wild date palm, *Phoenix reclinata* Jacq. (Fig. 6). On the slopes,

11. Beehive partly made with *Raphia* petioles and fibers. Oku, 2016. Photo by Thomas L.P. Couvreur.





12. Map focusing on the Cameroonian Grassfields, indicating the villages where we undertook our research and other places of importance. The shades of grey represent altitude (black = above 2800 m).

surrounding these *Raphia* stands, we found coffee or cocoa plantations and farming plots with cocoyam, maize, cassava, banana, sweet potatoes in addition to the majestic oil palm, *Elaeis guineensis* Jacq. (Fig. 6).

At Fotsem-Lessing, 12 km to the North-West of Fondjomekwet, the *R. vinifera* stands are also widespread, following streams and bordered by wild date palms, oil palms, *Dracaena arborea*, banana trees and other tree species (Fig. 2). Cultivated plots and fallows directly surround these gallery forests. In contrast to Fondjomekwet, the hilltops are characterized by herbaceous or shrub savannahs, resulting in an open landscape (Fig. 2). In chiefdoms with higher population densities, like Batcham or nearby urban areas (e.g. Dschang), it seems that *R. vinifera* is the mono-dominant species along the valleys, and wild date palms are absent. During the pre-colonial period and up to the beginning colonial times, the trunks of wild date palms were used for the construction of noblemen's houses. In order to have the privilege of enlarging and embellishing one's home through the use of wild date palm trunks,

candidates had to make considerable payments to notables (Warnier 1985).

During our fieldwork, at Elak-Oku and nearby localities, around Bamenda, Bafut, Babadjou, Bagam, Bamendjinda, Bangang and Batcham we were surprised to observe the cultivation of *R. vinifera* both in and outside of humid valleys where it is known to occur naturally, extending now into farming plots. Numerous hillsides were planted with *Raphia vinifera* stands of varying densities, often mixed with other crops such as maize (Fig. 13). On these dry hillsides, we observed either scattered individuals on farming plots (e.g. at Bangang, Batcham or Bamendjinda), or dense stands (e.g. at Babadjou) (Fig. 14). Interestingly, we noted morphological differences between *R. vinifera* individuals cultivated on these hillsides versus the ones found in the humid valleys. The former generally had thinner petioles and in particular shorter leaves leading to a short overall size, no taller than 2.50 m (Fig. 15). In addition, the wine tapped from these hillside growing palms was suggested to have a much better taste. A wine tapper, M. Lalong, from Babadjou told us that: "Tapping wine from down



13 (top). *Raphia vinifera* cultivated on a hillside, among food and tree crops at Babadjou. In the background the Mont Lefo (2534 m), 2019. 14 (bottom) *Raphia vinifera* stands on a hillside, Babadjou, 2019. Photos by Ariane Cosiaux.



15. Detail of a *Raphia vinifera* individual cultivated on a hillside, note the short leaves. Babadjou, 2019. Photo by Ariane Cosiaux.

[in the valleys] and tapping wine from up [on hillsides], it's two different worlds. The [raphia] wine from up [from hillsides] is better" (Fig. 16). Interestingly, these hillside plantations of *R. vinifera* are rarely, if ever, reported in literature by botanists. Without further research, it is hard to say if botanists simply did not mention the cultivation of raphias on hillsides, or whether this is a new practice. Digging a bit deeper, we found only two written sources from Cameroonian geographers mentioning the cultivation of *R. vinifera* outside humid valleys. According to Kuete (2012), farmers planted *Raphia* palms on slopes to increase soil moisture. Kaffo et al. (2013), explain the species was also used as shade-trees for coffee plantations; interestingly they also note the role of women in spreading this species outside humid valleys, despite the management of *Raphia* palms normally being a male activity. However, they do not detail when and in which localities (except Babadjou) this practice emerged, or how it has evolved over time. The cultivation of *Raphia* palms on hillsides was also not reported by the keen eye of the Swiss botanist Carl Ludwig Ledermann (1875–1958),

who travelled across the western highlands of Cameroon in 1908, providing detailed descriptions of landscapes, floristic composition and cultivated species he saw. Indeed, he never mentioned the presence of planted *Raphia* on dry hillsides. Here is one of his descriptions where palms are especially mentioned: "At 10 o'clock we had the forest behind us and entered a prealpine landscape with scattered bushes and scattered trees. (...). *Phoenix reclinata* rises again on the slopes, *Raphia* palms and *Dracaena arborea* become visible in the galleries (...). The whole water network of the country is in front of us and below us, clearly recognizable by the grey-blue serpentines, which are mainly caused by the *raphia* stands of the riverbanks" (Ledermann, 1912). Later in the 1940s, the French botanist Roland Portères (1906–1974) was the first to mention cultivation of *R. vinifera* in humid valleys. He also observed at Balatchi (a locality bordering Babadjou) "in the ravines, and overflowing onto the plateaus, the cultivated stands of *Raphia* [vinifera]" (Portères 1946). This could potentially be the first written mention of cultivated *Raphia* outside of the humid valleys



16. Mr. Lalong, a *Raphia* wine tapper, showing a *R. vinifera* palm ready to be tapped, Babadjou, 2019. Photo by Ariane Cosiaux.

and streams. Unfortunately, it is not clear what Portères meant by the word “plateau.” In the other localities he visited across the West region (former French Cameroon), he only mentioned the presence of *Raphia* stands in humid valleys. Perhaps Portères unknowingly witnessed the emergence of a new cultivation practice in some localities.

However, understanding of this landscape should not only be derived from incomplete colonial and botanical observations by foreigners, but also by consulting and working with inhabitants of the Grassfields themselves. Information collected during interviews, informal discussions and visits of *Raphia* groves, confirmed the old but still current

practice of planting *R. vinifera* in humid valleys, either by enrichment of an existing stand or by actively planting *Raphia* where it was previously absent. The most common practice, previously mentioned in the literature is through transplanting seedlings. However, several informants explained that because of intensive wine tapping, which prevents fructification, seedlings are sometimes locally scarce. At Elak-Oku, Babadjou and Bamendjinda, informants told us about the existence of a seedling trade between villages. Knöpfli (2001) also observed seedlings trade in the weekly markets of the North-West region, especially during the peak months of the rainy season (June, July and August). Further studies are needed to document the exchanges of seedlings, and the consequences of these practices on the genetic diversity of *R. vinifera*.

Besides *R. vinifera*, other *Raphia* species are sometimes introduced from the lowlands through immigration. For example, at Fondjomekwet, we noted the cultivation of *Raphia hookeri* G. Mann & H. Wendl. The introduction of this lowland species, together with some of its utilizations and know-how appears to have begun in the last few decades. From the 1950s, populations from the Grassfields, immigrated to the Mungo area, to the South-West of the Grassfields. Some later returned to their villages of origin, bringing seeds of *R. hookeri*, planted them and then started to tap them for *Raphia* wine as they did when they lived in the Mungo area. This, however, was only observed at Fondjomekwet. We also observed the species *R. monbuttorum* Drude planted along the road to Elak-Oku.

Our preliminary observations highlight the significant lack of knowledge that many scientists have on the history of management practices of *R. vinifera* by Grassfields societies. More specifically, information is lacking about how, why, when and who started to cultivate this species along the hillsides, outside of its natural distribution in humid valleys. We can also ask how this species adapted to these drier environments. In addition, we have yet to understand how changes in use have influenced or not the evolution of cultivation practices of this *Raphia* species. Finally, the social and cultural role of this palm is under-documented. The main questions raised by this contribution will be further explored by the first author's doctoral research, using the interdisciplinary research framework proposed by historical ecology (Crumley 2017),

combining ethnography, and the analysis of written sources and aerial images.

Acknowledgments

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PALM LITERATURE

PALMAS DE ESPAÑOLA – Eladio Fernández and Adolf Gottschalk. 2017. Privately published by Grupo Sid, 159 pages, color illustrations. Price unknown.

The Caribbean island of Hispaniola, with Cuba to the west and Puerto Rico to the east, comprises the two countries of Haiti and the Dominican Republic. Slightly less than two thirds of the island make up the Dominican Republic. There have been at least two accounts of Dominican palms, both now somewhat out-of-date (Moscoso 1945, Hoppe 1998), but no account of the palms of the whole island. Until now.

Palmas de Española is an illustrated account of all 15 genera and 30 species native to the island. However, to call it an illustrated account is a bit like saying the Sistine Chapel has a painted ceiling. The illustrations, taken by Eladio Fernández, are simply spectacular, by far the best I have seen in any book on palms. The images of *Coccothrinax boschiana* on page 113, and of *Copernicia ekmanii* on page 177, are particularly outstanding.

The text is in both Spanish and English. There is an opening chapter on cultivation and landscaping of Hispaniolan palms. The remainder of the book is in a field guide format. For each species, general information is given, including scientific names and common names, distribution, habitat, a brief description and notes on uses. Also included is a very useful, accurate distribution map for each species. This is followed by several images for each species, and these are, as I have said



before, spectacular. Although no references are cited, the information given appears completely up-to-date and accurate.

This review is based on a pdf of the book sent by the first author to the reviewer. The book appears to be generally unavailable, and is not listed, for example, on Amazon. According to the first author, this book was privately published and only 1500 copies produced, most of which went to the corporate sponsor. However, the authors plan to make the book available as an e-book.

I came away from looking at this book wondering if an artist such as Eladio Fernández would ever team up with a scientist and produce an illustrated monograph of some group of palms. That would be something.

Hoppe, J. 1998. *Palmas en la República Dominicana*. EDUCA, Acción para la Educación Básica, Santo Domingo.

Moscoso, R. 1945. *Palmas dominicanas*. Universidad de Santo Domingo.

ANDREW HENDERSON,
New York Botanical Garden

Palms on the Brink: Conservation Status of the Threatened Palms *Dypsis saintelucei* and *Beccariophoenix madagascariensis* in the Littoral Forests of Sainte Luce, Southeastern Madagascar

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Initial population assessment of the palms *Dypsis saintelucei* and *Beccariophoenix madagascariensis* in the littoral forests of Sainte Luce between 2008 and 2011 revealed that despite their integral role as community resources, local populations were under significant pressure. Given their low abundance in the area, high utility and an increasing demand for resources driven by a rapidly expanding human population, these threatened species warranted systematic and rigorous monitoring. Eight years later, we reassessed the subpopulations of each species

across five forest fragments. All previously recorded individual palms (n=239) were revisited, and additional individuals (n=38) were identified. Results indicate that *D. saintelucei* has experienced a substantial decline, with a total mortality of 64% over an 8-year period, whilst *B. madagascariensis* has experienced more modest but still substantial losses (25%). The majority of palm losses (63%) can be attributed to anthropogenic factors. Our findings underline the need for urgent conservation intervention, and in this paper, we offer several suggestions to mediate further losses and potentially reverse the trend.

Madagascar supports a grand and globally important palm flora (Arecaceae) characterized by high phylogenetic clustering and morphological diversity (Dransfield & Beentje 1995, Callmender et al. 2011, Kissling et al. 2014). The vast majority of described species (+208) belong to the subendemic genus *Dypsis*, with most being distributed along the eastern margins of the island within the humid rainforests. Numerous new species have been described since the comprehensive monograph compiled by Dransfield and Beentje was published in 1995 (summarized in Eiserhardt et al. 2018), with increased field work and wider expedition coverage indicating that the discovery phase for Malagasy palms is incomplete. Furthermore, many species are considered range-restricted and as a result, further discoveries are anticipated in the highly fragmented and remote areas of the island (Eiserhardt et al. 2018). Such species, however, are inherently at higher risk of extinction through destructive processes on a local scale, and indeed, many of the newly described taxa are classified as Threatened by the International Union for the Conservation of Nature (IUCN, 2020).

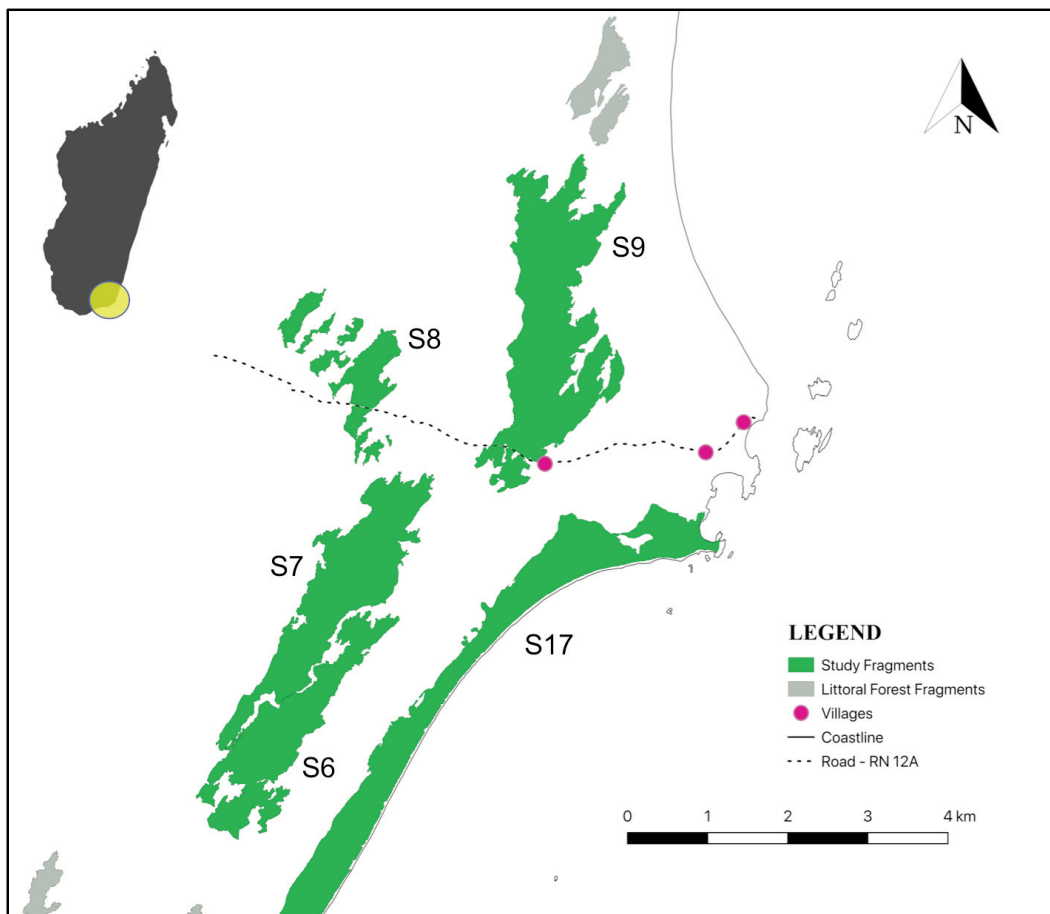
Palms are regarded as Madagascar's most endangered plant group, with a comprehensive assessment concluding that 83% of species are threatened with extinction (Rakotoarinivo et al. 2014). An array of anthropological threats including deforestation, unsustainable harvesting practices, and fire, are considered the leading causes for concern (Rakotoarinivo et al. 2014). Palms play key ecological roles in tropical ecosystems but are also regarded as being amongst the most important plant families to humans (Couvreur & Baker 2013, Bennett 2001). They provide numerous highly valued resources from food and medicinal products to materials for construction and weaving, and their economic

value is particularly important in impoverished countries such as Madagascar (Dransfield et al. 2008). The socio-economic importance of palms is most significant at local and rural levels where reliance on forest products and natural resources is most pronounced. As a result, many palm species are susceptible to unsustainable harvesting as human populations continue to grow and demands for finite forest resources increase (Dransfield & Beentje 1995, Johnson 1996, Ratsirison et al. 1996, Byg & Baslev 2001, Hogg et al. 2013a).

The monitoring of palm populations, therefore, is critical from both a biological and economic perspective. In this study, we assess the population status of two palm species, *Dypsis saintelucei* and *Beccariophoenix madagascariensis*, within the littoral forests of Sainte Luce over a period of eight years.

Study Site

Sainte Luce (Fig. 1; 24°46'52"S; 47°10'28"E) lies within Madagascar's humid bioclimatic zone in the southeastern coastal lowlands, ca.45 km north of Tolagnaro/Fort Dauphin (the Anosy regional capital). The area receives an average annual rainfall of 2690 mm, with temperatures relatively constant with a mean annual temperature of 28°C (Goodman et al. 1997, Vincelette 2007). The area supports an estimated 10% of the island's remaining littoral forests (Bollen & Donati 2006). These specialized humid evergreen woodlands are adapted to low altitude (0–50 m a.s.l), sandy coastal substrates and support high levels of diversity and endemism. Approximately 13% of Madagascar's total indigenous flora is known to exist within this habitat type and over a quarter of the species supported by littoral forests are considered endemic (Du Puy and Moat 1998, Dumetz 1999, Consiglio et al. 2006).



1. The location of each of the main study fragments and the relative position of Sainte Luce in the extreme southeast of Madagascar. Villages from left to right: Ambandrika, Ampanasatomboky, Manafiafy. Fragments S6 + S7 constitute the Community Resource Zones (CRZ) and S8, S9 and S17 constitute Conservation Zones (CZ).

Nationwide, only an estimated 10% of original littoral forest cover remains (Moat & Smith 2007) and the remaining forests are now heavily fragmented and degraded (Ingram & Dawson 2006). The littoral forests of Sainte Luce are no exception yet are considered amongst the most intact examples of this habitat remaining (Rabevohitra et al. 1996, Dumetz 1999, Bollen and Donati 2006). The Sainte Luce formations currently comprise 17 disconnected forest fragments, ranging in size from ca. 6 ha to 350 ha, and cover a total estimated 1500 ha (Ramanamanjato 2007, Vincelette et al. 2007). The human community of Sainte Luce comprises three hamlets – Ambandrika, Ampanasatomboky and Manafiafy – with a combined total

population of approximately 2500 (Berina, Chef de Fokontany, pers. comm., January 2020), who all rely to some extent on natural forest resources. As a result, significant pressure is exerted on the surrounding littoral forests

for food, construction materials and livelihoods, and palms are regularly utilised (Vincelette 2003, Bollen & Donati 2006, Rasolofoharivelo 2007, Hogg et al. 2013a). The area is also subject to a proposed mining operation by QIT Madagascar Minerals (QMM), a subsidiary of the large international corporation Rio Tinto, who plan to exploit the heavy mineral sands to extract ilmenite, a titanium-iron oxide mineral (Temple et al. 2012). As a result of the mine's presence, the area has received a relatively extensive botanical assessment and the vegetation has been well characterised (Lowry & Faber-Langendoen 1991, Rabevohitra et al. 1996, Du Puy & Moat 1998, Dumetz 1999, Consiglio et al. 2006).

This study focuses on five of the most intact forest fragments (Fig. 1), positioned most proximally to the villages, named S6, S7, S8, S9 and S17 during the initial mining prospecting. Both S6 (170ha) and S7 (220ha)



2. A solitary adult *Dypsis saintelucei* in exposed swampy habitat near S8.

now represent the most degraded fragments, after designation as community resource zones (CRZs) in 2015 prior to their proposed future clearance for ilmenite extraction. Both S8 (90ha) and S9 (340ha) are now designated IUCN Category IV protected areas and are managed by QMM as part of their conservation offset target (Temple et al. 2012). Forest fragment S17 is currently under private ownership and exists outside of the mining zone.

Given the status of littoral forests as a whole in Madagascar, their importance for supporting biodiversity and their vastly diminished distribution, this habitat type is recognised as one of the nation's highest conservation priorities (Ramanamanjato et al. 2002, Ganzhorn et al. 2001, Bollen & Donati 2006). Until recently, very few patches of littoral forest were included within the existing protected areas network (Consiglio et al. 2006), and whilst this has increased over the past



3. A sub-adult *Beccariophoenix madagascariensis* at the boundary between forest and a cassava plantation near S8.

decade (Goodman et al. 2018), an accurate picture of littoral forest health and conservation status nationwide is still lacking. At present, there are 13 species of palm in the Sainte Luce area (Hogg et al. 2013a); however, this study focuses on just two species, both of which had been considered as being high

conservation priorities in the past and remain locally threatened.

Study Species

Dypsis saintelucei (Fig. 2) had been formerly classified as Critically Endangered by the IUCN; however, upon the discovery of three

additional subpopulations away from its type locality in Sainte Luce, its conservation status was downgraded to Endangered (B2ab(ii,iii)) in 2012 (Dransfield & Beentje 1998, Rakotoarinivo & Dransfield 2012). The wider distribution now includes Ampasimanolotra, Vondrozo and Tsitongambarika (Rakotoarinivo 2008, Rakotoarinivo & Dransfield 2012), a highly disconnected range spanning a total area of approximately 650 km² along the east coast. Rakotoarnarivo and Dransfield (2012) estimated 300 adults exist over the three sites, with approximately half occurring in Sainte Luce’s littoral forests (Hogg et al. 2013b).

Beccariophoenix madagascariensis (Fig. 3) is another species whose conservation status has been downgraded in recent times, considered Critically Endangered up until 2012, it is now considered as Vulnerable (B1ab(iii)+2ab(iii)) after the discovery of two further populations. Its wider distribution now encompasses Vondrozo (where it is again sympatric with *D. saintelupei*) and the large protected area of Mantadia National Park. Similar to *D. saintelupei*, the distribution of *B. madagascariensis* is highly fractured with each population separated by hundreds of kilometres (Rakotoarinivo & Dransfield 2012). Population density is thought to vary greatly between the three localities, and the overall population is believed to comprise of approximately 900 mature individuals (Rakotoarinivo & Dransfield 2012). Sainte Luce is believed to support a little over 5% of the total of known adults (Hogg et al. 2013a).

Hogg et al. (2013a) identified the main uses of these two palm species in Sainte Luce. Both *D. saintelupei* and *B. madagascariensis* have been selectively harvested in the past and used in the manufacture of lobster pots. Lobster fishing has long been a major source of income within the Sainte Luce community (Holloway, 2013), and demand for these palms has been high. *Dypsis saintelupei* is also harvested for construction purposes and for its edible palm heart, whilst *B. madagascariensis* is also used for cultural purposes. Hogg et al. (2013a) noted that the unsustainable harvesting of palms, as well as land clearance for agricultural purposes, is driving dramatic population declines.

Methods

Between 2008 and 2011, a systematic search methodology was employed to identify and locate all adult and sub-adult *D. saintelupei* and *B. madagascariensis* palms in the forest fragments S6, S7, S8, S9 and S17 (Fig. 1). Surveying east to west with 100 m line spacing and following a zigzag search pattern, the sweep was designed to maximize forest coverage and the number of palms recorded in the study. In addition to the standardized search method, individual palms known to the local guides were visited and included in the dataset to provide a comprehensive baseline dataset that could be used for future monitoring. Once an individual was located, morphological data, GPS location and the health status of the palm were recorded, and each individual was given a unique ID code. Individual maturity was assessed following Hogg et al. (2013b) (Table 1). The early baseline studies found neither palm species in the large coastal fragment S17, and despite repeated expeditions in recent years, no individuals have been discovered.

In November and December 2018, all known sub-adult and adult *D. saintelupei* individuals across the four forest fragments were revisited. Similarly, between April and June 2019, all *B. madagascariensis* individuals were revisited. Over the course of the study, 18 inventories were carried out including the additional ad hoc surveys in fragment S17. Data collected in 2018 and 2019 mirrored that of the earlier studies and included a range of morphological characteristics as well as notes on the general condition (cut marks, fire damage, rot, etc.), habitat type and, crucially, its status as alive or dead. Each individual was retagged where necessary for future monitoring purposes. When an individual was found dead, the cause of death was determined as accurately as possible based on the available evidence. In instances where individual palms could not be located, either alive or dead, a further search for remains (stump, felled log, stripped bark) in the surrounding vicinity was conducted. Palms that were classified as “assumed dead” were those where no obvious evidence of the

Table 1. A basic description of the maturity classes for *D. saintelupei* used to assess individuals in the study.

Classification of individual maturity status	
Maturity Phase	Description
Seedling	Seedling leaves (<4) possess a single leaflet pair (<15 cm in length)
Juvenile	No visible trunk; Early juveniles possess leaves with 2 or more leaflet pairs; leaves grow to 2 m+ in length in older juveniles
Sub-adult	Development of the crownshaft and a short trunk, no visible signs of reproductive maturity.
Adult	Visible signs of reproductive maturity; trunk usually 4 m in height

palm remained, despite being previously recorded in relatively open areas with good visibility.

Results

Dypsis saintelucei

During the initial surveys, between 2008 and 2011, 147 adult and 34 sub-adult individuals of *D. saintelucei* were recorded across the four study fragments, along with 102 juveniles. The distribution of adult palms was heavily skewed with 116 adults identified in association with forest fragment S7 (78.4%), 26 in S8 (17.6%), four in S6 (2.7%) and just a single adult palm in S9 (0.7%). Of the sub-adult palms identified, 19 (55.9%) were located in S8 and the remaining 15 (44.1%) were found in S7. All 102 juvenile palms were recorded within S7.

In 2018, 49 adult and 10 sub-adult *D. saintelucei* were found alive. Seventy adult palms (47.6%) were confirmed as dead and 15 were assumed as being dead (10.1%). A further nine (6.1%) were missing and four individuals (2.7%) were inaccessible. Twenty (58.8%) sub-adult *D. saintelucei* palms were confirmed dead, one (2.9%) was assumed dead and three (8.8%) were missing. Overall mortality for both adult and sub-adult palms was very high over the survey period, at 63.4% and 67.7% respectively. The 16 individuals that could not be located due to accessibility issues and difficulties associated with locating the palm have not been included in population losses; however, those we “assumed as dead” are included as they were in locations with good visibility and some evidence of their presence

could be expected if still alive. Total mortality for adult and sub-adult individuals combined is 64.2% across the four study fragments over the study period. The survival rate of juveniles was not assessed during this phase of the project due to time constraints.

Over the eight-year period, a minimum of 85 adults and 21 sub-adult *D. saintelucei* has been lost from the population, corresponding to a mean annual loss of 13.25 palms and a population decline of 8.0% per year. However, the discovery of a further 16 additional adult palms and 10 sub-adults during 2018 increases the known minimum population size in Sainte Luce to 65 adults and 20 sub-adult palms.

Beccariophoenix madagascariensis

During the initial surveys, 48 adult *B. madagascariensis* palms were located, with 30 individuals identified in S8 (62.5%), 11 in S6 (22.9%), five in S7 (10.4%) and two palms in S9 (4.2%). Of these, 36 were alive in 2019. Total mortality for the Sainte Luce population was 25.0% over the study period, with an average loss of 1.5 adult palms per year. However, an additional 14 adult palms were located in 2019, although two of these individuals were dead upon discovery. Therefore, despite the loss of 25.0% of the original study population, the current census of *B. madagascariensis* remains unchanged at 48 known adult individuals as of June 2019.

Palms in the Community Resource Zones (CRZ) – Fragments S6 + S7

Unfavourable weather conditions and flooding meant that access to large parts of S6, which

Table 2. A summary of *D. saintelucei* and *B. madagascariensis* population trends in Sainte Luce. The 300 juvenile *B. madagascariensis* juveniles estimated by Hogg et al. (2013) are not included as their distribution across Sainte Luce is unknown. * represents adjusted values based on missing palms that could either not be assessed during the follow-up study or could not be located but neither confirmed dead. ** represents the minimum number of surviving palms in 2016 from a project for which several hundred juveniles were transplanted in ca. 2013. CRZ = Community Resource Zone, CZ = Conservation Zone.

Palm demographics for each of the study fragments in the littoral forests of Sainte Luce		S6	S7	S8	S9	CRZ	CZ
<i>Dypsis saintelucei</i>	Total Adults 2011	4	116	26	1	120	27
	Total Adults 2018	1*	33	15*	0	34*	15*
	Mortality	0%*	69.45%	40%*	100%	68.81%	40%*
	New Adult palms 2018	0	16	0	0	16	0
	Min. population size	1*	49	15	0	50	15
	Total Sub-adults 2011	0	15	19	0	15	19
	Total Sub-adults 2018	0	9	1*	0	9	1*
	Mortality	0%	35.71%*	94.12%*	0%	35.71%*	94.12%*
	New Sub-adult palms 2018	0	9	1	0	9	1
	Min. population size	0	18	2	0	18	2
<i>Beccariophoenix madagascariensis</i>	Total juveniles 2011	0	102	222**	0	102	222**
	Adult palms 2011	11	5	30	2	16	32
	Adult palms 2019	7	4	23	2	11	25
	Mortality	36.36%	20.00%	23.33%	0.00%	31.25%	19.57%
	New palms 2019	5	2	5	0	7	5
Min. population size		12	6	28	2	18	30

Table 3. A summary of presumed cause of death in assessed *D. saintelupei* and *B. madagascariensis* palms. *indicates that in some cases the cause of death is likely a combination of factors, with fire used as a tool to kill and clear trees in areas subsequently used for agriculture.

Inferred cause of death		Agriculture	Felled	Fire	Natural causes	Unknown
<i>Dypsis saintelupei</i>	Adult (n=80)	11*	30	8	15	16
	Sub-adult (n=20)	9	0	7	2	2
		20.0%	30.0%	15.0%	17.0%	18.0%
<i>Beccariophoenix madagascariensis</i>	Adult (n=14)	2*	3	2	0	7
		14.3%	21.4%	14.3%	0.0%	50.0%
	Combined (n=114)	22*	33	17	17	25
Total		19.3%	29.0%	14.9%	14.9%	21.9%

contains many swampy areas was limited. As a result, three of the four known adult *D. saintelupei* palms could not be monitored in December 2018. The one accessible individual was found alive. In S7, the fragment found to support the highest density of *D. saintelupei* palms in 2011, only 33 of the 108 monitored adults (30.6%) and nine of the 14 (64.3%) sub-adults remained alive. Eight adult palms were recorded as being missing, and one individual could not be accessed. The *D. saintelupei* subpopulation in S7 has experienced a total decline of 65.6% over the eight-year monitoring period, with an average loss of 9.38 adult palms per year. However, the majority of new *D. saintelupei* individuals were also discovered in S7, with 16 further adults and nine sub-adults added to the number of known individuals. Total mortality for adult and sub-adult *D. saintelupei* combined in the CRZs was 65.0% over the study period, whilst the minimum known population stands at 50 adults and 18 sub-adults (Table 2).

Similarly, total mortality for *B. madagascariensis* in the combined CRZ fragments stands at 45.5% over the eight-year period. During the follow up study, four of the 11 palms located in S6 were dead (36.4%), along with one of the five palms in S7 (20.0%). However, six of the newly discovered palms (five living individuals and a single dead palm) were found in S6, and two further living and healthy individuals were recorded in S7 along with an additional dead palm. The current number of known adult *B. madagascariensis* within the CRZ stands at 18 individuals (Table 2).

Palms in the Conservation Zones (CZ) – Fragments S8, S9 + S17

In the forest fragment S8 and its satellite remnants, ten of the previously recorded 26 adult and 16 of the 19 sub-adult *D. saintelupei* palms were found deceased. One adult and two sub-adults could not be located. Total losses correspond to a 61.9% overall decline in the number of known *D. saintelupei* in the

area. A single sub-adult palm was discovered during the 2018 survey, leaving the minimum population of S8 at 15 adults and two sub-adults. The only known *D. saintelupei* in the largest protected forest fragment in Sainte Luce, S9, could not be found in 2018, and it is now highly likely that the S9 subpopulation stands on the brink of extirpation.

The forest fragment S8 supported the largest number of adult *B. madagascariensis* during the initial 2011 assessment, however seven of the 30 individuals (23.3%) had died during the intervening years. A further five individual adults were discovered during the 2019 surveys. Both of the known individual palms in S9 remained alive. The total number of known *B. madagascariensis* palms in the CZs stands at 30 adults (Table 2). To date, no palms of either species have been recored in fragment S17.

Threats

A breakdown of inferred cause of death for both species is provided in Table 3. When all cases are combined (for all assessed *D. saintelupei* and *B. madagascariensis* palms), the leading cause of palm mortality is deliberate felling (29.0%, n=33). However, the difficulties of post-mortem assessment are reflected in the number of palm deaths categorized as “unknown” (n=25), the second largest mortality category (21.9%). Agricultural practices and land conversion are a further substantial driver behind the decline of both species, accounting for the loss of 22 palms (19.3%), whilst 17 cases (14.9%) were each attributed to both fire and natural causes. However, it is difficult to disentangle fire and agricultural practice as the definitive cause of mortality as both are often linked, with fire utilized as a means of clearing ground for crops. Combined, anthropogenic factors (agriculture, felling and fire) account for 63.2% of overall palm mortality, natural causes were attributed to 14.9% of cases and 21.9% were unsolved. Whilst the inferred cause of death

appears to be largely consistent for both adult and sub-adult *D. saintelupei* palms with regards to both fire and agriculture, the apparent lack of evidence for the deliberate felling of sub-adults may reflect differentiated harvesting practices associated with both age classes (Hogg et al. 2013a). In contrast, the seemingly disparate number of deaths attributed to natural causes may be age-related.

Discussion

The remaining littoral forests in the extreme southeastern corner of Madagascar are predicted to lose a number of plant and animal species in the coming decades as high levels of deforestation, forest fragmentation and an increasing pressure on forest resources exact their toll on the natural environment (Bollen & Donati 2006). The impact of the proposed ilmenite mine in the region provides a further overarching threat to endangered species in the region (Ganzhorn et al. 2001, Bollen & Donati 2006, Watson et al. 2010, Rakotoarinivo & Dransfield 2012, Goodman et al. 2018). The implications of the results presented here further signal the grave threat faced by many species over the coming decade. Whilst we resist the temptation to predict timeframes for the possible extirpation of both palm species, it is clear they face an uncertain future in Sainte Luce and the next few years could prove critical to the long-term future of both species. The limited number of adult palms remaining is a real concern, as is the realization that the majority of *D. saintelupei* exist outside of the recognized conservation zones and within the community resource zones, areas that are also under the proposed mining footprint (Temple et al. 2012, Hogg et al. 2013a).

Whilst it is highly likely that further undiscovered palms exist within the study fragments, the number is likely low given the intimate degree to which local forest guides know the area and individual trees within the forest, and also the time invested locating palms over the course of this study. It is also more likely that further individuals of both species may be found in the CRZs than in the CZs, since these forests are less explored and still maintain areas that are difficult to access. However, such new discoveries, although promising in the short term, provide no security for the future of either species if current mortality rates are unchecked and mining operations proceed as anticipated. Furthermore, whilst it may be obvious that

resources in close proximity to human communities should be the most exploited, the current distributional pattern also raises questions as to the underlying ecological health of the forest fragments themselves, and it is plausible that different fragments have a differentiated capacity to regenerate certain species. Moreover, it is important to note that a further 12 forest fragments exist beyond the study forests, comprising an additional ca. 380 ha of unexplored habitat within the wider landscape. Although these smaller forest fragments are considered to be more degraded than the CRZ and CZ forests, they may still support a significant number of individual palms.

The population status of *B. madagascariensis* in Sainte Luce appears to be consistent with the estimates of Hogg et al. (2013a) with slightly fewer than 50 adult palms remaining in the area. However, this figure has remained stable only with the discovery of previously unknown individual palms and masks the steady decline in the number of persisting adults. The population estimate of approximately 85 adult and sub-adult *D. saintelupei* seems reliable; however, it is plausible that a relatively large number of the 102 juveniles discovered in 2011 remain alive and are developing. While Ellis (unpub. 2003) placed the number of adult palms at 130 in fragment S8 alone (Hogg et al. 2013b), the sub-population has been severely depleted, with our results indicating that as few as 15 adult palms may remain in the fragment despite its protected status. Even more worrying is that no known mature individuals persist in the largest protected fragment (S9).

The rapid loss of adult palms revealed in this study further highlights the unsustainable rate at which both palm species are being lost and emphasises the role of anthropogenic factors in the declines. Less than 15% of diagnosable palm deaths were attributable to natural causes, which is similar to findings reported by Hogg et al. (2013b). It is clear that conservation interventions are needed now if the species are to survive long-term. In saying this, the needs of the local communities must be addressed and preserving livelihoods must be a key consideration in any future conservation actions. Lobster fishing in particular is an important livelihood in Sainte Luce and commercial exports contribute substantially to the local economy (Sabatini et al. 2007). Although many species can be

used in lobster pot construction, the durability of *Dypsis* rachis (represented locally by *D. saintelupei*, *D. scottiana* and *D. prestoniana*) mean that palms are a favored resource. Prior to ca. 1990, the vine *Flagellaria indica* was the preferred species locally for trap manufacture, but overharvesting has led to its near disappearance. Subsequent diversification of materials then led to the rapid depletion of the local *D. scottiana* population and has also placed increasing pressure on *D. saintelupei* (Hogg et al. 2013a). Local demands are evidently unsustainable and the pressure on these resources is having a serious detrimental impact on local populations.

This study found that in 56.7% of cases where the *D. saintelupei* had been felled, only the crown and leaves had been harvested. In such cases, the trunk remained at the site, indicating that the recovery of wood for construction or fuel was not the objective reason for the logging. This cutting technique and wasteful resource use was also observed by Donati and Bollen (2006). Amidst the crown of *D. saintelupei* is the edible palm heart, a vegetable commonly harvested by previous generations (prior to ca. 1985); however, this practice seems to have faded out over time and is considered unlikely to have influenced recent tree felling (Hogg et al. 2013b). Despite almost one in five adult *D. saintelupei* exhibiting axe wound damage to the trunk, a test of maturity and its readiness for construction purposes, we conclude that the felling of individual palms for their rachis and leaves at all life stages, presents the most damaging and direct threat to *D. saintelupei*. Furthermore, the non-lethal practice of harvesting the fibrous leaf rachis has been shown to render young trees in a quasi-juvenile state and stalls the development of affected palms (Dransfield & Beentje 1995, Hogg et al. 2013a).

Whilst the principal cause of death could not be determined in 50% of cases, adult *B. madagascariensis* palms are demonstrably still vulnerable to human activities. Adult palms were found to have succumbed to deliberate felling, fire and agricultural clearing. Whilst Hogg et al. (2013a) surmised that the species is infrequently used by local communities, despite utility in a diverse range of applications, any upsurge in its use could present significant population level problems given the low number of remaining palms.

In nutrient-depleted areas such as Sainte Luce, forested land often holds the most fertile soil

and illegal slash and burn practices such as “tavy” can provide a quick fix of nutrients for growing crops and grass pastures for cattle grazing. Whilst there is no heavy dependence on agriculture in Sainte Luce, cassava – a hardy, drought-tolerant crop – is a staple in the local diet and is widely cultivated. Despite large areas of available open ground, the borders around some fragments (most notably S6 and S8 along with its satellite remnants) are being transformed into small-scale agricultural plots used almost exclusively for cassava cultivation. In some areas, these micro plots are rapidly encroaching into standing forest. Either through targeted removal or uncontrolled burning, 39 individual *D. saintelupei* and *B. madagascariensis* have been lost as a result of agricultural practices over the course of this study.

Conservation actions

A number of ambitious conservation initiatives have previously been introduced into Sainte Luce in an effort to counter the well acknowledged palm declines, with varying degrees of success. Both SEED Madagascar and QMM have fully operational plant nurseries and have in the past invested significantly in the cultivation of numerous palm species, including both *D. saintelupei* and *B. madagascariensis*. Previous work by SEED Madagascar growing *D. saintelupei* in the nursery had germination and first-year survival rates of over 90%. Similarly, a small number of transplanted *D. saintelupei* and *B. madagascariensis* saplings also show high survival rates after the first year (>70%) (SHR, pers obs. November 2019). Therefore, ex-situ cultivation in local nurseries and future palm transplantation initiatives may play an important role in future conservation planning and species management. Fragments S9 and S17 should be considered as priority recipient fragments, given their protected status and very low number of existing adult palms. However, the apparent absence of palms in S17 is curious and suitability trials should precede a fully committed trans-planting programme.

Whilst the threat posed by unsustainable harvesting is difficult to address, recent attempts to cultivate alternative resources (e.g. *Flagellaria indica* and *Bambusa multiplex*) in Sainte Luce should be supported. If successful and adequately scalable, these plantations could provide a sustainable solution for the construction of lobster traps, and relieve

pressure on a number of local species (including *D. saintelucei*, *D. scottania* and *B. madagascariensis*). Similarly, they may provide a more environmentally acceptable option to other proposed alternatives such as gill-netting and plastic (Girldes et al. 2015). However, given the huge demand for such material locally and the slow growing nature of *F. indica* (Rabenantoanandro et al. 2007), meeting demand could be problematic.

Recommendations

The local threats faced by both palm species are well understood and have been adequately documented (Rakotoarinivo & Dransfield 2012, Hogg et al. 2013a, 2013b). Whilst the challenges associated with successfully overcoming these difficult problems are substantive, the limited success of past conservation efforts is reflected in the continual decline of both species over the past decade. In order to address this conservation problem, a dedicated, long-term and well-coordinated strategy must be developed focusing on several core aspects: the functional protection of remaining individuals across Sainte Luce, the provision of accessible alternative resources for community livelihoods, and the restoration of wild populations through supplementation. Whilst local projects have attempted to address the latter, follow up studies are now crucial in order to determine their success. Furthermore, a reliable and sustainable alternative source of materials for lobster trap construction is still required and the protection of the remaining adult palms needs urgent attention.

A potential short-term solution to abate the loss of threatened palms could be a locally enforced moratorium on the felling or exploitation of at-risk species. Such a dictate could effectively prevent the imminent loss of further palms but the timing of such an intervention would be crucial. A reliable supply of alternative resources, such as *F. indica* and *B. multiplex* (Rabenantoanandro et al. 2007) would be required to sustain livelihoods in the period whilst cultivated juvenile palms mature and prevent the harvesting pressure simply being shifted on to other palm species (Hogg et al. 2013a).

At the local level, the regulation of natural resources and the management of protected areas are the responsibility of COBA and FIMPIA respectively and both would need increased empowerment to ensure known palms and other valuable species are

safeguarded. Working closely with NGOs, both entities could incorporate tailored monitoring regimes into existing patrols. Both bodies will be integral to the conservation of both palms; however, legal enforcement is a sensitive matter in impoverished rural communities, as compliance with regulatory frameworks and enforced financial consequences can endanger livelihood quality. This fundamental problem is demonstrated by the local use of tavy, which despite being nationally outlawed and prohibited locally around the protected areas, remains one of the most destructive environmental practices in Sainte Luce. Both community awareness and engagement will be critical to any successful scheme.

In the meantime, extensive cultivation and transplanting schemes must be reinvigorated, with local plant nurseries dedicating some proportion of their capacity to threatened species and prioritising those with high utility. Such schemes should dedicate a proportion of their output towards conservation and restorative purposes but also towards sustainable community use. The location of transplanted palms must also be very carefully considered, with the position of community resources informed by local stakeholders as well as the fundamental ecological requirements for optimal development. Finally, the opportunity to improve our understanding of both species through research should not be missed. Concurrent studies detailing the optimal growing conditions for both species *in situ* and *ex situ* will provide vital lessons for the future and a comprehensive monitoring programme should be developed to ascertain the success and survivorship rates of palms in different settings. Similarly, the refinement of cultivation and transplantation techniques is essential, building on the lessons learned during past projects (Azafady 2012). Finally, crucial ecological detail is still also lacking in terms of the natural pollinators, dispersers and predators of both palm species, and an understanding of these important natural history details will improve our collective ability to conserve these species long-term.

Acknowledgments

First and foremost, we are indebted to the kindness and expertise of the Sainte Luce community and the local guides on whom this project has relied so heavily – Babaly, Solo, Raziva and Altera. We would like to extend our gratitude to all of those who contributed to the field work over the duration of this

project, including former SEED Madagascar (previously ONG Azafady) staff and volunteers, who each devoted their hard work and time. Special thanks to Dr. J. Dransfield who kindly helped us to improve the initial versions of the manuscript. Finally, our sincere respect goes out to all of those working to conserve the precious wildlife and ecosystems of Madagascar. *Misoatra betsaka*.

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Pinanga andamanensis Becc.

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1. *Pinanga andamanensis* at the original locality, Mount Harriet National Park, South Andaman Island.



The Andaman-Nicobar Islands or the Bay Islands in the Bay of Bengal are remarkable for their diversity of palms. These islands are known to host around 43 species, of which 37 species are indigenous including 21 endemics. Among the palms are apparently wild populations of the coconut and the betel nut palm. The occurrence of wild coconut palms

from the Andaman Islands was first reported in 1891 by David Prain, a Scottish botanist (Prain 1891), and the betel nut palm was recorded in 1876 from the evergreen forests of Great Nicobar Island by the German botanist Wilhelm Sulpiz Kurz, who was the curator of the Herbarium at the Royal Botanic Garden Calcutta (Kurz 1876).

Pinanga andamanensis is critically endangered and one of the least known endemic palms of the Andaman Islands. It has remarkable horticultural potential. In general appearance it is similar to the common betel nut palm with a 5–6 m tall trunk that is 10–15 cm in diameter and with highly ornamental, bright pink inflorescences and shining black fruits. This elegant species is a promising avenue palm for gardens. It was originally described by Odoardo Beccari and published posthumously in 1934. He based his description upon an old herbarium specimen collected by E.H. Man, who was the British Assistant Superintendent of the Andaman Administration, during the latter part of the 19th Century. The species was not recorded again and was thought to be extinct until 1992. While working on the Flora of Andamans under the Flora India Project of the Botanical Survey of India, Mathew and Malick in 1992 came across a few populations of this species in Mount Harriet National Park (Mathew & Malick 1992). It has so far been reported from only a few evergreen forest pockets on South Andaman Island emphasizing its vulnerability.

According to the geographical mapping studies on *Pinanga andamanensis* carried out by Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), it has a small gene pool, reduced out-breeding due to geographical barriers and vulnerability due to catastrophic events such as cyclones, earthquakes and tsunamis threatening the species with possible extinction in the near future.

In this context, *Pinanga andamanensis* was introduced in the JNTBGRI Field Gene Bank in 1994, but unfortunately these living collections were eaten by wild elephants in 2012. Later in 2014 a few seedlings from Mount Harriet were introduced again at JNTBGRI Field Gene Bank and started flowering in 2019. Once these plants set fruits, seed germination experiments under controlled conditions were initiated as part of the conservation strategy.

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2. *Pinanga andamanensis*. Close-up view of the unopened prophyll. JNTBGRI Field Gene Bank.



PRAIN, D. 1891. The vegetation of the Coco group. Journal of Asiatic Society of Bengal 60: 283–306.

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Becc. from the Andaman Islands, India. Bulletin of Botanical Survey of India 34: 217–219.

3. *Pinanga andamanensis*. Shedding the prophyll and revealing a new inflorescence. JNTBGRI Field Gene Bank.





4. *Pinanga andamanensis*. Bright pink, ornamental mature flowers. JNTBGRI Field Gene Bank.

5 (facing page). Mature infructescence with bright, shiny black fruits contrasting with the pink branches of the infructescence. Mount Harriet National Park.







6 (facing page). Mature, dried fruits of *Pinanga andamanensis* collected from Mount Harriet National Park for seed germination at JNTBGRI Field Gene Bank.

7 (top). Mature infructescence on *Pinanga andamanensis* at Mount Harriet National Park. 8 (bottom). Two-year old plant of *Pinanga andamanensis* at JNTBGRI Field Gene Bank.

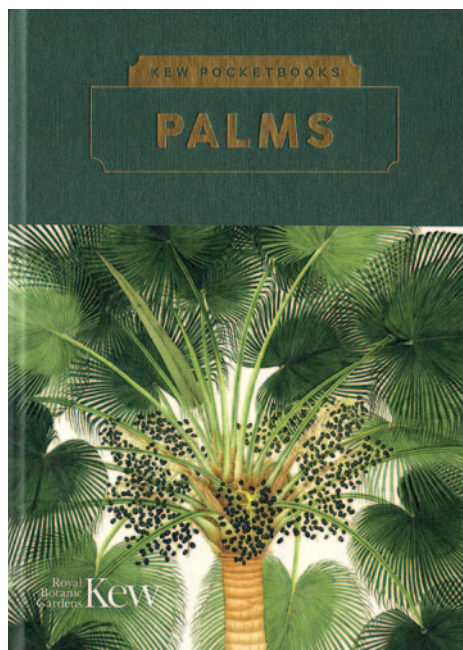
Palm News, continued from p. 160

In conservation news, a study of how dams in the Amazon basin affect palms determined that **palm species are differentially affected by flooding and have different risks of local extinction**. The study site was an area behind the Jirau hydroelectric dam on the Madeira River, Rondônia, Brazil. Threats to palms are manifold. *Bactris concinna* and *Oenocarpus minor* form clonal clusters and had more than 90% of their individuals occurring in the area to be flooded by the reservoir. *Bactris riparia*, which is restricted to riverbanks, is highly vulnerable to habitat loss. Other species susceptible to habitat loss are those associated with floodplain environments, even if these are far from the riverbanks. Palms not directly submerged may still be affected; species intolerant of flooded soils, such as *Bactris acanthocarpa*, *B. elegans* and *B. gastoniana*, may be the first species to suffer extinction locally if their habitat is subjected to changes in groundwater levels. The paper, by E.A. dos Santos et al., was published earlier this year in *Forest Ecology & Management* (<https://doi.org/10.1016/j.foreco.2020.118032>).

In another conservation-related study published in *Ecology & Evolution* (<https://doi.org/10.1002/ece3.6697>), C.J. Butler and M. Larson found that **some palm species from the southeastern USA will be climate change “winners” and others will be “losers.”** Using models for habitat preferences and climate changes over the next fifty years, they found that *Sabal minor* and *S. etonia* will likely suffer serious range reductions, while habitat available to *Sabal palmetto* and *Serenoa repens* will likely expand. The habitat available to *Rhapidophyllum hystrix* will remain relatively unchanged.



Scott Zona



Palms. Kew Pocketbooks. Introduced by William J. Baker and curated by Gina Fullerlove, is a nicely produced little book of 40 palm illustrations selected from the extensive holdings of the Library at Kew. There is brief text to accompany the illustrations. The book is intended to be an attractive souvenir for the visitor to Kew. (ISBN 978 1 84246 711 4; Price £8.99, \$12.95).

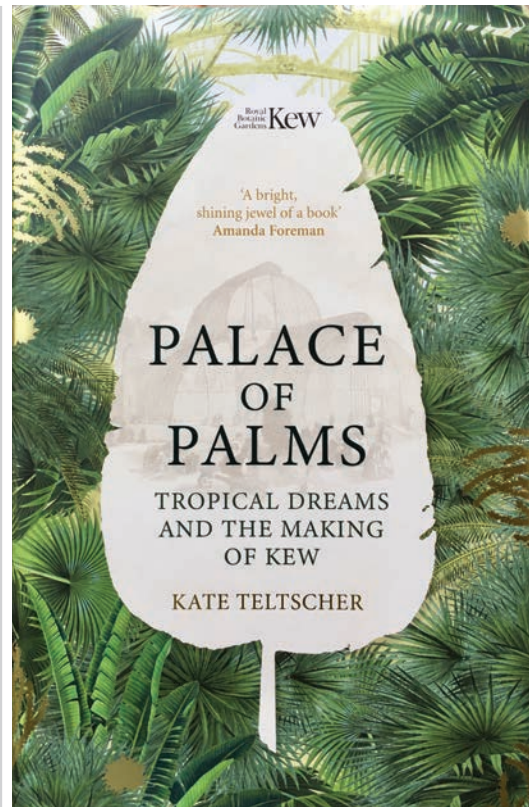
PALM LITERATURE

PALACE OF PALMS: TROPICAL DREAMS AND THE MAKING OF KEW – Kate Teltscher, Picador, London. 2020. Hardcover. ISBN: 978 1 5290 0485 4. Price £25/US\$36. Pp. 382 + color & halftone illustrations.

The Palm House at the Royal Botanic Gardens, Kew, is as much a landmark today as it was when it was completed in 1848. Anyone fortunate enough to visit the Palm House can appreciate why this structure is designated Grade I (Exceptional Interest) by the National Heritage List for England. Its soaring columns and graceful arches sheathed in elegantly curved glass set the standard for large glasshouses, which prior to Kew's Palm House had been designed as large, glass boxes. Kate Teltscher's book explores the history of how this magnificent structure came into being.

The story of the Palm House begins with the story of the early days of Royal Botanic Gardens, Kew, how it started as a small garden attached to a royal residence and eventually became a state-owned property open to the public, if only after one o'clock and to visitors "respectably attired." It is also the story of men who vied for the leadership of the fledgling garden. The struggle between botanist Sir William Hooker and horticulturist John Smith involved conflicts of class, ambition and famous friends, all played out in the pages of England's many gardening and horticulture magazines. Hooker eventually prevailed, and so began the Hooker dynasty at Kew. As soon as William Hooker was installed as director, he began a backroom campaign for his son, Sir Joseph Hooker, to succeed him, which he did upon Sir William's death in 1865. Sir William's engineering of his son's education, scientific standing and career at Kew demonstrates that "helicopter parenting" is not a 21st century phenomenon.

Of course, the real engineering at the heart of this book is the design and construction of the Palm House. The innovative plan for the structure was the creation of foundry owner Richard Turner, who is as much the subject of



this book as his Palm House. As Teltscher describes him, Turner was a wizard with iron but a hopelessly incompetent businessman. As an Irishman and a struggling businessman, Turner was unable to secure the bonds necessary for such a large government contract, and ultimately, he had to allow Decimus Burton to be named as the lead architect on the Palm House project. Burton was a well-established and accomplished businessman, but more importantly in the eyes of some, he was a gentleman and an Englishman. For these reasons, in the early days of the Palm House, Turner was not given full credit for his design.

Although having Burton's name on the project was galling, Turner was able to have complete control over the construction. Once again, Turner's management skills were not up to the task, and inevitably the delays and cost overruns began to weigh heavily on Turner's shoulders. One reason for some of the delay and added expense, was a substitution of more costly structural materials soon after the project began. Turner read of an innovation in shipbuilding, the use of a wrought iron

beam (the precursor to today's I- or H-beam), which he realized would be stronger and lighter than the beams originally specified in his plan. He was the first to apply these new beams in building construction, allowing him to reduce the steel to glass ratio and bring more light into the Palm House.

William Hooker's dream of a majestic Palm House was eventually completed and opened to great public acclaim. One of the great strengths of Teltscher's book is providing the historical and social context in which the English citizenry thought about palms as symbols of the exotic, symbols of Empire and symbols of Nature. These are the "tropical dreams" in the book's subtitle. Palms in popular literature of the day were often imagined as symbols of abundance and unfettered sensuality, an idyll far removed from the constraints of class and the social and economic hardships of Victorian England. To experience the Palm House, lush, warm and steamy with the fragrance of moldering vegetation, was to experience firsthand a land that for most Londoners had existed only in their imagination. Teltscher explains brilliantly how palms, in this context, became so popular, despite being difficult – and expensive – to grow in London's climate.

Through his many contacts, Hooker was able to fill the Palm House with palms and other plants from across the British Empire and beyond. Testscher describes William Hooker's frustration at not being able to obtain seeds of some of the most desirable palms and his disappointment when some species failed to thrive. Many readers will recognize these feelings. They will also recognize Joseph Hooker's pain at having to remove prized palms that became too big for their surroundings. Teltscher also describes William Hooker's struggle to make the Palm House relevant and thus secure continued state funding. This, too, is a modern problem of museums and botanical gardens. Despite nearly two centuries of horticultural and botanical progress, some things never change.

Palace of Palms is a fascinating look into the history and context of one of the world's great palm conservatories in one of the world's most important botanical gardens. If you know the Palm House, this book will give you a new appreciation for its genesis and significance; if you have not experienced the Palm House, this book will make you want to plan a visit. Brava to Kate Teltscher for such an entertaining and enlightening book.

SCOTT ZONA

The interior of the Palm House, ca. 1865. Stereogram courtesy of Photos of the Past.





The interior of the Palm House, 2017. Photo courtesy of Arne Halvosen.

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