



## Medicinal palms (Arecaceae) in Madagascar—undocumented or underutilized?

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Palms (Arecaceae) are conspicuous in traditional medicine in Africa, contributing to health care of rural and urban dwellers. Palm species richness in Africa is much lower than in either tropical America or tropical Asia, whereas palm species richness in Madagascar is among the highest in the world when its area is taken into consideration. The African continent is 50 times larger than Madagascar, but has only 65 species of palms, whereas Madagascar in a much smaller area has three times as many species of palms. The objective of this survey was to gather all published ethnobotanical data on medicinal uses of palms in Madagascar and to compare this with the extent of palm use in continental Africa. Information on medicinal uses of palms in Madagascar was found in only 13 published references. We found 55 medicinal use records for at least 17 palm species, of which 14 were endemic to Madagascar and three were introduced. The most used palm was *Cocos nucifera*, followed by *Raphia farinifera*. For most of the species, however, we found only a single medicinal use. There are many parts of Madagascar yet to be explored for palms. Further studies and collecting trips may generate a more complete picture and suggest answers to why (or if) there are so few medicinal uses of palms in Madagascar compared to other parts of the world. © 2016 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2016

ADDITIONAL KEYWORDS: Ethnomedicine – ritual – traditional knowledge.

### INTRODUCTION

This paper addresses the apparent paradox that palms (Arecaceae) in Madagascar are not much used for medicinal purposes despite the fact that the palm flora of the island is rich and that elsewhere palms are much used for medicine and many other purposes. Palms play a key role in the subsistence economy of many communities throughout the tropics and subtropics (Johnson, 2011). The earliest record of palm uses by human societies dates back > 10 000 years (Roosevelt *et al.*, 1996). Palms are sources of raw materials for consumption, construction, clothing, handicrafts, medicines and other functions of daily livelihoods (Burkill, 1997; Macía, 2004; Lee & Balick, 2008). The importance of palms in the Neotropics has been demonstrated in numerous studies on the local (Balick, 1988; Gragson, 1992), regio-

nal (Campos & Ehringhaus, 2003; Albán, Millán & Khan, 2008) and larger geographical scales (Macía *et al.*, 2011). Quantitative methods have been used to analyse the knowledge and use of palms by local people (Byg, Vormisto & Balslev, 2006; Zambrana *et al.*, 2007; Brokamp *et al.*, 2011; Macía *et al.*, 2011; Cámara-Leret *et al.*, 2014; Martins, de & Albuquerque, 2014). Focused studies on medicinal uses of palms have highlighted the role of many Neotropical palm species in curing various diseases and disorders (Sosnowska & Balslev, 2009; Cámara-Leret *et al.*, 2014). It has also been shown that palms are conspicuous in traditional medicine in Africa, contributing to the health care of rural and urban dwellers (Gruca, Blach-Overgaard & Balslev, 2015) and palms are known to play a role in healing rituals and ceremonies in sub-Saharan Africa (Gruca, van Andel & Balslev, 2014a). As yet, no such survey has been conducted for Madagascar, one of the most palm-rich islands (Dransfield *et al.*, 2008).

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Madagascar is among the 'hottest' biodiversity hotspots (Myers *et al.*, 2000). Its palm diversity exceeds that of the whole African continent three-fold (Dransfield *et al.*, 2008), with 206 native and naturalized species, of which 199 are endemic (M. Rakotoarinivo & J. Dransfield, pers. comm.), three are non-endemic but native and four are introduced and naturalized. Despite, or maybe as a consequence of, the high species richness, the majority of the native palms has restricted distribution ranges (Dransfield & Beentje, 1995; Rakotoarinivo *et al.*, 2014). Many are threatened with extinction or severe reductions in their wild populations due to high deforestation rates on the island (Dransfield & Beentje, 1995; Rakotoarinivo *et al.*, 2014). The high biodiversity of the island goes in tandem with its rich cultural heritage. The Malagasy are an unusual mixture of Indonesian, African and Arabic cultures (Quansah, 1988). There are 14 extant languages spoken on the island (Ethnologue, 2015) and 18 officially recognized ethnic groups, of which the largest is Merina in the highlands, followed by Betsimisaraka in the eastern coastal area. Despite access to a great diversity of natural resources, the population of Madagascar (nearly 23 million today; Ethnologue, 2015) is burdened by economic poverty. Most inhabitants rely on medicinal plants as a primary source of medical care especially in remote areas with limited healthcare alternatives (Golden *et al.*, 2012; Lyon & Hardesty, 2005; Novy, 1997; Rabearivony *et al.*, 2015; Razafindraibe *et al.*, 2013). Traditional medicine is often preferred for cultural reasons and traditional values (Novy, 1997; Randrianarivelojosia *et al.*, 2003). Ethnobotanical surveys recording medicinal plant families and species exist for various parts of Madagascar, including eastern (Novy, 1997; Randrianarivelojosia *et al.*, 2003), western (Norscia & Borgognini-Tarli, 2006), northeastern (Quansah, 1988) and southeastern Madagascar (Beaujard, 1988; Lyon & Hardesty, 2012; Razafindraibe *et al.*, 2013).

The objective of this bibliographical survey was to gather all the ethnobotanical data on medicinal uses of palms in Madagascar and contribute to comprehensive ethnomedicinal datasets already existing for the Americas (Sosnowska & Balslev, 2009; Cámara-Leret *et al.*, 2014) and Africa (Gruca *et al.*, 2015). Given the recorded usefulness of palms in traditional medicine in other parts of the world and the rich palm flora in Madagascar, we expected that palms would be extensively used in Madagascan traditional medicine. Additionally, we compared the extent of medicinal palm uses in Madagascar to continental Africa, anticipating that the number of uses on the adjacent island would far outreach those recorded in Africa. These expectations were not confirmed. Instead we found that the documented ethnomedicinal

uses of palms in Madagascar does not reflect the richness in species on the island.

## MATERIAL AND METHODS

The study concerns ethnomedicinal uses of palms in Madagascar. Apart from palms native to the island the introduced, naturalized *Cocos nucifera* L. and the possibly introduced *Raphia farinifera* (Gaertn.) Hyl. and *Elaeis guineensis* Jacq. (Dransfield & Rakotoarinivo, 2011) are included in the present study. References were found through bibliographic searches using several sources including PubMed, Embase and Google Scholar and search engines of the State and University Libraries of Aarhus, National Library of Denmark and Copenhagen University Libraries, Harvard University Libraries and the Mertz Library. Information was extracted and digitized in a database created and analysed in MS Excel 14.0.0. (Appendix S1). Medicinal use records were characterized by each activity/disorder, plant part used, mode of preparation, application or ethnic group mentioned for a palm species in each publication.

Medicinal uses were organized according to palm species and categories of health disorders following the *Economic Botany Data Collection Standard* (Cook, 1995). *Ritual/magical uses* (Gruca *et al.*, 2014b) were added as an additional category to the analysis.

Palm nomenclature follows the *World Checklist of Palms* (Govaerts *et al.*, 2015) and author names are included in Appendix S1. *Elaeis guineensis* var. *madagascariensis* Jum. & H.Perrier (Decary, 1964) was treated as *E. guineensis* and *Raphia pedunculata* P.Beauv. (Heckel, 1910) and *R. ruffia* (Jacq.) Mart. (Terrac, 1947) were treated as *R. farinifera*. Not all the records referred to in the papers we cite have identities vouchered by herbarium specimens and some records with voucher herbarium specimens may not be correctly identified. Furthermore, local names are sometimes applied to several different species and thus notoriously unreliable.

Information on palm species richness in Madagascar was derived from Rakotoarinivo *et al.* (2013), who constructed palm species richness maps by overlaying the estimated distributions of 193 palm species. Rakotoarinivo *et al.* (2013) obtained palm distributional data from an extensive palm database of Madagascan palms managed by the Royal Botanic Gardens, Kew. The palm species richness map used in the present study was originally constructed by modelling the distributions of 83 species for which sufficient occurrence records were available at the present time using species distribution modelling

and combining these modeled distributions with the observed localities for the remaining 110 species for which there were insufficient locality records for modelling. The richness pattern was derived by extracting information on palm species presence or absence for the 193 species in 0.2° grids covering the entire country (Rakotoarinivo *et al.*, 2013). We subsequently mapped the locations of limited ethnobotanical surveys that recorded medicinal uses of palms in Madagascar on top of the palm species richness pattern to be able to depict the ethnobotanical sampling effort in relation to the current species richness pattern in Madagascar.

## RESULTS

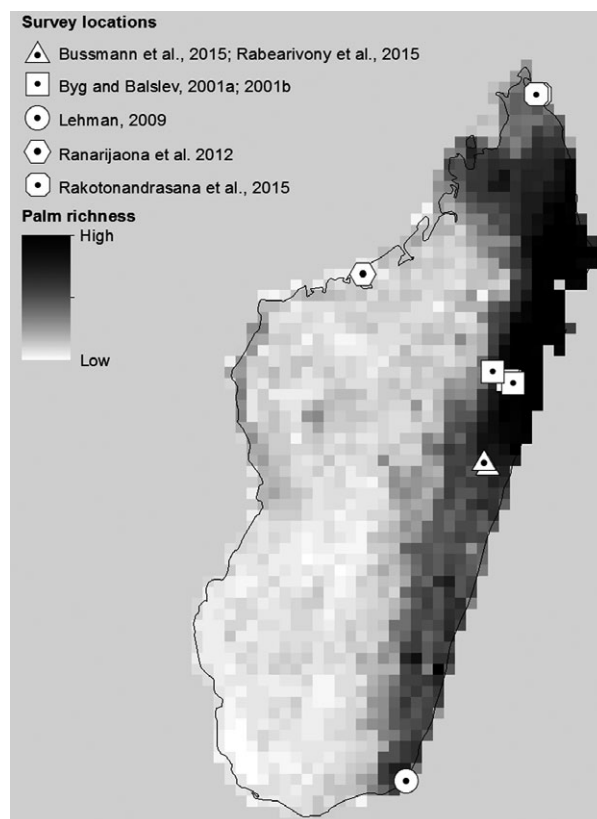
We found information on medicinal uses of palms in Madagascar in only 13 references, published between 1910 (Heckel, 1910) and the present day (Busmann *et al.*, 2015; Rakotonandrasana, Rakotondrafara & Ratsimbason, 2015). Since our literature search was rather intensive we conclude that there are only few ethnobotanical studies focusing on the usefulness of palms in Madagascar (Decary, 1964; Byg & Balslev, 2001a, b, 2003; Busmann *et al.*, 2015; Rakotonandrasana *et al.*, 2015).

Despite the high palm species richness across the island we found that medicinal uses of palms had been investigated in only a few locations. Many areas with low species richness as well as areas where species richness is very high remain unexplored (Fig. 1).

We found 55 medicinal use records for at least 17 palm species, of which 14 were endemic and three were introduced to the island. Some records were assigned to genus only, and in total seven genera were distinguished (Table 1). The most used palm was *C. nucifera*, followed by *R. farinifera*. For most of the species, however, we only found a single medicinal use. Of the 55 use records 39 originated from four ethnic groups: Antakarana (one), Tsimihety (two), Antanosy (eight) and Betsimisaraka (28), coinciding with the distribution of palm diversity.

Medicinal uses belonged to 14 use categories (three remained unspecified) (Fig. 2). The most common categories were *Digestive system disorders* and *Ritual/magical uses*, followed by *Respiratory system disorders*. The most commonly used species, *C. nucifera*, was used for at least eight of the recorded use categories.

In total, we distinguished eight different palm parts used in medicines. Most uses were linked to stem and leaf, but seed, fruit, root, palm heart, inflorescence-sap (as palm wine) and the entire palm tree (in rituals) were also used (Fig. 3).



**Figure 1.** Modelled palm species richness across Madagascar based on estimated palm distributions for 193 species (data: Rakotoarinivo *et al.*, 2013) overlaid with locations of limited ethnobotanical surveys that have recorded medicinal uses of palms. The map was constructed in ArcGIS 10.2.2 (ESRI, Redlands, CA, USA).

Palm medicines were used raw or in the form of decoctions, infusions and salt-extracted through boiling. Medicines were applied internally and externally depending on the ailment. However, information on preparation methods and medicine application were missing for 67% and 80% of the records, respectively.

## DISCUSSION

Our expectation that palms would be used extensively in Madagascan traditional medicine and far more than on the African continent was not confirmed by our survey of the pertinent literature. Based on the published information the usefulness of palms in Madagascar is remarkably low. Despite the striking contrast in palm species richness between Madagascar and continental Africa, the former with over three times as many species as the latter, Madagascar palms have few recorded medicinal uses.

**Table 1.** List of palms used in traditional medicine in Madagascar, including number of medicinal use records, use category(-ies), distribution, IUCN Red List status and references to each palm species

Palm species*	Number of medicinal use records	Use categories†	Distribution	Status‡	References§
<i>Cocos nucifera</i> L.	12	1, 3, 4, 5, 7, 8, 9, 10	Introduced	Cu	1, 2, 8, 9, 12, 13
<i>Raphia farinifera</i> (Gaertn.) Hyl.	9	1, 3, 6, 12	Introduced (?)	Cu	1, 2, 6, 10, 13
<i>Dypsis</i> spp.	8	1, 4, 5, 6	–	–	7
<i>Dypsis fibrosa</i> (C.H.Wright) Beentje & J.Dransf.	5	2, 3, 4, 11	Endemic	LC	2,3
<i>Dypsis pinnatifrons</i> Mart.	4	2, 3	Endemic	LC	2
<i>Ravenea sambiranensis</i> Jum. & H.Perrier	3	1, 2, 5	Endemic	LC	2
<i>Ravenea</i> spp.	2	2, 14	–	–	2
<i>Dypsis andrianatonga</i> Beentje	1	8	Endemic	VU	5
<i>Dypsis canaliculata</i> (Jum.) Beentje & J.Dransf.	1	3	Endemic	CR	2
<i>Dypsis crinita</i> (Jum. & H.Perrier) Beentje & J.Dransf.	1	2	Endemic	NT	5
<i>Dypsis lastelliana</i> (Baill.) Beentje & J.Dransf.	1	2	Endemic	LC	2
<i>Dypsis louvelii</i> Jum. & H.Perrier	1	4	Endemic	VU	1
<i>Dypsis madagascariensis</i> (Becc.) Beentje & J.Dransf.	1	7	Endemic	LC	5
<i>Dypsis tsaravoasira</i> Beentje	1	5	Endemic	VU	2
<i>Dypsis viridis</i> Jum.	1	7	Endemic	VU	2
<i>Elaeis guineensis</i> Jacq.	1	13	Introduced (?)	Cu	4
<i>Hyphaene coriacea</i> Gaertn.	1	5	Native	–	11
<i>Masoala kona</i> Beentje	1	3	Endemic	EN	5
<i>Ravenea glauca</i> Jum. & H.Perrier	1	3	Endemic	VU	5

\*Nomenclature follows World Checklist of Palms (Govaerts *et al.*, 2015) where authors' names for the species can be found.

†1. Digestive system disorders. 2. Respiratory system disorders. 3. Ritual/magical uses. 4. Infections/infestations. 5. Pregnancy/birth/puerperium disorders. 6. Pain. 7. Genitourinary system disorders. 8. Nutritional disorders. 9. Skin/subcutaneous cellular tissue disorders. 10. Circulatory system disorders. 11. Inflammation. 12. Injuries. 13. Nervous system disorders. 14. Poisonings.

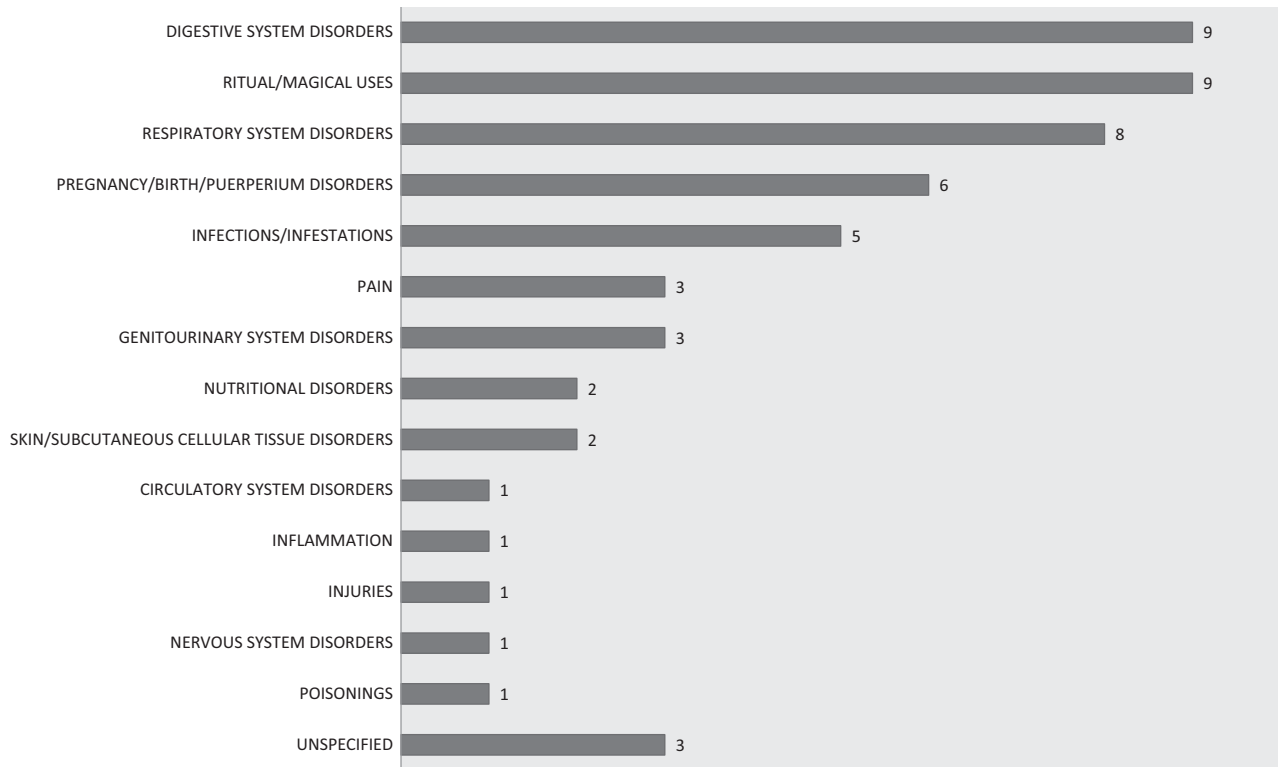
‡IUCN Red List of Threatened Species (IUCN, 2014): CR – Critically Endangered, EN – Endangered, LC – Least Concern, NT – Near Threatened, VU – Vulnerable; Cu – Cultivated.

§1. Bussmann *et al.*, 2015;. 2. Byg & Balslev, 2001a;. 3. Byg & Balslev, 2001b;. 4. Decary, 1964;. 5. Dransfield & Beentje, 1995;. 6. Heckel, 1910;. 7. Lehman, 2009;. 8. Pernet, 1957;. 9. Pernet & Meyer, 1957;. 10. Rabearivony *et al.*, 2015;. 11. Rakotonandrasana *et al.*, 2015;. 12. Ranarijaona *et al.*, 2012;. 13. Terrac, 1947.

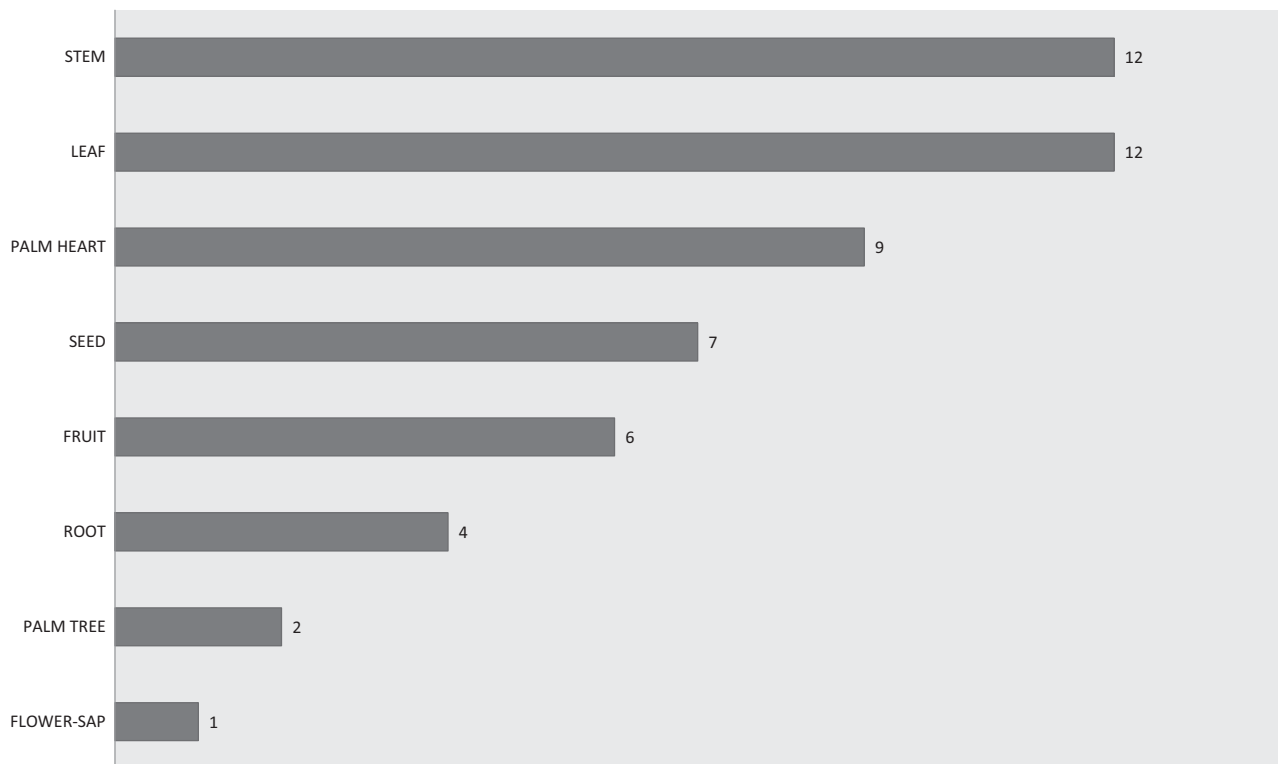
In our investigation of the 65 palm species in Africa, we demonstrated that at least 23 different species were used medicinally in 35 out of the 48 countries of Africa (Gruca *et al.*, 2015). We found 782 uses records mentioned in 156 references. In comparison, Madagascar medicinal palm uses are largely unknown (Table 2).

Even though there are only a few studies that mention palms in traditional medicine in Madagascar, we found a similar importance of cultural and spiritual values as we found on the African continent. The *Ritual/magical* use category was one of the top two in Madagascar, and it was the fourth

most common use category for palms in Africa. This confirms that traditional medicine is not only used to treat physical conditions, but often serves in spiritual healing. It remains important in the daily lives of the Malagasy. In fact, it has been noted that traditional healing in Madagascar is more valued now than ever before. As the population rapidly increases more traditional healers are required to care for people in need (Lyon & Hardesty, 2005). Nevertheless, our survey shows that searching for Arecaceae in ethnobotanical studies from Madagascar is of little avail. Does that mean that palms are not used in traditional Madagascan medicine?



**Figure 2.** Number of medicinal palm use records in Madagascar per category of health disorders following the *Economic Botany Data Collection Standard* (Cook, 1995).



**Figure 3.** Number of medicinal palm use records in Madagascar per palm part used.



**Table 2.** A comparison between Madagascar and continental Africa (Gruca *et al.*, 2015)

Number of:	Madagascar	Africa
Available palm species (palm richness)	206	65
Species used medicinally	17	23
Medicinal use records	55	782
Unique use categories	14	25
References	13	156

Table shows differences in palm richness, number of species used medicinally, number of medicinal use records, unique use categories and references in both regions.

Perhaps, the diversity of cultures contributing to the formation of Malagasy human society and the relatively recent colonization of the island by man are important in explaining traditional knowledge patterns. Ordinarily, when migrant populations settle in new places, they become intensively dependent on the new ecosystem (de Medeiros *et al.*, 2012). Presented with enormous biodiversity, Malagasy settlers in each region could select different useful resources from the full range available on the island (Dewar & Wright, 1993). However, the early expansion of human settlement in Madagascar is associated with progressive colonization of coastal zones by active participants in the Indian Ocean network of trade and cultural interchange. The newcomers imported various domesticates in addition to locally available natural resources and did not simply adapt to and rely on the latter (Dewar & Richard, 2012). It is safe to assume that palms, despite being known as a useful resource in the homeland, were unfeasible to acquire from their original ecosystem. In that situation, the migrant population tends to replace unavailable medicinal plants with plants found in the surrounding flora (de Medeiros *et al.*, 2012). Many species are likely to be replaced on the basis of their similarity in morphological features (shape, colour) or sensory qualities (smell, taste) rather than because of their shared physiological or chemical effects (de Medeiros *et al.*, 2012). However, without early ethnobotanical accounts, it is difficult to predict how local knowledge about the palm family has developed on the island over time, given that it is characterized by extremely high levels of endemism, with 97% of the available species being unique to the island and previously unknown to the newcomers regardless of their origin.

Given the high plant biodiversity on the island, it is plausible that many other plant families substitute or complement medicinal uses of palms. For example, in Nigeria, despite being the most investigated

country, less than half of the available palm species were used in traditional medicines (Gruca *et al.*, 2015). However, in this case the recorded uses represented various unique categories confirming ample knowledge of palm application in medicinal preparations. On the other hand, supposed low use of palms in Madagascar could simply be due to insufficient fieldwork and ethnobotanical surveys. We drew a similar conclusion in the case of the Democratic Republic of Congo where palm species richness and general biodiversity are high, but the limited ethnobotanical studies made it unfeasible to determine the actual extent to which palms are used medicinally in the region (Gruca *et al.*, 2015).

Local knowledge and usage of some of the medicinal plants may be uniform across the island due to movements and mixing of various ethnic groups. However, for other medicinal plants, ethnomedicinal knowledge may be strictly limited to the areas where they occur (Quansah, 1988). The majority of the native palms has restricted ranges and many are threatened with extinction or severe reductions of their wild populations; these factors most probably limit the knowledge and usefulness of palms that are difficult to locate and access by local people. Another reason for the low number of records of medicinal palm uses could be that some of the species have their main distribution in protected areas where collection of forest resources is limited or prohibited (Byg & Balslev, 2001a). In fact, all the ethnobotanical surveys that specifically mentioned medicinal uses of palms were conducted near to or in the protected areas Zahamena (Byg & Balslev, 2001a, b, 2003), Lokaro (Lehman, 2009) and Vohibe forest (Bussmann *et al.*, 2015; Rabearivony *et al.*, 2015). As a result, local people who use palms growing in the protected areas and buffer zones might not be willing to share that information. For example, *Dypsis fibrosa* (C.H.Wright) Beentje & J.Dransf. is commonly known as a multi-purpose species; but the majority of informants from the studied villages near Zahamena only cited one or two uses of the palm (Byg & Balslev, 2001b). Nevertheless, it appears from our observations that most of the protected areas in Madagascar are influenced by human activities and palms are part of natural resources often extracted without consideration (J. Dransfield, pers. observ.).

Cultivation of palms makes them widespread and easily accessible. It has been noted that traditional Madagascan healers do not have a preference for exotic or native plant species. Rather they use plants that are common (Lyon & Hardesty, 2012). Cultivated species are easier to locate, attract more attention and are prone to experimentation (Byg *et al.*, 2006; Cámara-Leret *et al.*, 2014). This is the case for *C. nucifera* and *R. farinifera* which are the two most used species for medicinal purposes in Madagascar,

both introduced and cultivated (Dransfield & Rakotoarinivo, 2011). On the African continent, *C. nucifera* ranked third, representing high diversity of medicinal applications (Gruca *et al.*, 2015). In fact, the efficacy of traditional uses of *C. nucifera* has been validated in a number of studies (Venkataraman, Ramanujam & Venkatasubbu, 1980; Alviano *et al.*, 2004; Rinaldi *et al.*, 2009). Therefore, knowledge of its medicinal values could be driven by abundance and general awareness of its healing properties. *Raphia farinifera* is regarded as emblematic of Malagasy rural life (Dransfield & Rakotoarinivo, 2011) and it is closely associated with human activity. The trunks are used to make baskets, chairs and mattresses and epidermis and hypodermis stripped from the young leaves provide material for cloths, hats, baskets, brooms etc. (Bussmann *et al.*, 2015). It is not a surprise that this palm is used in local medicinal practice. Even though *R. farinifera* is endemic and widespread in continental Africa, we did not record any medicinal uses of the palm on the continent (Gruca *et al.*, 2015). The leaf fibres are, however, used for weaving and basketry (Muhwezi, Cunningham & Bukenya-Ziraba, 2009).

Nevertheless, based on the gathered data, cultivation and abundance of palms do not necessarily imply their usefulness in traditional medicine. In sharp contrast to continental Africa where *E. guineensis* is the most used palm species with 258 medicinal records, we found only one medicinal use for that palm in Madagascar. It has been noted elsewhere that the African oil palm is of limited importance on the island (Johnson, 2011). Likewise, we did not record any medicinal applications of the cultivated *Phoenix dactylifera* L. In continental Africa, it is the second most used palm species in traditional medicine (Gruca *et al.*, 2015). *Borassus aethiopum* Mart. is widespread in sub-Saharan Africa and it is the third most used palm in traditional medicine (Gruca *et al.*, 2015). Although it occurs in Madagascar (Dransfield & Rakotoarinivo, 2011) we did not find any medicinal records of this palm. It could be due to its restricted range in north-western Madagascar. However, *B. aethiopum* occurs near human habitation and given the high usefulness of the palm on the continent, it would be expected that it could have some medicinal value to the local Madagascan population. *Hyphaene coriacea* Gaertn. occurs abundantly in western Madagascar which is poor in palms. It is sometimes intensively harvested for fibre, thatch and wine (Dransfield & Rakotoarinivo, 2011). Even though the palm is known to local people, we recorded only one medicinal application (Rakotonandrasana *et al.*, 2015). *Hyphaene coriacea* also has few medicinal uses in East Africa (Gruca *et al.*, 2015).

These examples show that more studies are needed better to investigate and understand the usefulness of palms in traditional medicine in Madagascar.

The few areas that have been subject to ethnobotanical studies (Fig. 1) are insufficient to give a complete picture of the usefulness of palms to the inhabitants of Madagascar. More detailed surveys are crucial in order to understand knowledge distribution among different regions and ethnic groups. Many parts of Madagascar remain unexplored and it is hoped that further ethnobotanical research will be conducted in all regions where palms occur close enough to settlements to provide products for human use. That includes not only the northeastern region where palm richness is highest, but also the western areas where the species are few but often occur abundantly.

## CONCLUSIONS

Despite the well documented contribution of palms to traditional medicine in many parts of the world (Sosnowska & Balslev, 2009; Cámara-Leret *et al.*, 2014; Gruca *et al.*, 2015), studies focusing on the usefulness of palms in Madagascar are scarce (Decary, 1964; Byg & Balslev, 2001a, b, 2003; Bussmann *et al.*, 2015). The few surveys that mentioned palms in lists of medicinal plants come from the times of French colonization (Heckel, 1910; Terrac, 1947; Pernet, 1957; Pernet & Meyer, 1957). Perhaps more information about medicinal uses of palms exists in unpublished sources, such as descriptions on herbarium specimens, although uses notes on all specimens cited in *Palms of Madagascar* (Dransfield & Beentje, 1995) were included in the book. Nevertheless, the few references we found show that there exists some traditional knowledge of the value of palms to local people. Thus, in our opinion, it should not be concluded that the role of palms in Madagascan pharmacopeia is negligible based on such a limited literature. The studies that did focus on palms only prove that there is an urgent need for further investigations and documentation of ethnomedicinal and ethnobotanical uses of palms in Madagascar. Further inquiries and collecting might lead to records of more species and uses, and could perhaps help to understand why (or if) there are so few medicinal applications of palms in Madagascar compared to other parts of the world.

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## SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

**Appendix S1.** Database including all medicinal palm use records in Madagascar (Excel file).