The Useful Palms of Sainte Luce: Implications for Local Resource Availability and Conservation

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The community of Sainte Luce, southeast Madagascar, has traditionally relied on palms for a wide range of applications that underpin local livelihoods, but unsustainable extraction and forest cover loss are reducing palm numbers and habitat extent in the area. Six of the ten native palm species found within the littoral forest of Sainte Luce are threatened with extinction (IUCN 2012). This investigation reveals that local dependence on these palms remains high, raising concerns both for resource availability and conservation. The potential onset of large-scale mining operations in the area intensifies the need to address these concerns.

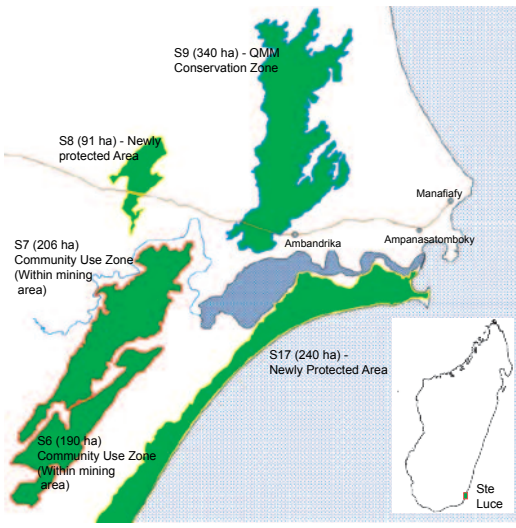
Palms (Arecaceae) are essential to subsistence and small-scale commercial livelihood strategies across Madagascar (Dransfield & Beentje 1995, Byg & Baslev 2001); however, documentation of the uses of palm species in many ecologically significant regions remains limited. Understanding utilization is an important prerequisite for planning *in situ* species conservation initiatives (Johnson 1996, Heywood & Dulloo 2005) and for informing community-based natural resource management plans.

The littoral forest of Sainte Luce is one of three remaining stands of intact littoral forest within the Tolagnaro region (as defined by Vincelette et al. 2007). These fragmented forests are home to exceptional plant diversity and endemism; over 25% of the 1535 plant species found are endemic to the littoral forest habitat (Consiglio et al. 2006). In comparison to the region's other littoral forests, Mandena and Petriky, the palm family is best represented at Sainte Luce, where ten native species are found, six of which are threatened with extinction (IUCN 2012). Other impressive areas for palms can be found in the southeast too, most notably amidst the large, pristine tract of humid evergreen forest, known as Tsitongambarika, which cloaks the Vohimena mountain range just to the west of Sainte Luce and the lowland coastal plain (see Dransfield & Rakotoarinivo, 2012).

Along with *tavy* (slash-and-burn agriculture) and persistent logging, mining is a significant threat to the littoral forest of Sainte Luce. QIT Madagascar and Minerals (QMM), a subsidiary of Rio Tinto, has targeted 57% of Sainte Luce's littoral forest to be cleared for the extraction of ilmenite (Vincelette et al. 2007), a titanium-iron oxide mineral that is eventually used as a whitening agent. In 2008, mineral extraction at the pilot site Mandena began, and by 2012, prefeasibility studies in Sainte Luce were underway, but due to weaker market conditions for their products these operations have been recently suspended (1 Feb 2013). Given the environmental context, QMM is committed to achieving a net positive impact (NPI) on the region's biodiversity (see Temple et al. 2012).

Azafady, a local non-governmental organization, has been working in Sainte Luce for over a decade and has been focusing research efforts towards the *in situ* conservation of threatened palm species alongside other initiatives including biodiversity monitoring, local capacity building and environmental education. Azafady has a team of staff and volunteers working permanently in Sainte Luce who are able to record the local uses of the palm flora while also collecting information on palm morphology, ecology and harvesting practices. The ultimate goal of this paper is to draw attention to issues regarding palm conservation and resource availability in relation to five of the largest littoral forest fragments in Sainte Luce - S6, S7, S8, S9 and S17 (Fig. 1).

1. The study area at Sainte Luce: forest fragments S6 & S7 (community use zones), S8 & S17 (Newly Protected Areas formed in 2003) and S9 (QMM conservation zone), note that S17 extends further south than shown; the three hamlets; the river & road. S6 and S7 are situated within the mining area.



METHODS

Study Area

Sainte Luce (24°45'S, 47°11'E) is situated along the southeastern coastline of Madagascar approximately 45 km north of Tolagnaro, the urban center of the Anosy region, and comprises three hamlets with a total human population of around 2000 inhabitants (Chef de Fokontany, personal communication, 1 June 2012). Sainte Luce is part of the humid bioclimatic zone, as defined by Cornet (1974) and Schatz (2000), with relatively constant and high temperatures throughout the year, high annual rainfall and no well-defined dry season. The littoral forest stands over poor, sandy soils, in extreme proximity to the coast and at a low altitude of 0–20 m. All three hamlets in Sainte Luce – Ambandrika, Ampanasantomboky and Manafiafy – are within a 30-minute walk to the nearest forest fragment. Fifteen littoral forest fragments remain in Sainte Luce, in varying degrees of degradation, ranging from 1 to 340 hectares with a total littoral forest cover area of approximately 1500 hectares (Ramanamanjato 2007, Vincelette et al. 2007).

Study Species

Nine of the ten palm species native to Sainte Luce were included in the survey (see Table 1). The large trichistous arboreal palm *Dypsis mananjarensis* was excluded from the survey, as

Table 1. The palms of Sainte Luce: the conservation status and distribution according to the IUCN (2012); species highlighted in bold are thought to be introduced to the Sainte Luce area; ****Dypsis mananjarensis* **excluded from survey.

Species	Distribution
Beccariophoenix madagascariensis (VU)	E Madagascar; between Tolagnaro and Mantadia
Dypsis brevicaulis (CR)	SE Madagascar; Tolagnaro region
Dypsis fibrosa (LC)	E & NW Madagascar; widespread
Dypsis lutescens (NT)	E Madagascar; widespread
Dypsis nodifera (LC)	E & NW Madagascar; widespread
Dypsis mananjarensis (NT)*	E Madagascar; between Tolagnaro and Ampasimanolotra
Dypsis prestoniana (VU)	SE Madagascar; between Mahanoro and Tolagnaro
Dypsis psammophila (EN)	SE & NE Madagascar; littoral forests and lowland humid evergreen forests (e.g. Tsitongambarika)
Dypsis saintelucei (EN)	E Madagascar; SE littoral forests, Vondrozo, Vatovavy, south of Toamasina
Dypsis scottiana (VU)	SE Madagascar; between Tolagnaro and Farafangana
Raphia farinifera	Tropical Africa, N & E Madagascar
Ravenea sambiranensis (LC)	E, W & NW Madagascar
Cocos nucifera	Pantropical

only three individuals have ever been located in the area according to local reports and extensive explorations by Azafady researchers. However, some observations of *D. mananjarensis* are provided. In addition, the pantropical coconut (*Cocos nucifera*), *Dypsis lutescens* and *Raphia farinifera* are not included, as they are found outside the littoral forest and are considered introduced to the area.

Survey

Between April and May 2012, 54 semi-structured interviews (six for each species) were conducted with 21 different interviewees. All interviewees were male (age range 25–67) and were resident in Sainte Luce. Two survey approaches were adopted; pre-arranged interviews with local people and opportunistic interviews carried out with local people encountered in the forest. For both approaches, an adult and a juvenile of the palm species was visited in S7, S8 or S9 with the interviewee, the primary researcher, a Malagasy translator and a local guide. Depending on time availability, one to four species were visited with each interviewee. The species are presented in alphabetical order according to their scientific name with the vernacular name(s) provided in brackets.

Preliminary interviews found that it was difficult to discern whether the interviewee's answers referred to common uses or personal use. Therefore, it was decided that the investigation would focus on common village uses rather than person specific uses. Indeed, distinguishing between knowledge of common uses and actual uses in the community is important – some applications that are common knowledge may be historical and no longer applied today. To address this, observations of palm harvest and use by households were recorded between February 2011 and July 2012 to confirm which applications were current and to gauge the frequency of use by the community.

Previous studies have shown that local knowledge of resource availability can reveal changes in actual resource abundance (Gadgil et al. 1993, Duffield et al. 1998). The survey therefore asked interviewees whether they had perceived any changes in the availability of

the species in question over the last 20 years. For some of the younger interviewees, the question was rephrased to account for changes over the last ten years.

Ecology and Conservation

Information on local distribution, habitat preference, morphology and life history were recorded between February 2011 and July 2012 in forest fragments S6, S7, S8, S9 and S17, and are presented in the Results section in correlation with the survey findings. Concerns for conservation of palm species in Sainte Luce are briefly touched upon in the Results section but are examined in greater detail, along with observations of palm harvest and use, in the Discussion section.

RESULTS

Beccariophoenix madagacascariensis (Boakamainty or *Lafa)*

Beccariophoenix madagascariensis has fewer than 50 known adults and fewer than 300 juveniles remaining in the area, with the largest subpopulations located in S6/S7 and S8. Several adults have survived *tavy* practices and now stand outside the forest edge (Fig. 2).

2. *Beccariophoenix madagascariensis* standing in a *tavy* field near to the southern edge of forest fragment S8 (Photograph by David Meyer).

However, seedlings require forest interiors and well-drained soils with generous canopy cover for survival.

Uses: At present, the local community does not frequently use *B. madagascariensis*: however, applications remain diverse. The fibrous leaf rachis of juveniles and sub-adult trees are harvested at the base, stripped longitudinally and woven into lobster traps. However, the durability of the lobster trap is poor and a possible reason as to why other species (e.g. *D. scottiana, D. saintelucei* and *D. prestoniana*) are selected more regularly for this purpose. The long majestic leaves, typical of individuals during sub-adult stages of development, are sometimes cultural ornaments during ceremonies. The strong, dead leaf rachises are cut from the adult tree prior to abscission for a carrying implement, known locally as *bao*. Several interviewees also mentioned historical uses such as making beehives and flooring from trunk sections.

Availability: Decrease (3 respondants out of 6), No change (2/6), Increase (1/6)

Life History: Beetles have been observed predating young fruit.

Conservation Concerns: The need to protect this species appears to be common local knowledge, in all likelihood due to educational programs by local NGOs and independent researchers raising awareness. Harvesting and use is very rare. QMM and Azafady are cultivating seedlings in Sainte Luce.

Dypsis brevicaulis

This incredibly rare dwarf palm is restricted to the littoral forests of Sainte Luce, the lowland humid evergreen forests of Tsitongambarika and an area just south of Manantenina (J. Dransfield, personal communication, 10 Nov. 2011). Unexpectedly, preliminary census efforts in a 10-hectare section of forest fragment S8 have revealed high densities (more than 400 adults) and interesting morphological details (see below). *Dypsis brevicaulis* is known from two major forest fragments in Sainte Luce; S8 (protected area) and S7 (within the mining area) and occupies well-drained soils and tolerates low canopy cover. Its distribution could possibly extend to other fragments too.

Uses: No local names or uses for this species were mentioned during the surveys.

Life History/Morphology: Eggs of *Phelsuma* spp., possibly *Phelsuma quadriocellata,* were found nestled within the crown (Fig. 3). *Habit:* both solitary and clustering (<6 stems). *Trunk:* either hidden underground or exposed and up to 2 m in length. *Fruit* 1-seeded, ovoid, ca. 12 × 7 mm, red at maturity (Fig. 4). *Seed* elongate, ca. 11 × 5 mm, endosperm homogeneous. Morphological details recorded from individuals at S8.

Conservation Concerns: No immediate threats at Sainte Luce, although further explorations are needed to determine its exact local distribution.

***Dypsis fibrosa* (*Boakandambo* or *Palima*)**

In Sainte Luce, *Dypsis fibrosa* commonly inhabits riparian zones with well-saturated soils, and is found across all major fragments (S6, S7, S8 and S9) except for the coastal S17 forest. Local knowledge on this species appears to be limited.

Uses: Over half the interviewees were unable to name the species, and no interviewees gave any local uses. At other locations along the east coast, *Dypsis fibrosa* is an important forest resource for weaving products such as basketry and thatch (Byg & Baslev 2001). However in Sainte Luce, like most villages across Anosy, the community uses *mahampy* reeds *Lepironia mucronata* (Cyperaceae) for basketry and the leaves of *ravinala*, *Ravenala madagascariensis* (Strelitziaceae), for roofing.

Availability: No change (6/6).

Life History: None available.

Conservation Concerns: No immediate threats at Sainte Luce.

Dypsis nodifera (Raobe)

Dypsis nodifera seems to have similar habitat preferences to *D. fibros*a – alongside riparian habitats and preferring good shading. This slender palm is found in all major forest fragments (S6, S7, S8, S9 and S17) in Sainte Luce. Juveniles can be confused for *raotry* (*D. scottiana*) however the larger stature (DBH 5–7 cm) of sub-adults/adults is unmistakable. Some local people differentiate these two species more accurately by examining the leaves; *D. nodifera* possesses more strongly grouped and arcuate leaflets than *D. scottiana*.

Uses: The local uses of *D. nodifera* are diverse. The fruit (ellipsoid, green ripening to yellow) is consumed as a snack. Stems of more supple juveniles are stripped length ways to weave lobster traps. The stiffer stems of adults are cloven in two and sharpened to pierce together

3 (top). Eggs of *Phelsuma* sp. found in the crown of *Dypsis brevicaulis* in S8. 4 (bottom) Fruit of *Dypsis brevicaulis.* (Photographs by David Meyer)

the petioles of *Ravenala madagascariensis* in wall construction (known as *manohy falafa*) for local housing. Fishermen use the mature stems to increase the wall-height of sea-bearing pirogues (dug-out canoes); these stems are long-lasting and do not often need replacing. The leaflets of juveniles and sub-adults are foraged and brewed into tea by local healers for treating *tonporaza*, a disease with similar symptoms to epilepsy.

Availability: No change (5/6), Decrease (1/6)

Life History: None available.

Conservation Concerns: *Dypsis nodifera* is still fairly abundant across Sainte Luce; however, the recent increase in targeted extraction may be a cause for concern in the future.

Dypsis mananjarensis

One sub-adult can be found in a *tavy* field to the southwest of S8 and two adults can be seen in the western sub-fragments of S8 with limited signs of regeneration apparent. Recent observations by Azafady have confirmed that *D. mananjarensis* is also found in higher numbers at Farafara-Vatambe, a village located near to Tsitongambarika forest (approximately 25 km west of Sainte Luce).

Dypsis prestoniana (Boakabe - adults, ***Boaka*** - juveniles***)***

Dypsis prestoniana is distributed across all major fragments (S6, S7, S8, S9 and S17) with the largest population lying in the northern parts of S9 and possibly southern S7. Habitat preferences vary, although well-drained interior soils and generous canopy cover appear most advantageous.

The Uses: The leaf rachises of all age cohorts (2–3 m juveniles most frequently) are used to fashion lobster traps. The trunk is sectioned, cloven and the soft core left to decompose before flattening into flooring for construction (very rare). Similarly to *B. madagascariensis*, the

majestic leaves of large sub-adults are sometimes used as cultural ornaments at ceremonies and festivities. Dead abscised leaf sheaths of large adults are used as shoulder padding by lumberjacks when carrying planked timber.

Availability: No change (4/6), Decrease (2/6)

Life History: Massive infructescences bear an important food source for the red-collared brown lemurs (*Eulemur collaris*) during the lean season.

Conservation Concerns: As mentioned previously, the largest population of adults is located to the north of S9, a QMM conservation zone, which provides some security for the species at Sainte Luce. However, non-timber forest products, like the leaf rachis of juvenile *D. prestoniana*, are regularly harvested at S9.

Dypsis psammophila (Hanjo)

Currently absent from the species list for the area (see Rabenantoandro et al. 2007a), *D. psammophila* is abundant across the northern reaches of S9 and throughout S8, S7 and possibly S6. As suggested by its etymology (sand-loving), this palm prefers sandy, well-drained soils and tolerates high sun exposure.

Uses: Its most common use is to combine petioles of *Ravenala madagascariensis* together in wall construction for housing. As with *D. nodifera*, the more mature, stiffer stems are selected, split and sharpened to a point, which are then pierced through multiple *R. madagascariensis* petioles to create a wall panel. Observations suggest that *D. psammophila* is becoming more frequently used for this purpose, as adult *D. nodifera* and *D. scottiana* stems are becoming increasingly difficult to find.

Life History: The locally endemic and Critically Endangered day gecko, *Phelsuma antanosy*, has been observed frequently on this palm, which appears to be an important foraging microhabitat for this gecko species (Azafady, unpublished data). Local people have observed flying foxes, *Pteropus rufus*, feeding on the fruit.

Availability: No change (5/6), Decrease (1/6)

Conservation Concern: No immediate threats at Sainte Luce.

Dypsis saintelucei (Telopoloambilany)

Dypsis saintelucei is locally named *telopoloambilany,* 'thirty trees to fill a cooking pot,' presumably because of its edible palm heart. Previously thought to be restricted to the littoral forests of Sainte Luce, *D. saintelucei* has since been found in other areas further up the east coast (J. Dransfield, personal communication, 10 Nov. 2011). Today, the largest populations of *D. saintelucei* in Sainte Luce are found in S7, followed by S8, and although juveniles are relatively abundant in S9, only one mature individual is known. This palm prefers medium soil saturation and generous canopy cover, especially for younger individuals. Older individuals occupying drier, more exposed areas are often stunted and display poor vigor in the crown.

5. Lobster traps (at right) made of *Dypsis scottiana* (Photograph by Naidi McDonnell).

Uses: Palm hearts, *tavolo*, were more commonly harvested in the past (before ca. 1985) when the adult trees were more abundant and during times of food insecurity. Several interviewees recalled that only a few households possessed the skills for harvesting the bitter palm heart, and the study revealed that this practice has been discontinued by the younger generation. In terms of current usages, the leaf rachises of juveniles (most commonly), sub-adults and adults are harvested and woven into lobster traps. Other applications include the use of trunks for flooring but this seems to be very uncommon.

Life History: No observations of any seed dispersers. Seeds commonly land and

germinate at the base of the parent tree. Bees have been seen frequenting inflorescences of trees in forest fragment S7.

Availability: Decrease (6/6)

Conservation Concerns: Adults are being lost to habitat destruction from *tavy* and occasionally for lobster trap or construction materials. There is widespread evidence of rachis harvesting of juveniles despite reports of low frequency of use, which may be impacting the growth and development of this younger age cohort. Trunk axe marks (for testing maturity) may be correlated with the prevalence of a soft rot. The potential loss of S6 and S7 to mining is of major concern the future of this emblematic species at Sainte Luce. Azafady and QMM cultivate this species at tree nurseries based in Sainte Luce.

Dypsis scottiana (Raotry/Raotsy - adults, ***Amboza*** – juveniles***)***

Dypsis scottiana is located in all major forest fragments occupying a range of habitat types, including dry forest edges and moist interior patches. Of all the palms, immature *D. scottiana*, locally known as *amboza*, is possibly the most frequently utilized in Sainte Luce.

The Uses: The stems of this threatened clustering palm are cut at ground level and just below the oldest petiole, stripped longitudinally and woven into lobster traps (Fig. 5). Adult stems are used in a similar fashion to those of *D. nodifera* and *D. psammophila* – to pierce and combine *R. madagascariensis* stems for wall construction (the panels are known locally as *manohy falafa*) (Fig. 6), the slight difference being that the stems of *D. scottiana* are thin enough (<4 cm DBH) to be used whole rather than split in two. According to the survey, *D. scottiana* is the first choice material for this common wall-building technique, although scarcity has prompted diversification to other slender palms for this purpose (*D. nodifera* and *D. psammophila*). As with *D. nodifera*, timber panels are bound to the side of the pirogues with adult *D. scottiana* (*raotry*) stems to increase the height of pirogue sidewalls to reduce seawater spilling over during rough conditions.

Availability. Decrease (6/6)

Life History: None available.

Conservation Concerns: The combination of extraction for *manohy falafa* and lobster traps has critically reduced numbers in Sainte Luce. Sexually mature individuals are increasingly hard to find, making seed collection challenging. Cultivation research and a species recovery plan are needed.

Ravenea sambiranensis (Vakapasy)

This medium to large dioecious palm is relatively low in abundance throughout forest fragments S6, S7, S8 and S9. It has not been reported from or observed in S17. It occupies a range of habitat types from swamp areas to dry, well drained soils. As inferred by the interviews, it is highly likely that a large proportion of the local community are unable to identify it as a separate species from other large palms, especially *B. madagascariensis*.

Uses: Leaf rachises of juvenile *R. sambiranensis* are harvested for lobster trap weaving materials, but used infrequently in comparison to other palm species. Two older interviewees mentioned the use of the trunk to make sharpened spears for protection when travelling; indeed, the trunk is remarkably strong and resistant to axe damage. A large population of *R. sambiranensis* is situated 29 km southwest, near the village of Mahialambo.

Availability: Decrease (3/6), No Change (3/6)

Life History: None available.

Conservation Concerns: Low density, increasing fragmentation/habitat destruction and the recent extraction of juveniles for lobster traps may be compounded by its dioecious habit.

DISCUSSION

Vernacular-Scientific Name Correspondence

Indigenous Malagasy criteria for naming are often based on appearance, physical properties and applications of the plant (Randriatafika & Rabenantoandro 2007). Interestingly, immature *D. scottiana* is differentiated from mature individuals by name (*amboza* and *raotry* respectively), presumably due to the differences in their applications (*amboza* – lobster traps, *raotry* – construction material). The survey did not reveal local names for either *D. brevicaulis* or *D. fibrosa*. Local names for palm species may be different between neighboring communities, for example, people from the mountain village Volobe, 20 km to the west of Sainte Luce, refer to *R. sambiranensis* as *anivo*. It is therefore important to note that the vernacular-scientific name correspondence outlined in this paper is only relevant within the community of Sainte Luce, and should be verified by scientific identification whenever possible.

6. *Dypsis scottiana* stems being used to make wall panels (Photograph by Naidi McDonnell).

Palm Harvest and Application

Diversification of Material Use for Lobster Traps

Palms are an essential part of the economics of the lobster trade as they provide the materials for trap construction. At present, the fishermen are able to use seven species of palm to weave traps – the most economically significant application of palms by people in Sainte Luce.

Lobster is a top commercial export for the Anosy region and productive fishing centers such as Sainte Luce have attracted a growing migrant population to join the cottage industry. This population increase, combined with the average regional population growth, places enormous pressure on high preference lobster trap materials. Prior to ca. 1990, the liana *Flagellaria indica* (Flagellariaceae), known locally as *vahipiky*, was the most frequently used material for constructing lobster traps and is now at the brink of extirpation in Sainte Luce. In an effort to resolve this problem, cultivation trials by Rabenantoandro et al. (2007b) found that the liana is easily propagated from seed (rather than cuttings) but found that its slow growth rate would hinder its effectiveness as a long-term solution. Other natural materials have been tested in the area, including a Bamboo species, *Bambusa multiplex* (Poaceae), but traps proved to be very weak when woven from dried materials and according to the fishermen sharp edges damaged the lobsters (Rabenantoandro et al. 2007b).

Although traders continue to bring a declining reserve of *Flagellaria indica* from the Tsitongambarika forests (25 km to the west), the community of Sainte Luce have diversified their material usage to other forest resources. Palms, primarily *D. scottiana*, now constitute the majority of traps woven in Sainte Luce; however, it must be noted that *Ravenala madagascariensis* is a regular alternative material too (Shrum et al., in review). To make one trap, which lasts a maximum of three weeks in good sea conditions, twenty stems of *D. scottiana* (*amboza*) are required (Shrum et al. in review). Hundreds of fishermen using up to ten traps each at any one time, throughout the ten-month fishing season, constituting a huge annual demand (Shrum et al. in review). This coupled with the use of adult *D. scottiana* (*raotry*) for the common wall construction technique, *manohy falafa*, is rapidly exhausting the Sainte Luce population. When asked about changes in resource availability over time, all interviewees had noticed a decrease in the availability of *D. scottiana*. This is a priority species for both conservation and natural resource management at Sainte Luce.

The Juvenilization of Palm Populations

The juvenilization of populations through intensive rachis pruning has been observed in useful palm species (Dransfield & Beentje 1995). At Sainte Luce, *D. saintelucei* may be one palm subject to this process. Typically, of juveniles, the youngest developing leaf shoot is left untouched during rachis harvesting for making lobster traps. It can be assumed that in some cases the youngest is left intact because its small size is unsuitable for the purpose; however, some interviewees stated that this was a practice to maintain resource availability. Indeed, rachis harvesting is not fatal to the individual but may be preserving the population in a quasi-juvenile state, possibly explaining the demographic imbalance of *D. saintelucei* in Sainte Luce (Azafady unpublished data).

Other arboreal and solitary palm species (*D. prestoniana, R. sambiranensis*) have been subjected to an increased frequency of rachis harvesting of juvenile individuals for lobster traps over the last seven to ten years. Some interviewees did comment on this diversification in material use, stating that the depletion of *D. scottiana* and the absence of *F. indica* the main contributing factors. Assessing optimal rachis harvesting has been done with other useful palms in Madagascar, such as *Dypsis decaryi* (Ratsirarson et al. 1996), and could be considered with *D. saintelucei*.

At present, the harvest of mature adult arboreal palms (*B. madagascariensis, D. prestoniana, D. saintelucei* and *R. sambiranensis*) is very uncommon; however, the felling of several adult *D. prestoniana* (in S9) and *D. saintelucei* (in S7) for house construction was observed between the period of February 2011 and July 2012. Adult *D. saintelucei* have also been cut down to access the crown for weaving lobster traps in S7. These people were probably from villages outside Sainte Luce (Ebakika, Tsiharoa or Mahatalaky) highlighting the need to encompass outlying resource-dependent communities in conservation, resource management and awareness raising initiatives.

Stem Collection of Clustering Palms

Stems of the more slender clustering palms *D. scottiana* and *D. psammophila* (and *D. nodifera* which sometimes exhibits a clustering habit) are used in the common wall construction technique, *manohy falafa,* and for other purposes such as pirogue modification. According to field observations and survey findings, two harvesting practices are followed; only some of the stems are taken to promote stem regeneration, or every stem is cut, often leading to plant death. Indeed, some stems may be left if they are unsuitable for the purpose required, but there is evidence to suggest that some fishermen adjust their harvesting practices in an attempt to manage valued natural resources. The exact socio-economic parameters that influence which groups of people follow which practice are unknown. However, immigrants to Sainte Luce are perceived by the native people to be less sensitive to the traditional set of rules (the *dina*), which aim to promote the sustainable and fair use of both forest and marine resources.

Potential Impacts of Mining on Palm Populations and Resource Availability

QMM is committed to achieving a net positive impact on biodiversity (NPI) whilst taking into account the needs and rights of the local Anosy communities bordering the project zone, Sainte Luce. However, the expected loss of several large community use zones to mining, primarily S6 and S7, will directly impact immediate local resource availability and palm population biology at Sainte Luce.

Forest fragment S8 has been a protected area since 2003 and lies outside the designated mining area. This fragment is an important location for the palm flora of Sainte Luce, with all ten species present. However, despite falling under the responsibility of the "*Communauté de Base*" (CoBa, or local forest management committee), areas of S8 continue to be degraded and lost to prohibited activities. In recent years, the Sainte Luce CoBa has been largely non-functional, non-representative and lacked the support of the local community. This may change following recent elections and ongoing institutional capacity building by QMM; however, capacity and transparency issues with CoBas seem to be persistent and island-wide (see Hockley & Andriamarovololona 2007).

The main community use zones, forest fragments S6 and S7, represent a significant proportion of Sainte Luce's palm flora but are within the mining area. These fragments are home to the largest population of *D. saintelucei* (with over 100 adults recorded), the second largest population of *B. madagacariensis,* the Critically Endangered *D. brevicaulis* and the Endangered *D. psammophila* (IUCN 2012,

Azafady, unpublished data). In addition, S7 is an important collection site for *D. scottiana* and other species used for lobster traps. The loss of S6 and S7 will place massive pressure on S8 to continue contributing palm resources to local livelihoods whilst maintaining viable populations for the area as a whole. S9 (QMM conservation zone) and S17 (Protected Area) are largely lacking in palm diversity and density but may be important locations to consider for *in situ* conservation measures.

Recommendations

Further research is needed to determine the exact palm distribution and population sizes/trends of all threatened palm species across the different forest fragments at Sainte Luce. The likely inclusion of S6 and S7 in the mining path strongly necessitates the sustainable (community-based) management of S8's natural resources and habitat, with effective population (participatory) monitoring and possible population reinforcements. The QMM conservation zone, S9, will offer the best protection for all flora and fauna in Sainte Luce, and could play an important role in species recovery plans. As a priority, the investigation and application of alternative materials for lobster traps is essential for both palm and overall habitat conservation in Sainte Luce.

CONCLUSIONS

Palms are among the most widely utilized plants in Sainte Luce. Their applications are diverse: fishing tackle, medicine, house and pirogue construction, food, utensils and cultural ornaments. Fabricating lobster traps is currently the most frequent and economically important local application of palms, employing seven of the ten species native to Sainte Luce. However, unsustainable extraction is depleting palm populations. Most urgently, *Dypsis scottiana* appears to be facing a similar path to extirpation as the previously utilized *Flagellaria indica*. Intensive rachis harvesting of juvenile *D. saintelucei*, and potentially other solitary arboreal palms, may be causing the juvenilization of the population.

Rapid human population increase is placing further pressure on the littoral forest to contribute natural resources, like palms, to local livelihoods at Sainte Luce. Mining at locations known to support high palm densities, reducing palm population size and extent, may compound this issue. Nursery-reared or alternative resources for fabricating lobster traps should be investigated further, involving the meaningful participation of local fishermen at every stage of the process. A functional community-based institution (CoBa or other) must be in place to manage existing forest resources, support sustainable extraction of resources at the conservation zone (S9) and protected areas (S8, S17), and monitor overall habitat protection. We hope that this report contributes in some way to the conservation of these beautiful plants in their natural habitat.

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Literature Cited

Byg, A. and H. Baslev. 2001. Diversity and use of palms in Zahamena, eastern Madagascar. Biodiversity and Conservation 10: 951–970.

Consiglio,T., G.E. Shatz, G. McPherson, P.P. Lowry, J. Rabenantoandro, Z. Rogers, R. Rabevohitra and D. Rabehevitra. 2006. Deforestation and plant diversity of Madagascar's littoral forests. Conservation Biology 20: 1799–1803.

Cornet, A. 1974. Essai de cartographie bioclimatique à Madagascar. Notice explicative No 55, ORSTOM, Paris.

Dransfield, J. and H. Beentje. 1995. The Palms of Madagascar. Royal Botanic Gardens Kew and the International Palm Society.

Dransfield, J. and M. Rakotoarinivo. 2012. The palms of Tsitongambarika, southeast Madagascar. Palms 56: 162–179

Duffield, C., J.S. Gardner, F. Berkes and R.B. Singh. 1998. Local knowledge in the assessment of resource sustainability in Himachal Pradesh, India, and British Columbia, Canada. Mountain Research and Development 18: 35–49.

GADGIL, M., F. BERKES AND C. FOLKES.1993. Indigenous knowledge for biodiversity conservation. Ambio 22: 151–156.

HEYWOOD, V.H. AND M.E. DULLOO. 2005. In situ conservation of wild plant species: a critical global review of best practices IPGRI Technical Bulletin 11. IPGRI, Rome, Italy.

HOCKLEY, N.J. AND M.M. RANDRIAMAROVOLOLONA. 2007. The Economics of Community Forest Management in Madagascar: Is There a Free Lunch? US AID, Washington, D.C.

IUCN. 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 23 October 2012.

JOHNSON, D. 1996. Palms: Conservation and their Sustained Utilization. Status Survey and Conservation Action Plan. IUCN, Gland, Switzerland and Cambridge, UK.

RABENANTOANDRO, J., F. RANDRIATAFIKA AND P.P. LOWRY II. 2007a. Floristic and structural characteristics of remnant littoral forest sites in the Tolagnaro area. Pp. 65–93, in: GANZHORN, J.U., S.M. GOODMAN, AND M. VINCELETTE, EDS. Biodiversity, Ecology and Conservation of Littoral Ecosystems in Southeaastern Madagascar, Tolagnaro (Fort Dauphin). SI/MAB Series #11. Smithsonian Institution, Washington DC, USA.

RABENANTOANDRO, J., L. RANDRIHASIPARA, M. VINCELETTE AND J. RAKOTO. 2007b. Testing the propagation and growth of the liana *Flagellaria indica*, used to make lobster traps, and *Bamusa multiplex* as an alternative source. Pp. 363–368 In: GANZHORN, J.U., S.M. GOODMAN, AND M. VINCELETTE, EDS. Biodiversity, Ecology and Conservation of Littoral Ecosystems in Southeastern Madagascar, Tolagnaro (Fort Dauphin). SI/MAB Series #11. Smithsonian Institution, Washington DC, USA.

RAMANAMANJATO, J-B. 2007. Reptile and amphibian communities along the humidity gradient and fragmentation effects in the littoral forests of southeastern Madagascar. Pp. 167–179, in: GANZHORN, J.U., S.M. GOODMAN, AND M. VINCELETTE, EDS. Biodiversity, Ecology and Conservation of Littoral Ecosystems in Southeaastern Madagascar, Tolagnaro (Fort Dauphin). SI/MAB Series #11. Smithsonian Institution, Washington DC, USA.

RANDRIATAFIKA, F. AND J. RABENANTOANDRO. 2007. Correspondence between vernacular and scientific names of littoral forest plants in the Tolagnaro area. Pp. 95–117, in: GANZHORN, J.U., S.M. GOODMAN, AND M. VINCELETTE, EDS. Biodiversity, Ecology and Conservation of Littoral Ecosystems in Southeaastern Madagascar, Tolagnaro (Fort Dauphin). SI/MAB Series #11. Smithsonian Institution, Washington DC, USA.

RATSIRARSON, J., J.A. SILANDER, JR., AND A.F. RICHARD. 1996. Conservation and management of a threatened Madagascar palm species, *Neodypsis decaryi*, Jumelle. Conservation Biology 10: 40–52.

SHATZ, G.E. 2000. Endemism in the Malagasy tree flora. Pp. 1–9, in: LOURENÇO W.R. & S.M. GOODMAN, EDS. Diversité et Endémisme à Madagascar. Mémoires de la Société de Biogéographie, Paris, France.

SHRUM, M., E.R. ELLIS, S. FUNNELL, F. HOGG AND M.S. RANDRIANANTENAINA. In review. The usage of natural resources in the lobster fishing community of Sainte Luce and implications for the future of the industry. Madagascar Conservation and Development.

TEMPLE, H.J., S. ANSTEE, J. EKSTROM, J.D. PILGRIM, J. RABENANTOANDRO, J-B. RAMANAMANJATO, F. RANDRIATAFIKA AND M. VINCELETTE. 2012. Forecasting the Path Towards a Net Positive Impact on Biodiversity for Rio Tinto QMM. Gland, Switzerland: IUCN. x + 78pp.

VINCELETTE, M., M. THEBERGE, AND L. RHANDRIHASIPARA. 2007. Evaluations of forest cover at regional and local levels in the Tolagnaro region since 1950. Pp. 49–58, in: GANZHORN, J.U., S.M. GOODMAN, AND M. VINCELETTE, EDS. Biodiversity, Ecology and Conservation of Littoral Ecosystems in Southeaastern Madagascar, Tolagnaro (Fort Dauphin). SI/MAB Series #11. Smithsonian Institution, Washington DC, USA.