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***Adonidia zibabaoa*, a Remarkable New Palm Species from Samar Island, Philippines**

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Ripe fruits of *Dypsis brevicaulis*. See article by S. Hyde Roberts et al., p. 31. Photo by S. Hyde Roberts.



FRONT COVER

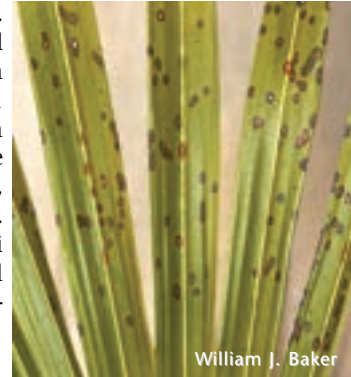
Adonidia zibabaoa, a newly described species from the Philippines. See article by J.T. Adorador et al., p. 5. Photo by J.T. Adorador.

BACK COVER

Nypa fruticans has an inflorescence structure unlike any other in the palm family. See article by L.L. Arneaud, p. 21. Photo by L.L. Arneaud.

PALM NEWS

Fungi and plant pathogen specialists D.S. Pereira and A.J.L. Phillips published “Exploring the diversity and ecological dynamics of palm leaf spotting fungi—a case study on ornamental palms in Portugal” in *Journal of Fungi* 11 (<https://doi.org/10.3390/jof11010043>). The article is Open Access. By examining just 134 lesions on 100 palms, the researchers found a staggering 2064 palm leaf spotting fungi, representing 320 possible species distributed across 97 genera. Such diversity was unexpected. Understanding which fungi infect palms and how they interact with one another is crucial for developing sustainable management strategies for ornamental and agronomic palms.



William J. Baker



Scott Zona

In “Simulated impacts of harvesting *Chamaedorea linearis* and *C. pinnatifrons* (Arecaceae): Implications for their conservation” (*Biotropica* 57; <https://doi.org/10.1111/btp.13420>), P. Cepeda and colleagues examined the effects of harvesting seedlings, leaves and fruits. Using ecological modeling, they showed that harvesting palms can be sustainable. They found that up to 20% of fruits of either species can be harvested annually with no adverse effects on the populations; however, populations suffered if 20% of fruits were harvested twice or four times per year. They concluded that protecting juveniles is critical for population stability and that fruit (seed) harvesting for propagation can be a sustainable strategy that does not conflict with conservation goals.

In a first-of-its-kind study, R.E. Tomasko and colleagues published “Vascular and non-vascular plant diversity of a Fan Palm (*Licuala ramsayi*) dominated swamp forest in Mission Beach, Queensland, Australia” in *North Queensland Naturalist* 54: 79–93. 2024. This survey of both vascular and non-vascular plants found surprising diversity in a swamp dominated by *Licuala ramsayi*. They found 238 species of vascular plants (182 genera in 80 families) and 40 species of mosses and liverworts (25 genera in 13 families). This study highlights the ecological diversity of the *Licuala ramsayi* swamp forests and brings awareness to their importance in preserving biodiversity in northern Queensland.



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Adonidia zibabaoa, a Remarkable New Palm Species from Samar Island, Philippines

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Adonidia zibabaoa Adorador & Fernando (Areceae; Ptychospermatinae) is described as new to science. Due to the problematic delimitation of genera within the subtribe, a phylogenomic analysis based on 151 nuclear genes was undertaken to determine the placement of the new species. This provides robust evidence that the new taxon is sister to the two currently accepted species of *Adonidia*, with which it shares many morphological characters. Field surveys show that this horticulturally appealing palm is restricted to the tops of karst formations in central Samar Island, Philippines and is assessed as Critically Endangered based on IUCN guidelines.

The Philippines is home to about 20 genera of native palms, a fact that has been known since the last synopsis of the family over a century

ago (Beccari 1919). Most of the country's palm genera are derived from Sundaic elements and several taxa are yet to be accounted for,

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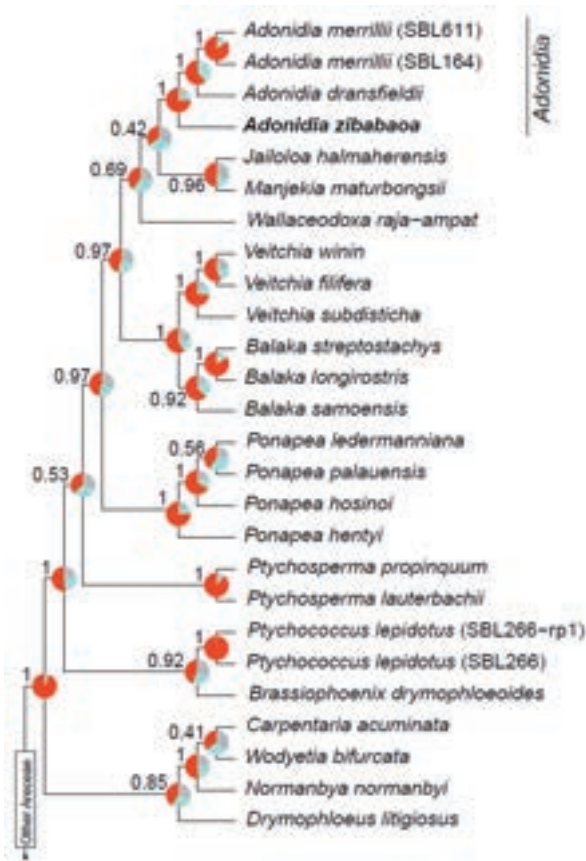
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1. Phylogenetic relationships among all genera of subtribe Ptychospermatinae obtained by multispecies coalescent summary analysis of 151 genes (redrawn from Pérez-Calle et al. 2024). The placement of the Samar palm, *Adonidia zibabaoa*, is highlighted in bold. Numbers on branches represent the local posterior probability (LPP) of each clade. Pie charts show quartet support of the displayed topology (red), of the first alternative topology (blue) and of the second alternative (gray).

especially on Palawan and the Sulu–Tawi-Tawi island arcs (Fernando 1990, Fernando et al. 2020). However, some genera centered on the Sahul shelf are also represented in the archipelago, namely *Heterospatha*, *Orania* and *Adonidia* (Fernando 1990, Baker & Couvreur 2012). The last genus belongs to Ptychospermatinae, a largely New Guinean subtribe that is also distributed throughout East Malesia to Fiji, Samoa and Australia (Dransfield et al. 2008). Remarkably, *Adonidia* is found only on the islands of Palawan and Danjungan in the Philippines and in northern Borneo (Fernando 1990, Fernando 2011, Wong et al. 2015), disjunct from the rest of the subtribe, and is the only Ptychospermatinae genus found west of Wallace’s Line. This biogeographic disjunction within Ptychospermatinae may be an artifact of palm undercollection on the intervening islands (Fernando 1990), an idea supported by a relatively recent new record for the subtribe on Halmahera in the intervening gap (Heatubun 2011, Heatubun & Baker 2014).

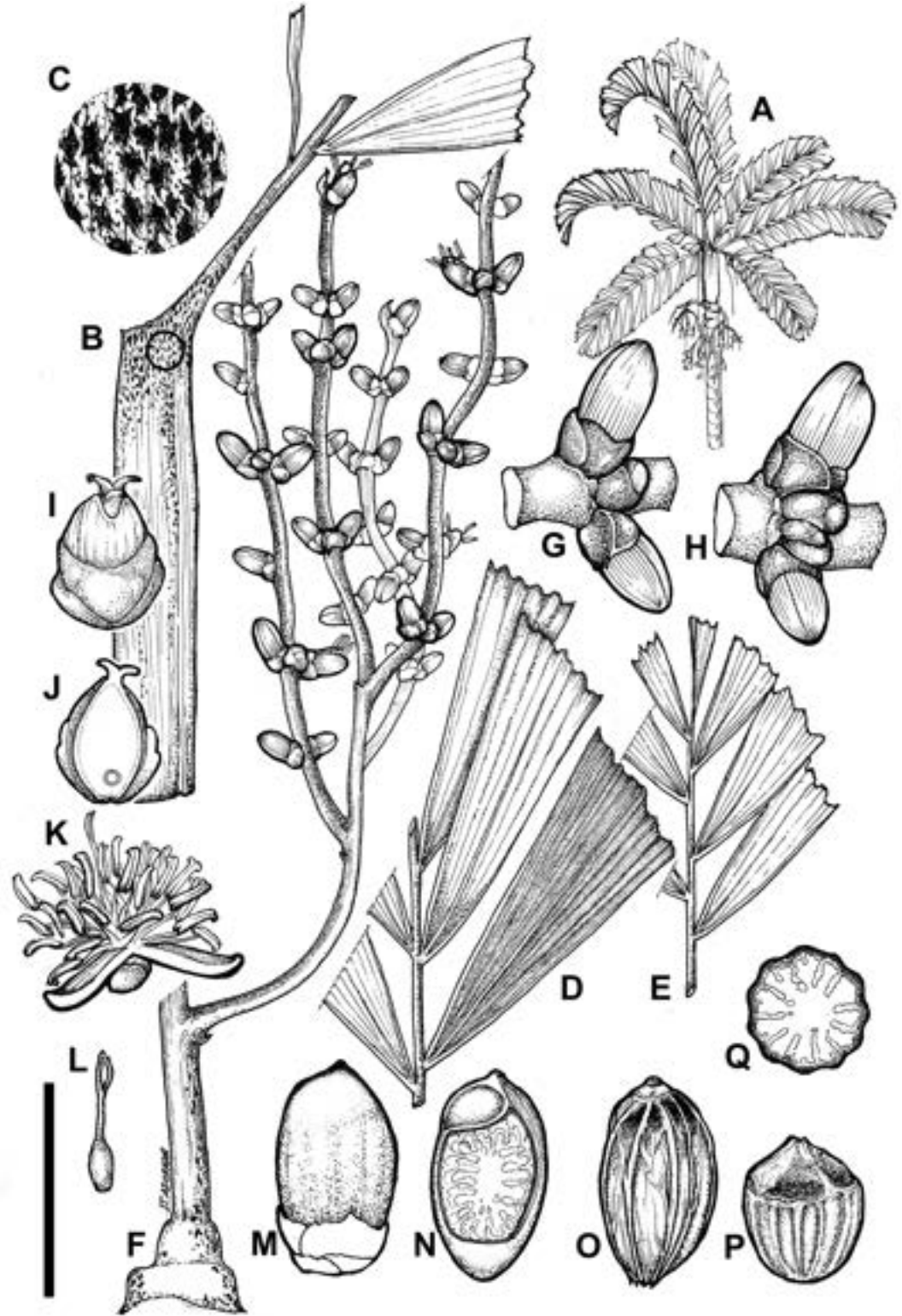
Only recently, phylogenetic relationships within the subtribe have become better

understood with the aid of both morphological and molecular data (Zona et al. 2011, Alapetite et al. 2014, Heatubun et al. 2014), shedding light on the group’s difficult taxonomy. This research resulted in several generic realignments (Zona et al. 2011, Zona & Baker 2014) as well as the description of three new genera, *Jailoloa*, *Manjekia* and *Wallaceodoxa* (Heatubun et al. 2014). Of these, *Manjekia* was initially described in the genus *Adonidia* as *A. maturbongsii*.

In 2013, an undescribed palm species was discovered on Samar Island in forest on limestone at around 380 m elevation (Adorador & Fernando 2017). Several expeditions were subsequently carried out since then (in 2015, 2016, 2019, 2021) to collect complete herbarium specimens and gather relevant ecological and natural history data. While clearly belonging to subtribe Ptychospermatinae, due to its praemorse leaflet apices, widely branched inflorescence and bullet-shaped staminate flowers with numerous stamens (Dransfield et al. 2008), the recent taxonomic changes in the group and the fine morphological differences

Table 1. Comparison of the expanded *Adonidia* with most related genera of Ptychospermatinae. The text in bold italics are unique to *A. zibabaoa*.

	Expanded <i>Adonidia</i>	<i>Manjekia</i>	<i>Wallaceodoxa</i>	<i>Jailoia</i>	<i>Balaka</i>	<i>Veitchia</i>
Leaf sheath indument	glaucescent to lepidote to <i>black scurfy</i>	gray scurfy with scattered purple-brown scales	thick, white, caducous, lannate indumentum interspersed with numerous large brown-black twisted hairs	brown to black irregular and matted fibrous scales	brown scales	gray to brown indumentum
Leaflet disposition	<i>slightly ascending</i> to conspicuously so	pendulous	pendulous	conspicuously ascending	in one plane	in one plane
Leaflets	linear to broadly lanceolate to <i>cuneate</i> , apices conspicuously bifid to <i>truncate, praemorse inconspicuously doubly incised</i>	broadly lanceolate, apices concavely praemorse	linear lanceolate, apices praemorse	linear lanceolate apices praemorse	tapered on both ends, apices obliquely truncate, acute, acuminate, or variously toothed	tapered on both ends, apices obliquely truncate, acute, acuminate, or variously toothed
Peduncle lenght relative to the rachillae	—	shorter	shorter	shorter	longer	shorter
Inflorescence color & degree of branching	white, 2–4	white, 2 or 3	white, 2	purple, 2	—, 2	—, 3 or 4
Rachillae	thin and short or <i>thick and flexuous</i>	thick and flexuous	thick and rigid-flexuous	thick and flexuous	thick and short	medium to long and flexuous
Stamen number	25–52	30–32	58–64	ca. 16	24–50	up to 100
Pistillode	legiform, filiform, <i>bifid</i> or trifid stylar section	lageniform with elongate stylar section	short, ellipsoid	lageniform with elongate stylar section, ± lobed	lageniform with long flexuous style	attenuate from a bulbous base
Fruit color (mature)	red	red	red	red	reddish orange	orange-red
Endocarp	terete or subterete, thin, with rather <i>sharp</i> or flattened broad and finer fibers <i>enclosing a bulging outgrowth at its apex</i> , or not	terete, thin, with flattened fine and broad, straw-colored fibers	terete, thin, with flattened fine and broad straw-colored fibers	terete, thin, with flattened fine and broad straw-colored fibers	thin, not operculate	thin fibers
Seed (cross-section)	terete to subterete, <i>with apical biconcave depression</i> , or not	terete without apical depression	terete without apical depression	terete without apical depression	4- or 5-angled	terete
Endosperm	ruminate	ruminate	ruminate	ruminate	homogeneous	homogeneous



between genera made it difficult to assign the new species to a genus confidently. Hence, to complete the formal taxonomic recognition

of the Samar palm, a robust molecular phylogeny of relevant Ptychospermatinae was needed. Here, we compare the morphology of

2 (facing page). *Adonidia zibabaoa* Adorador & Fernando. A. habit; B. leaf sheath and basal leaflets; C. peltate-lacerate scales; D. middle leaflets; E. apical leaflets; F. inflorescence; G. floral cluster in triad; H. in fours; I. pistillate flower at anthesis; J. longitudinal section; K. staminate flower at anthesis; L. lageniform pistillode; M. mature fruit; N. longitudinal section showing the apical spongy material and ruminant endosperm; O. fruit with pericarp removed, showing the sharp major fibers and the apical cavity when dried; P. seed after removing the endocarp; Q. seed in cross section. B–E. *Adorador 002 et al.*, E–H. from *Adorador 007 et al.*, I–L from *Adorador 001 et al.* (=holotype). Scale bar: B = 8 cm, C = 5 mm, D–E = 13 cm, G–L = 1.5 cm, M–Q = 2.5 cm. Drawn by J.T. Adorador.

the Samar palm with that of other Ptychospermatinae genera and explore its phylogenetic position in the subtribe based on 151 low-copy nuclear genes, enabling us to describe it as a species new to science, *Adonidia zibabaoa*.

Materials and methods

Morphological study: Measurements and character observations from living populations surveyed on Samar Island and fertile herbarium collections were made using a graduated ruler, tape measure, vernier caliper, hand lens and a stereo microscope (Novel NSZ-608TB). Literature reviews (Dransfield et al. 2008, Heatubun et al. 2014), herbarium studies (at P, FI, PNH, CAHUP, LBC, K [herbarium acronyms following Thiers 2015-continuously updated]), and examination of living collections of other *Adonidia* species from the Makiling Botanic Gardens (MBG) (Fernando et al. 2009) and ESF's private garden were

carried out to compare the new collections with known genera of Ptychospermatinae.

Phylogenomic analysis: Here we draw on a phylogenomic analysis of the western Pacific clade of tribe Areceae (sensu Norup et al. 2006) published by Pérez-Calle et al. (2024). All genera of subtribe Ptychospermatinae were represented in this study, as was a sample of the Samar Palm (*Adorador 095 with T. Rambacod*), providing comprehensive taxonomic coverage to determine the phylogenetic placement of the new species. DNA sequence data were obtained from 151 nuclear genes using target sequence capture, which were subjected to multispecies coalescent summary analysis. For all phylogenomic methods details, the reader is referred to Pérez-Calle et al. (2024).

Conservation status assessment: The conservation status of the new palm was derived using the GeoCAT tool (Bachman et al. 2011)

3. In situ population.





4. Habit.



5. Inflorescence and infructescence.

and following the criteria and guidelines of IUCN (2012) and IUCN Standards and Petitions Subcommittee (2017).

Results and discussion

Systematic affinity of the Samar palm: Based on the nuclear phylogenomic analysis of Pérez-Calle et al. (2024), the Samar palm is maximally supported as the sister lineage of a clade comprising the two currently accepted species of *Adonidia* (Fig. 1). This group falls within a well-supported major group (local posterior probability [LPP]=0.97) that also includes *Balaka*, *Jailoloa*, *Manjekia*, *Veitchia* and *Wallaceodoxa*. This major clade was also recovered in previous phylogenetic studies of the subtribe (Zona et al. 2011, Alapetite et al. 2014). Within this major clade, *Adonidia* (including the Samar palm) is very weakly supported as sister to a clade comprising *Jailoloa* and *Manjekia*. Thus, we can be highly confident of the placement of the Samar palm with existing *Adonidia* species but cannot be certain of this group's broader placement within the subtribe.

In contrast, the updated key to Ptychospermatinae genera of Heatubun et al. (2014) suggests that the Samar palm falls either in *Manjekia* or *Ponapea*, depending on whether one interprets the seed as either "somewhat

terete" or "subterete." In transverse section, the seed of the Samar palm is sub-terete or slightly ridged exactly where sharp major fibers adhere to the endocarp. These genera are somewhat similar to the Samar palm in their broad lanceolate to cuneate leaflets, whitish inflorescence axes, shorter peduncle relative to the rachillae and red mature fruits. However, the extensive nuclear phylogenomic evidence placing the Samar palm as sister to *Adonidia*, which also shares several morphological characters, is overwhelming. Therefore, the most efficient taxonomic solution for the new palm from Samar is to place it in *Adonidia*, as *A. zibabaoa*. We recognize, however, that genera are finely delimited in Ptychospermatinae (Table 1) and that future phylogenomic efforts may result in refinements to the genus-level classification of the subtribe.

Overall, the Samar palm fits comfortably within the morphology of *Adonidia* (see Table 1 for morphological comparisons of the expanded *Adonidia* with closely related genera). It also shares a preference for limestone areas with *A. dransfieldii* and *A. merrillii*. However, *A. zibabaoa* differs from the other two species in its leaf sheath being covered with peltate lacerate dark brown scales over whitish-gray scurfy tomentum (vs. just whitish-gray scurfy

tomentum), in the slightly ascending leaflets (vs. markedly ascending, linear-lanceolate leaflets held in slightly different planes), the far fewer leaflets per side of the rachis (up to 20 vs. more than 40) that are broader lanceolate to cuneate with truncate, praemorse apices (vs. linear with narrow and inconspicuously praemorse or bifid apices), long and flexuous rachillae (vs. relatively shorter and thin rachillae), endocarp with rather sharp broad fibers (vs. with flattened fine and broad longitudinal fibers in the other species), and a suite of seed shape characteristics.

Description of the new species

Adonidia zibabaoa Adorador & Fernando, sp. nov.

Diagnosis: Immediately distinguished from the other two known *Adonidia* species, *A. dransfieldii* and *A. merrillii*, in its leaf sheath covered with dark peltate lacerate dark brown scales (vs. with whitish-gray scurfy tomentum), up to 20 leaflets per side of the rachis (vs. at least 40) that are broadly lanceolate to cuneate and apically truncate, praemorse (vs. linear-lanceolate leaflets which are apically narrowed and inconspicuously bifid), and thick flexuous rachillae (vs. short and thin), endocarp enclosing an apical bulge containing a spongy tissue (vs. endocarp not enclosing a similar structure), and the seed being transversely slightly ridged or subterete and apically biconcave with obliquely conical rostrum (vs. transversely terete and apically rounded). Type:— PHILIPPINES. Samar Island: Samar Province, Paranas, Barangay Tenani, 380 m elev., 12 July 2015, *J.T. Adorador 001 with Z.D. Meneses & R. Lugasán* (holotype: PNH! Isotype: CAHUP!) (Figs. 2–10).

(Characters in italics are unique to the new species as compared to other *Adonidia* spp.).

Moderately slender, solitary, unarmed, pleonanthic, understory to midstory tree palm. **Stem** erect, 5–15 m tall, 5–12 cm diam., tapering towards apex, surface smooth, internodes 1–2(–5) cm apart. **Leaves** ca. 8 in crown; sheath tubular, 18–30 cm × 2.4–4.7 cm, forming a well-defined crownshaft up to 40–50 cm × 8–10 cm, glabrous adaxially, abaxially covered in thin, whitish-gray caducous tomentum interspersed with minute scurfy light brown scales *and larger peltate lacerate dark brown scales that are more abundant near the sheath apex and junction with the petiole*; petiole present, slender, (1–)6.7–9 cm long, up to 1.7 cm wide at base, shallowly channelled

adaxially, rounded abaxially, covered with scales and indumentum as with the sheath; rachis long and slender, 62–120 cm long, up to 1.2 cm wide at mid-point, bifacial adaxially, rounded abaxially, with scales and indumentum as on petiole; leaflets 8–20 each side of the rachis, single-fold with inconspicuous main vein, arranged regularly, subopposite to alternate, *broadly lanceolate to cuneate*, in one plane or slightly ascending, concolorous, glabrous on both surfaces, apices truncate, praemorse, inconspicuously doubly incised, basal leaflets lanceolate, 7–13 cm long, 1–5 cm wide, sometimes with rein up to 1 m long, middle leaflets broadly cuneate, 16–36 cm long, 5–12.5 cm wide, widest and longest at the middle, apical leaflets 6–13 cm long, 1–4.5 cm wide, not fused except sometimes at the very base. **Inflorescence** infraxillary, up to 37 cm long, held horizontally, diffusely spreading, branched to 2 or 3 orders, the axes white, glabrous or with very sparse minute, brown scales, the bracts with sparser covering as the leaf sheath; prophyll 18–28 cm long, 2.3–4 cm wide, greenish white, laterally flattened, rather thin, 2-keeled laterally, somewhat striate, thin leathery, persistent, splitting apically into two parts by the expanding inflorescence; peduncular bracts first peduncular bract 19–24 cm × 2–2.3 cm, attached 20 mm above prophyll insertion, underdeveloped second peduncular bract attached up to 3.2 cm further, other bracts inconspicuous, triangular and incomplete, leaving semi-annular scars about halfway along the peduncle length, rachillae bracts inconspicuous; peduncle 5–8.5 cm long, 0.6–1.5 cm wide, relatively slender, elongate, somewhat flattened, shorter than rachis; rachis longer than peduncle, angled, tapering; rachis bracts low, somewhat triangular to rounded; primary branches 8–10, the basal 2–4 branches further branched, spirally arranged; rachillae 7–22 cm long, 1–3 mm diam., basal 4–32 mm devoid of triads, floral triads 4–23 mm apart, *rather thick and flexuous*, ± trigonously angled, tapering, bearing spirally arranged strongly-protandrous triads or *sometimes in fours (2 pistillate flowers between 2 staminate flowers) [in robust-stemmed individuals]* throughout or 3/4 its length, distal flower clusters of paired or solitary male flowers, floral bracteoles low, rounded or truncate. **Staminate flowers** 10–11 mm long, 3–4 mm diam., pale green to greenish white in bud, turning purplish white at anthesis, strongly protandrous, bullet-shaped in bud, glabrous; sepals 3, 2–4 mm long, 4–5 mm wide, broad, distinct, strongly



6 (top). Floral triad. 7 (bottom). A pair of pistillate flowers.

imbricate, orbicular, coriaceous, thickened abaxially, thinning towards the margin, margins minutely ciliate; petals 3, 8–9 mm long, 3–4 mm wide, valvate, ovate, striate; stamens numerous, 39–52, anthers 2–3 mm long, dorsifixed, sagittate, latrorse, filaments

1–2 mm long; pistillode lageniform, 6–10 mm long, c. 1.5 mm diam, *with an elongate bifid apex up to half its length*. **Pistillate flowers** ovoid, up to 9 mm long, 8 mm diam, pale green to greenish white; sepals 3, 5 mm long, 7 mm wide, strongly imbricate, thickened,

rounded, somewhat asymmetrical; petals 3, 4–8 mm long, 4.5 mm wide, strongly imbricate, similar to sepals but striate; staminodes 6, ca. 2 mm long, subulate; gynoecium ovoid-conical, ca. 8.5 mm long, 5 mm diam., stigma trifid, minutely ciliate adaxially, white at anthesis, reflexed, ovule basal. **Fruit** ellipsoid, 2.4–3 cm long, 1.3–1.9 cm diam.; stigmatic remains apical, persistent, brown-black; perianth cupule 1–1.5 cm long, 1.1–1.5 cm wide; entire pericarp 1.6–3 mm thick, epicarp smooth, somewhat shiny, thin, ripening through orange to red; mesocarp sparsely fibrous, thinly fleshy; endocarp thin, straw-colored, 2–2.7 cm long, 1–1.6 cm diam., with adherent 9–14 rather sharp broad fibers enclosing an apical bulge filled with a spongy tissue, becoming an air-filled cavity upon drying, interspersed with a secondary layer of branching finer fibers. **Seed** 1.3–2.4 cm long including the short obliquely conical rostrum, 1.2–1.5 cm diam., ovoid-ellipsoid, laterally attached, subterete in cross-section or very slightly ridged along the adherence of major fibers, apex with a biconcave depression and a short oblique conical rostrum along side of endocarp adherence; hilum elliptical, elongate, running from base to apex; raphe branches anastomosing; endosperm ruminant; embryo basal, white. Germination adjacent-ligular, eophyll bifid, 4-costulate, up to 10 cm long, 1.5 cm wide.

Specimens examined: PHILIPPINES. Samar Island: Samar Province, Paranas, Barangay Tenani, 380 m elev., 12 Jul 2015, *J.T. Adorador 001 with Z.D. Meneses & R. Lugasan* (CAHUP! PNH!), 002 (K!, LBC!), ca. 350 m elev., 13 Jul 2015, *J.T. Adorador 013 with Z.D. Meneses & R. Lugasan* (LBC!), 015 (LBC!), 5 Feb 2016, *J.T. Adorador 054 with Z.D. Meneses & T. Rambacod* (LBC!, PUH!), 11 Dec 2016, *J.T. Adorador 096 with Z.D. Meneses & T. Rambacod* (LBC!), Barangay San Isidro, 300 m elev., 28 Feb 2016, *J.T. Adorador 095 with T. Rambacod* (LBC!). Eastern Samar Province, Taft, Barangay San Rafael, ca. 270 m elev., 19 Jul 2015, *J.T. Adorador 007 with Z.D. Meneses & T. Rambacod* (LBC!, PNH).

Distribution: Endemic to the Philippines, only found on the island of Samar.

Habitat: Forest over limestone (270–420 m elev.) on Samar Island.

Phenology: Flowering and fruiting are observed throughout the year but are more frequent during May–July and December–February. It takes about 3 or 4 months for the fertilized flowers to develop into mature fruits.

Conservation status: Critically Endangered [CR B1 b(i,ii) c(iii, iv); C1 + 2a(i)]. *Adonidia zibabaoa* is thus far documented near the summit of three karst areas in central Samar Island found

8. Staminate flower.





9. Mature fruits.



10. Mature fruit with the spongy apical region exposed.

within the Samar Island Natural Park (SINP). Palm surveys in February 2016 within six 20 m × 20 m quadrats across three forests over karst, accounted a total of 184 individuals, of which only 34 are mature, 27 are saplings and 88 are seedlings. Using the GeoCAT conservation assessment tool (Bachman et al. 2011), the calculated extent of occurrence of the new species is just about 5 km² and area of occupancy at just 16 km². Hence, *A. zibabaoa* falls within the threshold for Critically Endangered category following IUCN (2012) and the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Subcommittee 2019). Although likely to be found atop numerous karst peaks across the central-southern portions of the island, its observed sporadic distribution and corresponding small population size of mature plants make this newly discovered plant susceptible to extinction especially during prolonged droughts or when the habitats are significantly altered.

Etymology: The specific epithet comes from the word “*Zibabao*” (sometimes spelled as “*Ybabao*” or “*Cibabao*”, a Hispanized version of “*Ibabao*” — an old name for Samar Island

[where the type was collected] and literally translates “atop” or “to the north.” In the Visayan language, *ibabao*’ (or “*ibabaw*”) means “atop” (to refer to the elevated mountainous interiors of the island) or to the north (which is geographically correct relative to the islands of Homonhon or Leyte where early navigators accounted Samar Island). Early cartographers and historians argue that the name could refer to the entire Samar Island or portions of it (see Velarde et al. 1734, Blair & Robertson 1903, Alcina et al. 2002).

Vernacular name: *Amuring* (Waray-Bisaya)

Uses: None recorded, but the new species has great horticultural potential.

Notes: Similar to characteristic plants thriving atop the karstic habitat, the seedlings may establish on crevices or the limestone rocks or anywhere that collects decomposing litter. As observed in the wild, the leaflets of the sapling individuals are stiffly erect, especially when sun-exposed (Fig. 11), while under shade the leaflets seem to droop. Nevertheless, taller plants approach the description once reproductively mature.

The atypical floral cluster form (two pistillate flowers flanked by two staminate flowers,



10. Young plants in cultivation at the Singapore Botanic Garden.

rather than the typical triad of two staminate flowers flanking one pistillate) is observed only in robust-stemmed individuals wherein it

could ultimately develop to mature fruits in pairs (as in *J.T. Adorador 007 et al.*). Such floral architecture is unreported in the subtribe and



11. Immature fruits (damaged by frugivorous birds) showing the stigmatic scar.

is interpreted as an elaboration of the triad (Dransfield et al. 2008, Uhl 1988). Notably, euglossine bees were observed to visit the male flower at anthesis.

The endocarp is unique in the presence of an apical bulge. This swollen portion is filled with a spongy tissue that completely disintegrates when dried and leaves an empty cavity suggesting possible water dispersal. Its bright

red colored epicarp and thin fleshy mesocarp readily suggest vertebrate dispersal (Zona & Henderson 1989). During our fieldwork, fruit doves (*Ptilonopus* sp.) were observed to feed on its fruits, and other large frugivorous avifauna even leave beak scars on the pericarp (Fig. 12).

Conclusion

The new palm's elegant appearance makes it highly sought after by palm enthusiasts.

Hence, further studies regarding its natural history and ecology should be conducted for its effective conservation and/or sustainable utilization. The discovery of this *Adonidia* partially resolves the subtribe's puzzling biogeographic disjunction, since Samar Island may have served as the stepping-stone into Palawan-Sabah from its New Guinean origins. A more complete taxonomic recircumscription of *Adonidia* (Adorador et al. in prep) awaits once further studies on the recently collected *Adonidia*-like palms from nearby islands are undertaken. Being critically endangered, this elegant taxon could be used as a flagship species for the conservation of the remaining forests over limestone within the Samar Island Natural Park (SINP).

Acknowledgments

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The Distribution of Nipa Palms (*Nypa fruticans*) in Trinidad and Tobago

LINTON LEE ARNEAUD^{1,2}

Although *Nypa fruticans* occurs in Trinidad and Tobago, there is no evidence that the species is reproducing in the wild, i.e. naturalized.

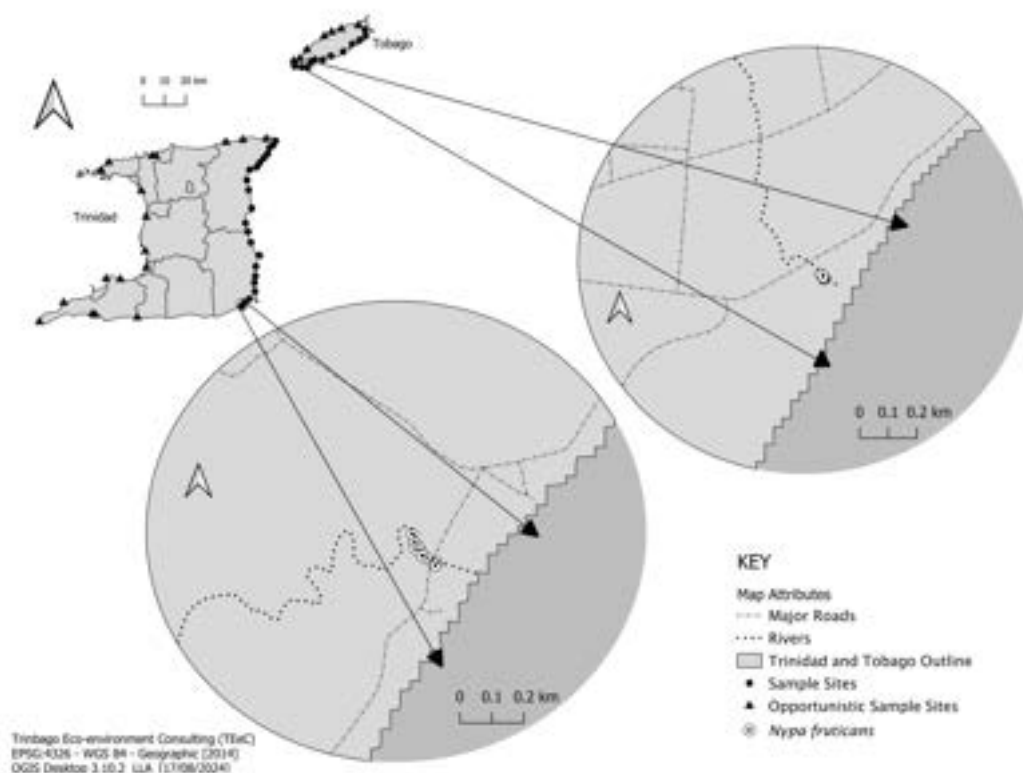
The nipa palm [*Nypa fruticans* (Wurmb) Thunb.] is the only palm species adapted to saline estuarine swamps or mangrove habitats (Tomlinson 1979). It is characterized by prostrate, dichotomous stems, unusual reproductive morphology, and large heads of fruit with viviparous seeds (Reddy 2008, Chomicki et al. 2014, Eddy et al. 2024, Rahman et al. 2024). It thrives in coastal, brackish water environments, forming extensive stands that play a crucial role in shoreline stabilization, carbon sequestration and provisional services in mangrove-dependent communities (Hamilton & Murphy 1988, Rahman et al. 2024).

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The present day distribution of native nipa palms stretches from the tropical Indo-West Pacific, extending from Sri Lanka through Asia to Japan, Northern Australia, and the Western Pacific islands (Rahman et al. 2024). Paleoecological evidence suggests the existence of nipa palms in the Neotropics millions of years ago when the climate was warmer and wetter, with extensive coastal wetlands (Muller 1980). Nipa palms have recently become established in Panama (Rahman et al. 2024) and are found in high densities in Guyana (Hollowell 2005) and within several countries along the central-west African coast (Moudingo et al. 2020, Rahman et al. 2024). Bacon (2001) proposed that nipa palm propagules, such as drupes or seedlings, which are naturalized in West Africa, may have crossed the Atlantic Ocean, to the Caribbean. This migration is estimated to have begun approximately a century ago. However, records indicate that there are thriving colonies of nipa palms along the Barima and Waini Rivers, Western Guyana (Hollowell 2005, Noblick &



1. The distribution of nipa palm (*Nypa fruticans*) in Trinidad and Tobago, West Indies.

Graveson 2014). Nevertheless, there is the possibility that nipa palm drupes and seedlings washing up on Caribbean beaches originated from South America via the Guiana Current (Pritchard 1993, Noblick & Graveson 2014).

Nipa drupes were first reported in Trinidad over a century ago (Guppy 1918) and have been successfully germinated over the years (Bacon 2001, Arneaud et al. 2024a). Many authors erroneously reported nipa palms as being naturalised in Trinidad (Kairo et al. 2003, Hollowell 2005, Teo et al. 2010, Moudingo et al. 2020, POWO 2024, Rahman et al. 2024), yet adult palms have never been seen until the present study. Additionally, Hollowell (2005) also recorded the possibility of nipa palm establishment along the Venezuelan portion of the Barima River, downstream towards the Southern Orinoco Delta, whereas Duke et al. (1998) suggested Guyana as another potential source of introduction for the nipa palms in Panama. Furthermore, Hollowell (2005) warned that the brackish waters of Trinidad's Caroni Swamp (Protected Area) and Nariva Swamp (Environmentally Sensitive Area) are areas that should be monitored for the potential establishment of nipa palms. This

paper aims to investigate the distribution of *Nypa fruticans* in Trinidad and Tobago, while documenting the population structure of established stands.

For decades, the Trinidad and Tobago Field Naturalists' Club (TTFNC) searched for nipa palm drupes and propagules within various coastal locations around the islands. They collected drupes and propagules, primarily along the east coast, including Matura, Salybia, Forest Port, Toco, Mayaro, Manzanilla, Guayaguayare, Rocky Bay, and Goldsborough Bay. They were unable to find any juvenile or adult nipa palms (see Table 1 for height classes) (Arneaud et al. 2024a).

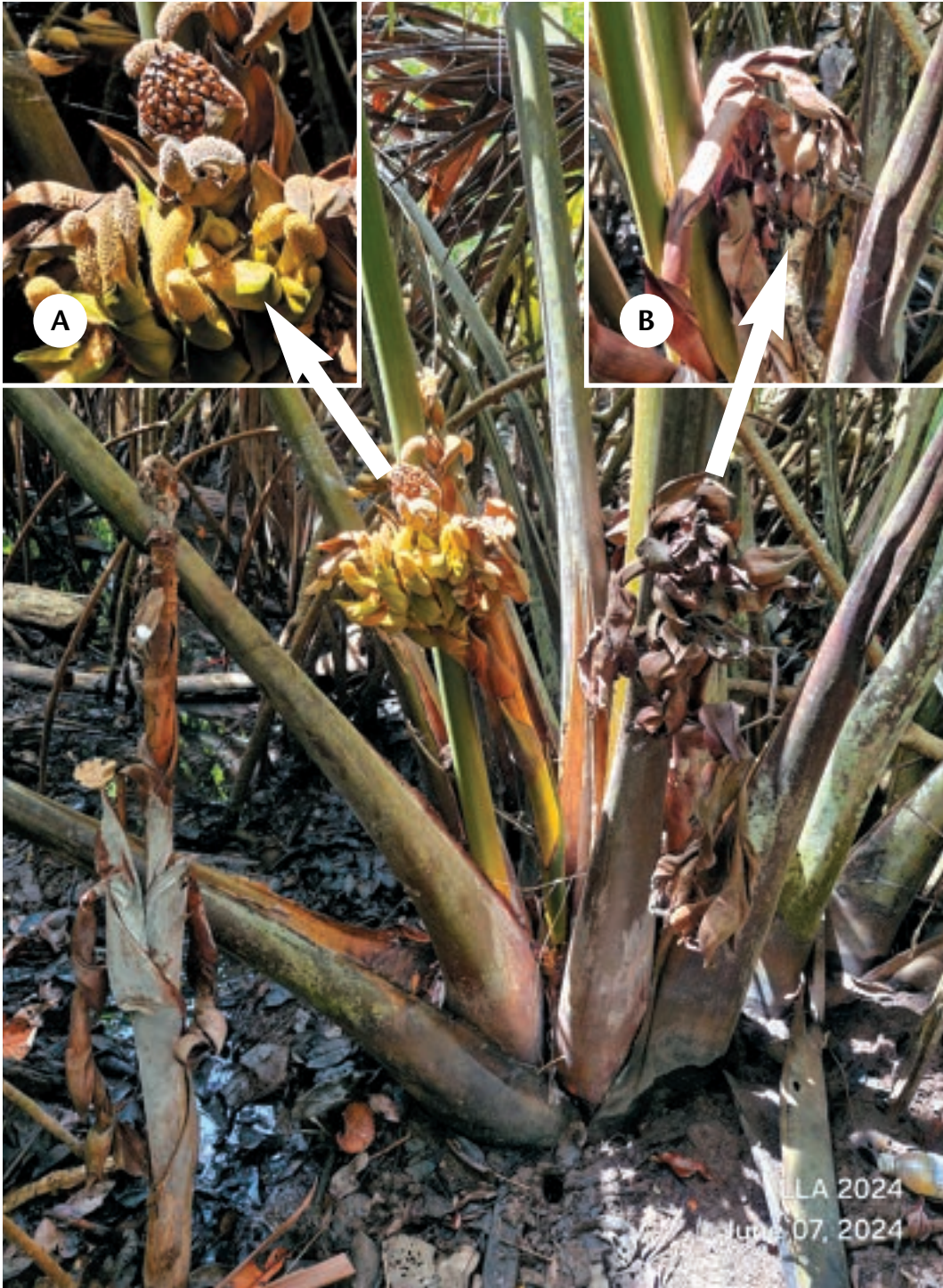
From March to July 2024, 40 sample plots were investigated (27 from Trinidad, and 13 from Tobago). Sample points were chosen based on suitable locations for nipa palm establishment at existing river and water channels along the eastern coast of both Trinidad and Tobago. When no suitable micro-habitats exist (i.e., no river or water channels), random sample plots were established approximately every 10 km and nipa palm populations were searched for within a 100 m transect along the coastline. At each sample site (with water channel/river),



2. Habitat and general morphology of non-reproductive nipa palms (*Nypa fruticans*) in south Tobago, West Indies. A. Older Juvenile. B. Older Seedling. C. Non-viable drupes.

a 100 m transect line was established, starting from the shoreline and following the watercourse inland. Whenever a nipa palm was found, a 50 m radial transect was created and thoroughly surveyed for additional palms, this method continued until no additional palms were found. Height of seedlings was measured at right angles to the ground to the

highest point on the leaf. For juvenile and adult palms, height was estimated using a Tangent Height Gauge from ground level to the highest point reached by the frond. Samples were taken to the National Herbarium of Trinidad and Tobago for vouchering. Additionally, 25 opportunistic sample plots (supplementing the TTFNC's field trip



3. Comparative morphology of a reproductive nipa palm (*Nypa fruticans*) in Trinidad. A. Monoecious inflorescence (separate male and female flowers). B. Aborted, senesced inflorescence (voucher L. Arneaud & D. Jaggermath 26956 deposited in the National Herbarium of Trinidad and Tobago).

locations) were established around the islands based on novelty, convenience and habitat suitability (see Figure 1).

Two nipa palm populations (stands) were identified, one on each island. In Trinidad, ten individuals (Table 1) were found, while in

Table 1. Nipa palm (<i>Nypa fruticans</i>) observed in Trinidad and Tobago, W.I.				
Size Class*	Growth Stage	Height (m)	# of individuals (East Trinidad)	# of individuals (East Tobago)
S0	New Seedling**	<0.25	0	0
S1	Established Seedling	0.25–0.50	3	1
S2	Older Seedling	0.5–1.0	2	2
J3	Young Juvenile	1.0–2.0	1	1
J4	Older Juvenile	2.0–3.0	0	2
A5	Adult	>3.0	4	0
Total:			10	6
*Size class distribution was modified from Arneaud et al. 2017.				
**or propagule				

Tobago, only six individuals were located. In Trinidad, palms were observed in swampy areas; possibly due to a cut-off lake or abandoned channel left after the river meanders and the oxbow lake disappeared. In Tobago, palms were observed along a small water channel that shows no sign of meandering. While individuals from Trinidad produced inflorescences, they failed to make any fruit, as illustrated in Figures 2 and 3. The absence of seedlings near adult palms suggests that the population is incapable of natural regeneration. This leads to the hypothesis that population growth may depend solely on the introduction of new individuals through migration. Altogether, palms were observed approximately 25–50 meters from the shoreline. Numerous drupes and propagules were found along the coastline, all of which are expected to die due to unfavorable conditions (see iNaturalist observation 180842806 for reference).

Richardson et al. (2000) defined naturalized plants as “alien species that reproduce consistently and sustain populations over many life cycles without direct intervention by humans; they often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural, seminatural or human-made ecosystems.” From the present study, Trinidad and Tobago eastern coastal habitats are unfavorable for nipa palm establishment, possibly due to strong wave energy, few water channels and the lack of sheltered areas such as estuaries, lagoons, and mangrove forests. Although a systematic survey was not conducted during this study, there remains a possibility that nipa palms may exist in the southern and western parts of the islands. However, given the less

favorable conditions along these coastlines, this seems unlikely. Nevertheless, nipa palms cannot be considered “naturalized” in Trinidad and Tobago, since until now, no other stands have been identified by researchers or naturalists who have been searching over the decades (Bacon 2001, Arneaud et al. 2024a, Arneaud et al. 2024b). Nipa palms in Trinidad and Tobago are perhaps best described as “casual alien plants” (Richardson et al. 2000).

Further research should be conducted to monitor the growth of the nipa palm populations discovered in this study. By tracking their growth rates, potential pollinators, genetic diversity, reproduction success and distribution patterns, scientists can evaluate their ecological impacts (whether negligible, significant, or detrimental) and develop effective management strategies. This information will be invaluable for preserving the rich biodiversity of Trinidad and Tobago and by extension, ensuring the long-term sustainability of coastal ecosystems throughout the Caribbean region.

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A New Species of Fossil Palm Described for Australia

JOHN LESLIE DOWE¹

Palaeobotanists Prof. David Greenwood and Dr. John Conran have recently described a new species of fossil palm for Australia, *Phoenicites insula-lacuna*, from the Eocene or Miocene Island Lagoon fossil site in South Australia. The proposed affinity of the fossil is with the subtribe Archontophoenicinae, with a possible relationship to the extant genus *Archontophoenix*.

Compared to the northern hemisphere, there have been relatively fewer palm fossils identified and named from sites in Australia (Dransfield et al. 2008, Dowe 2010, Greenwood et al. 2022). Macrofossil specimens with affinities to palms include leaves and fruits from Tasmania named as *Nypa australis* Pole & McPhail, a stem portion from Queensland named as *Palmoxylon queenslandicum* Conran & Rosefelds, a fruit from Queensland informally identified as a species of *Cocos*, a stem portion from Western Australia placed informally in Coryphoideae and a leaf ascribed to *Linospadix* in Victoria (Conran et al. 2015).

To these can now be added *Phoenicites insula-lacuna* D.R.Greenw. & Conran, based on leaves from South Australia (Greenwood & Conran 2024). Microfossils of pollen have been described for all Australian states, but aligning them to extant palms has mostly not been formalized. It is possible that the apparent lack of macrofossils of palms in Australia is related to the lack of focused research rather than natural paucity. The palm fossils that have been described indicate that palms were a noticeable component of former vegetation assemblages across the continent at various times in the past and were representative of paleoclimates that suited palms.

The new species has been placed in the fossil morphogenus *Phoenicites* Brongn., which accounts for many palm leaf fossils with pinnate venation (Teodoridis et al. 2015). The genus was established in 1828 by Adolphe Brongniart for a fossil leaf found in France,

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1. Fossil named as *Phoenicites insula-lacuna*. Photo: J.G. Conran.

and fossils under that genus name have worldwide distribution. The specific epithet, *insula-lacuna*, is Latin for Island Lagoon in recognition of the fossil site on the north shore of the dry salt lake of that name.

The specimens of the newly described fossil palm were unearthed in about 1970 from the Island Lagoon fossil site in South Australia, which is about 435 km northeast of the capital Adelaide and 300 km southwest of Kati Thanda-Lake Eyre, Australia's lowest inland point at about 15 m below sea level. The area is in the arid zone, and the present vegetation is dominated by *Acacia* mulga and chenopod

saltbushes. Rainfall is highly variable averaging 150–200 mm per year. The major land forms within this region include sand plains, sand dunes, gibber flats, drainage systems, salt lakes and uplands. The site is a surface outcrop of silicified fluvial sediments of Eocene or Miocene origin. The fossil specimens are held in the South Australian Museum.

The presence of the palm fossils, and other fossils referred to *Angophora*, *Banksia*, *Callistemon*, *Eucalyptus* and *Melaleuca* found at and near the Island Lagoon site, suggests a formerly moister climate for that area, resembling extant subtropical moist sclero-



2. Leaf of *Archontophoenix alexandrae*, abaxial surface. Photo: J.L. Dowe.

phyll vegetation. In addition to the primary and most complete fossil (Fig. 1), there are fragmentary sections of leaflets in various states of preservation. The primary fossil displays the abaxial surface of an intact section of a pinnate leaf. For comparison, the abaxial view of a similar leaf section of *Archontophoenix alexandrae* is presented here (Fig. 2).

The alignment of fossil palm specimens with extant palms is a matter of subjective but educated judgment. The designation of the

Lagoon Island site specimens as progenitors or relatives of the Archontophoenicinae appears a reasonable proposition, with morphological similarity of the fossil with leaves of extant species of *Archontophoenix*. However, other extant genera and species also have a morphological similarity, but given the present distribution of *Archontophoenix*, it is logical to consider the closest phylogenetic relationship of the fossil may be with those that are geographically closest.

Acknowledgments

I thank David Greenwood for the discussion on palm fossils. The image was photographed by John Conran. The full paper is available open access at <https://doi.org/10.1080/08912963.2024.2403591>

All fossils in South Australia are protected under heritage legislation, and collection requires both a permit and landowner or leaseholder permission.

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A Population Assessment of Six Threatened Palm Species in Sainte Luce, Southeast Madagascar: A Glimmer of Hope?

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Palms (Arecaceae) represent critically important natural resources for rural communities across Madagascar. In Sainte Luce, southeast Madagascar, the palm community includes six threatened species. A systematic transect-based methodology was used to assess population size, demographic structure and distribution within five core forest fragments (1,180 ha). A total of 153,616 palms were recorded over 194.6 km. Only 1.9% were classified as adults, with three species being represented by <100 mature palms. Distribution was highly uneven and species-specific. Whilst the large number of immature palms offers hope for the future, several species are at serious risk of short-term extirpation.

Madagascar supports one of the world's most spectacular and diverse assemblages of palms, with 214 indigenous species recognised among

17 genera (Govaerts et al. 2020, Rakotoarinivo et al. 2022, Eiserhardt et al. 2022, RBG Kew 2024). All but four species are considered endemic (98.1%). Palms are ubiquitous across Madagascar, distributed from the most humid zones to the driest bioclimatic regions, from coastal sites to the coldest regions of the central highlands and the highest mountains (Rakotoarinivo et al. 2022). However, many species are now on the verge of extinction, as environmental degradation proceeds nationwide, and forests continue to disappear. An estimated 4.36 million hectares (25%) of

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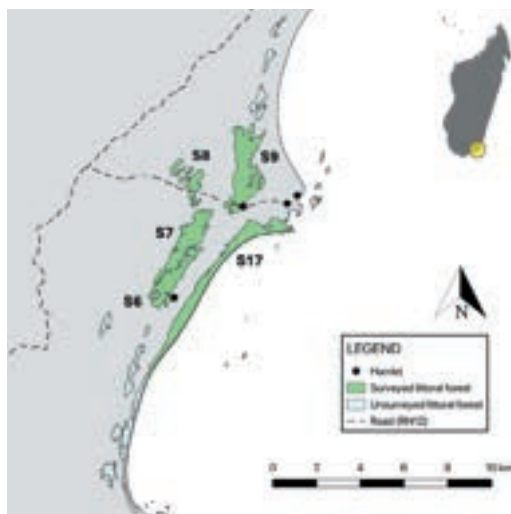
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Madagascar's forest cover was lost between 2001 and 2021 (Global Forest Watch 2022). Despite increased surveying efforts in recent decades, numerous palm species are still only known from single, often highly degraded localities, and many species appear to have extremely restricted ranges (Rakotoarinivo et al. 2022). This combination of extraordinary diversity and micro-endemism, coupled with precipitous ecological decline marks Madagascar as one of the world's highest conservation priorities (Myers et al. 2000).

Palms are undoubtedly one of the most useful plant families for humans (Bennet 2011, Rakotoarinivo et al. 2020), particularly in developing countries such as Madagascar, where they can have enormous economic and cultural significance (Dransfield & Beentje 1995, Antonelli et al. 2022). Unfortunately, palm harvesting is often fatal for the plant, and unsustainable harvesting can rapidly lead to population declines and local scarcity (Rakotoarinivo et al. 2022). As palms are generally slow to develop, the loss of mature individuals can have significant population level impacts. The latest IUCN (International Union for the Conservation of Nature) Red List assessment recognised 83% of described



1. Location of surveyed (S6, S7, S8, S9 and S17) and unsurveyed littoral forest fragments in Sainte Luce.

endemic palms on Madagascar as being threatened with extinction (IUCN 2024), a level four times higher than the global average for plants (Rakotoarinivo et al. 2014, RBG Kew 2016). At the same time, the Malagasy human population continues to increase at approximately 2.4% per annum (United

2. *Beccariophoenix madagascariensis*. Adult palm in vulnerable location beyond forest edge.





3. *Dypsis brevipaulis*.

Nations 2024) and with the majority of rural communities lacking adequate alternatives, it relies heavily on direct natural resource use. Thus, the true scale of the threat to palm diversity in Madagascar is perhaps not yet fully realised.

In Madagascar, littoral forests represent one of the most threatened ecosystems and are widely regarded as a national conservation priority (Ganzhorn et al. 2001, Consiglio et al. 2006, Hyde Roberts 2023). Distributed along the eastern seaboard, an estimated 90% of these coastal forests are already thought to have been lost (Green & Sussman 1990, Ingram & Dawson 2006). Today, the southeast Anosy region contains some of the best examples of littoral forest (Bollen & Donati 2006, Temple et al. 2012) and although fragmented, those in Sainte Luce are among the most intact. During early mining prospecting by QIT Madagascar Minerals, a series of intensive inventorying efforts served to demonstrate the area's exceptional floristic diversity and national importance (Lewis Environmental Consultants 1992, Dumetz 1999, Cadotte et al. 2002). Despite this, large tracts of land are currently slated for industrial ilmenite mining, with concessions overlapping sensitive littoral forest habitats.

As elsewhere in rural Madagascar, palms provide a critically important natural resource for the community. Approximately 2,600 people from Sainte Luce, as well as from other more peripheral communities, depend on local forests for the provision of natural resources associated with livelihoods, construction materials and firewood (Bollen & Donati 2006,

Hyde Roberts et al. 2020, SEED Madagascar 2021a).

Sainte Luce supports 13 species of palm, six of which are considered as being threatened with extinction by the IUCN: *Beccariophoenix madagascariensis* (Vulnerable), *Chrysalidocarpus prestonianus* (Vulnerable), *Chrysalidocarpus psammophilus* (Endangered), *Chrysalidocarpus saintlucei* (Endangered), *Dypsis brevipaulis* (Critically Endangered) and *Dypsis scottiana* (Vulnerable) (Rakotoarinivo & Dransfield 2012a, 2012b, 2012c, 2012d, 2012e, 2012f). Five of these are considered to be in decline with decreasing population trends, exhibit limited geographical ranges and are threatened by unsustainable harvesting practices and mining (Bollen & Donati 2006, Vincelette et al. 2007, Hyde Roberts et al. 2020). In contrast, no population trend data is available for *D. brevipaulis*. Five of these six threatened species are confirmed utilitarian plants (Hogg et al. 2013a). *Dypsis scottiana* trunks and the leaf rachises of *B. madagascariensis*, *C. prestonianus* and *C. saintlucei* are all harvested for use in the local spiny lobster fishery, the primary source of community income. The trunks of *C. prestonianus*, *C. psammophilus* and *D. scottiana* are also traditionally used for construction purposes (Hogg et al. 2013a). The palm heart (*tavolo*) of *C. saintlucei* was previously harvested during times of food insecurity; however, this practice appears to be uncommon now (Hogg et al. 2013a). There are currently no known uses for *D. brevipaulis* (Dransfield & Beentje 1995). This study aimed to provide a population-level assessment for all six threatened palm species in Sainte Luce, to understand better local pressures and to facilitate the development of conservation strategies.

Methods

Sainte Luce (also referred to as Ste. Luce and Manafiafy elsewhere) comprises 17 spatially clustered but disconnected littoral forest fragments, located approximately 50 km northeast of the regional capital Tolagnaro (Fort-Dauphin) (Fig. 1). Similar to other littoral forest habitats in the region (e.g., Mandena and Petriky), these forests fragments all exist within 5 km of the coastline, are restricted to low elevation (< 50 m) and are all distributed on top of mineral rich but nutrient poor sandy soils, interspersed with a matrix of savannah and marsh habitat (Lewis Environmental Consultants 1992). Average monthly temperatures range from 26.9°C in January to 20.3°C

in July (Temple et al. 2012). Rainfall in the southeast is highly variable but averages between 1500–2400 mm annually, with most rain concentrated between the months of November and April (Goodman et al. 1997, Ingram & Dawson 2006).

Several of the fragments in Sainte Luce are regarded as being in good condition relative to other littoral forests, although they have been subject to long-standing and on-going extractive processes. As a result, fragments vary in size and condition and consequently

4. *Dypsis scottiana*. Adult palm, flowering.



support differentiated and nested biota. This study was conducted across five core littoral forest fragments (S6, S7, S8, S9 and S17 – naming follows QIT Mineral Mining or QMM convention). Combined, these fragments represent the largest and most intact examples of littoral forest and cover some 1,180 hectares (ha). Today, a number of fragments (S8 and S9) are recognized as protected habitats (IUCN Cat. V), whilst others (S6 and S7) are considered community resource zones and are

experiencing intensive harvesting pressure. Fragment S17 comprises a small, protected area, a community resource zone and a large privately owned section. Some 12 of the 17 forest fragments in Sainte Luce exist within the projected mining footprint of QMM (QMM 2001, Temple et al. 2012).

A transect-based methodology was developed to assess populations of each of the six target taxa (*Beccariophoenix madagascariensis*, *Chrysa-*

5. *Chrysalidocarpus prestonianus*.





6. *Chrysalidocarpus psammophilus*.

lidocarpus prestonianus, *C. psammophilus*, *C. saintelucei*, *Dypsis brevipaulis* and *D. scottiana*). Study forest fragments were traversed by two groups of trained researchers simultaneously, with each group containing three recorders. Surveyors were positioned approximately 5 m apart, whilst groups were a minimum of 20 m apart to increase path width and to prevent double counting. Transects were walked East-West and West-East, from one forest edge to

the other using a compass for bearing (approximately 1 km/hour). Each perpendicular transect line proceeded 150 m north or south of the preceding survey line. Transects were repeated until each of the five forest fragments were completed (or as in S17, until private boundaries were reached). Surveys ran between October 2021 to February 2023. GIS tools were used to determine the area of forest surveyed.



7. *Chrysalidocarpus saintelupei*.

Palms were identified in situ and all individuals belonging to the six threatened species were recorded (Figs. 2–8). Life stage, geolocation and estimated height (m) were recorded for all adult palms. Juvenile and sub-adult palms were tallied over 30 m intervals due to high density in certain localities, with a GPS point recorded at the end of each interval. Sensitive locational data is not presented. Palm maturity was determined following descriptions by Hogg et al. (2013a) and local expert knowledge (Table 1).

Results

A total of 194.6 km of transect were surveyed (Table 2), resulting in an average forest

fragment coverage of 23.3% (min = S7: 15.9%, max = S8: 33.6%). A total of 153,616 palms belonging to the six target species were recorded (Table 3). Of these, some 98,267 (64.0%) were juvenile palms, 52,379 (34.1%) were considered sub-adult and 2,970 (1.9%) were deemed mature or adult. All species showed a consistent demographic trend, with large numbers of immature palms relative to fewer adult plants. Population sizes (including all life stages) varied considerably between species (lowest: *B. madagascariensis* $n = 756$ to highest: *D. scottiana* $n = 88,129$) and species distributions showed considerable spatial variation. The fewest number of observations were recorded in S17 (Andranangy), whilst the

Table 1. Description of palm maturity classes, based on descriptions for *C. saintelucei* by Hogg et al. (2013b) and adapted for use across all six palm species.

Life stage	Description
Juvenile	No visible trunk; early juveniles possess leaves with 2 or more leaflet pairs; leaves grow up to 2m in length in older juveniles.
Sub-adult	Development of a crownshaft and a short trunk; no visible signs of reproductive maturity; bark not yet established.
Adult	Visible signs of reproductive maturity (flowers/fruit); trunk is greater in height; bark is established.

most were recorded in protected area S9 (Agnalan’ ambandriky). Three species (*C. prestonianus*, *C. saintelucei* and *D. scottiana*) were observed in all five study fragments, whilst *D. brevicaulis* was only represented in the protected forest fragment S8 (Agnalavinaky). *Beccariophoenix madagascariensis* was present in four of the forest fragments, whilst *D. psammophilus* was only observed in three forest fragments.

The largest number of mature adult palm trees was found in the protected forest fragment S9 (n = 1,025), followed by the community resource fragment S7 (n = 983) and then the protected forest S8 (n = 824). The species with the largest proportion of adult palms different in each of these three fragments. In fragment S9, 66.8% of adult palms were *D. scottiana*, in S8, 46.4% of adult palms were *D. brevicaulis* and in S7, 59.4% of adult palms were *C. psammophilus*. Forest fragments S6 (n = 122) and S17 (n = 16) appear to support relatively few mature palms. The largest number of sub-adult palms was similarly recorded in forest fragments S7 (n = 17,805), S9 (n = 17,463) and S8 (n = 13,347), with far fewer observed in fragments S6 (n = 3,705) and S17 (n = 59). This trend is also reflected in the number of juvenile palm observations recorded (S9 = 36,040; S7 = 30,763; S8 = 23,042; S6 = 6,422 and S17 =

1,963). Species densities, proportional to the area of forest surveyed are provided in Table 4. Height profiles and relative comparisons between species are presented in Table 5 and Fig. 9.

Discussion

This census confirms anecdotal evidence that a number of palm species, commonly harvested and used by the local communities in the past, are now in serious danger of being lost from Sainte Luce. Notably, the three species *Beccariophoenix madagascariensis*, *Chrysalidocarpus prestonianus* and *Chrysalidocarpus saintelucei* are now represented by <100 mature individuals. The results of this census work also highlight important species-specific distributions that should be carefully considered and integrated into local future conservation management and development schemes. Further, we identify an interesting demographic phenomenon whereby although most species are well represented at immature life stages, few palms appear to be reaching maturity. Our results show that all six focal species are currently represented in the protected forest fragments (S8 and S9), with fragment S8 being particularly rich and therefore important from a conservation perspective. Forest fragment S17, despite being

Table 2. Study area and survey effort descriptors.

Fragment (Vernacular)	Designation	Area (Ha)	Effort (km)	Fragment Coverage (%)	Forest Status
Etazo	S6	162	22.7	20.8	Community resource zone
Ambondro	S7	221	42.8	25.8	Community resource zone
Agnalavinaky	S8	86	26.2	33.6	Conservation zone
Agnalan’ ambandriky	S9	346	57.2	20.5	Conservation zone
Andranangy	S17	365	45.7	15.9	Conservation zone

Table 3. Demographic data for the six threatened species of palm in Sainte Luce.

Species	Life stage	Forest Fragment					Total
		S6	S7	S8	S9	S17	
<i>Beccariophonix madagacariensis</i>	Juvenile	34	41	390	4	0	469
	Sub-adult	62	1	180	0	0	243
	Adult	11	8	23	2	0	44
	Total	107	50	593	6	0	756
<i>Chrysalidocarpus prestonianus</i>	Juvenile	928	1330	29	5414	1807	9508
	Sub-adult	1	11	2	137	13	164
	Adult	0	1	2	67	13	83
	Total	929	1342	33	5618	1833	9755
<i>Chrysalidocarpus psammophilus</i>	Juvenile	0	10,084	8904	5593	0	24,581
	Sub-adult	0	6614	5490	2634	0	14,738
	Adult	0	584	251	269	0	1104
	Total	0	17,282	14,645	8496	0	40,423
<i>Chrysalidocarpus saintelupei</i>	Juvenile	181	4026	3152	2396	55	9747
	Sub-adult	2	463	49	37	0	551
	Adult	6	22	10	2	0	40
	Total	126	4511	3211	2435	55	10,338
<i>Dypsis brevicaulis</i>	Juvenile	0	0	2381	0	0	2381
	Sub-adult	0	0	1452	0	0	1452
	Adult	0	0	382	0	0	382
	Total	0	0	4215	0	0	4215
<i>Dypsis scottiana</i>	Juvenile	5342	15,282	8186	22,633	101	51,581
	Sub-adult	3640	10,716	6174	14,655	46	35,231
	Adult	105	368	156	685	3	1317
	Total	9087	26,376	14,516	38,000	150	88,129
Total		10,249	49,561	37,213	54,555	2038	153,616

*Values represent numbers of individual palms recorded.

relatively intact, appears unfavourable for most species, likely due to its coastal location and strong marine influence.

Whilst we acknowledge that this census does not represent the entirety of the Sainte Luce littoral forest habitat, focusing on just five of the 17 forest fragments, these five fragments are by far the largest and most intact examples remaining. Additional individuals are likely to exist in the wider landscape; however, many of the unsurveyed fragments are either extremely small (< 10 ha), highly degraded or both (e.g., S1 and S2). Since palms represent important community resources (Hogg et al. 2013a), it may be assumed that these threatened species may be scarce in the wider

landscape. Thus, we feel that these selected forest fragments are representative of the Sainte Luce habitat in general and portray an accurate account of the target species' populations. However, given the non-uniform distribution of the focal species, further surveying in these fragments may yield important findings, particularly since all of the unsurveyed fragments exist within the proposed mining footprint (Temple et al. 2012). Whilst our survey effort was high, evidently the number of juvenile and sub-adult palms recorded in this work are substantial underestimates (based on forest fragment coverage). In contrast, the number of adult palms recorded in this census likely represent

Table 4. Density for the six threatened species of palm in Sainte Luce.

Species	Life stage	Density per hectare (ha)				
		S6	S7	S8	S9	S17
<i>Beccariophonix madagacariensis</i>	Juvenile	1.0	0.7	13.5	0.1	0.0
	Sub-adult	1.8	0.0	6.2	0.0	0.0
	Adult	0.1	0.0	0.3	0.0	0.0
<i>Chrysalidocarpus prestonianus</i>	Juvenile	27.5	23.3	1.0	76.4	31.2
	Sub-adult	0.0	0.2	0.1	0.2	2.8
	Adult	0.0	0.0	0.0	0.8	0.0
<i>Chrysalidocarpus psammophilus</i>	Juvenile	0.0	176.9	308.1	78.9	0.0
	Sub-adult	0.0	116.0	91.1	37.2	0.0
	Adult	0.0	2.6	2.9	0.8	0.0
<i>Chrysalidocarpus saintelupei</i>	Juvenile	3.5	70.6	109.1	33.8	0.9
	Sub-adult	0.1	8.1	1.7	0.5	0.0
	Adult	0.0	1.0	0.1	0.0	0.0
<i>Dypsis brevicaulis</i>	Juvenile	0.0	0.0	82.4	0.0	0.0
	Sub-adult	0.0	0.0	50.2	0.0	0.0
	Adult	0.0	0.0	4.4	0.0	0.0
<i>Dypsis scottiana</i>	Juvenile	158.5	268.1	283.3	319.2	1.7
	Sub-adult	108.0	188.0	213.6	206.7	0.8
	Adult	0.6	1.7	1.8	2.0	0.4

*Densities derived from the area of forest surveyed.

more accurate values, given that efforts were made to record all known individuals, including those beyond the transect lines.

This census recorded a total of 4,215 *D. brevicaulis* palms, including 382 adults, all of which were observed in the protected forest fragment S8 and its adjoining forest remnants. The last IUCN Red List assessment of *D. brevicaulis*, made in 2010, recorded a total of only 40 adult individuals (Rakotoarinivo & Dransfield 2012e). Given its small population size, highly restricted distribution and range of localised threats (habitat loss and mining), the species was classified as Critically Endangered (Rakotoarinivo & Dransfield 2012e). Given that only a single adult palm is known from a second locality beyond Sainte Luce (Dransfield & Rakotoarinivo 2012), S8 clearly represents the most important locality for this species. Despite recording additional adult individuals and several thousand immature palms during this work, the adult population in Sainte Luce remains small and highly clustered, and therefore vulnerable.

The low number of mature *C. saintelupei* ($n = 40$) observed during this study emphasizes the critical status and decline of the species locally. Some 147 adult palms were recorded during an initial census (Hogg et al. 2013b) in the same forest fragments in 2011, and these numbers had already dropped to 65 adults by 2018 (Hyde Roberts et al. 2020). All previously recorded plants that were alive in 2018 were revisited during this project, and only 40 individuals were found alive. Thus, there has been a 38.5% reduction in the number of remaining mature palms over a period of five years and a 72.8% decline over the past twelve years. Whilst this species is now known from other localities on the east coast, its persistence in Sainte Luce must be considered greatly threatened. Furthermore, the majority of the mature palms (70.0%) occur within the footprint of the QMM mining zone, whilst only 12 persist inside the protected areas. Since the last census in 2018, four mature palms (25.0%) have been lost from the protected areas, indicating that these protections may

Table 5. Summary descriptors of adult palm height (m) for the six threatened study species.						
Species	N	Mean	Median	Mode	Min	Max
<i>B. madagascariensis</i>	44	9.68	10.00	10.00	7.00	12.00
<i>C. prestonianus</i>	83	13.51	14.00	15.00	3.00	22.00
<i>C. psammophilus</i>	1104	6.75	7.00	7.00	2.00	12.00
<i>C. saintelucei</i>	40	11.81	12.00	14.00	5.00	17.00
<i>D. brevicaulis</i>	382	1.54	1.50	1.50	0.50	3.00
<i>D. scottiana</i>	1317	3.28	3.00	2.00	0.80	10.00

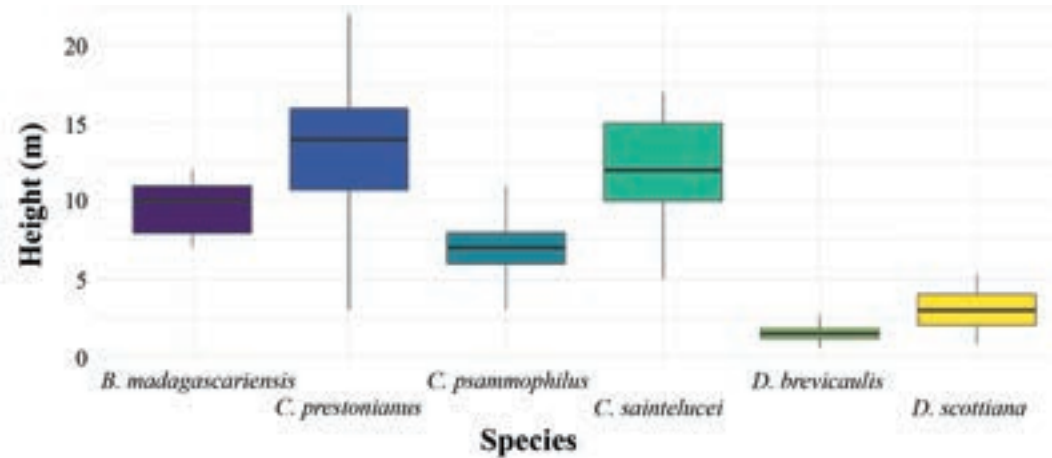
not be sufficient to sustain the existing adult population long-term. Optimistically, the current study identified several thousand immature palms within the protected areas, however it is unclear what percentage of these will survive to maturity and what factors beyond harvesting, may limit development. Only 0.39% of all *C. saintelucei* individuals recorded during this study were classified as mature.

This study recorded a total of 44 mature *B. madagascariensis* palms, four fewer than was recorded during the previous study (n = 48) (Hyde Roberts et al. 2020). Notably, *B. madagascariensis* was the rarest of the six focal species of the census, with less than 1,000 individuals in total (n = 756). Of the mature palms, 25 (56.8%) were found within the protected area forest fragments S8 and S9, with most in S8 (n = 23). During the 2018 census, 28 individuals were reported from S8, again potentially indicating that some harvesting is continuing inside the protected forests. Whilst the community resource forests (S6 and S7) still harbour small numbers of *B. madagascariensis*, these are ultimately situated

within the projected mining path and so have an uncertain future. Whilst the decline in this species is not as precipitous as that observed for *C. saintelucei*, it remains extremely vulnerable to unsustainable harvesting, agricultural expansion (several individuals now exist on or outside of the sharp forest boundary) and mining.

Similar to *C. saintelucei*, the number of mature *C. prestonianus* palms (0.85%) is low relative to the number of immature palms. Whilst the total number of recorded adults is extremely low (n = 83) and the species is clearly threatened in Sainte Luce, the vast majority of mature palms (98.8%) were recorded from inside the protected areas S8 (2.4%), S9 (80.7%) and the coastal forest fragment S17 (15.6%). Forest fragments S9 and S17 also support the greatest number of immature palms, providing some cause for optimism for species persistence long-term. Similarly, both *C. psammophilus* and *D. scottiana* are relatively well represented across Sainte Luce (particularly *D. scottiana*, which is present in all surveyed forest fragments) and both species remain present in the main protected areas (S8 and S9). *Dypsis*

9. Estimated height profiles (m) of the six focal palm species (adults).



scottiana was by far the most abundant species encountered during the census, comprising 73.4% of all observations. Whilst this species is harvested regularly by local communities, its smaller size and faster development likely translates to a more resilient population. However, fewer than 1,500 adults were recorded across the five fragments, suggesting that harvesting pressure is high and efforts to monitor this important utilitarian species should be considered. Both *C. psammophilus* and *D. scottiana* presently maintain important populations in the community resource fragment S7.

The low relative abundance of mature palms compared to immature palms is consistent for each of the six focal species in our study. Similar demographic patterns are reported elsewhere (Youlton et al. 2016), suggesting this is a typical, intrinsic demographic phenomenon linked to fecundity and mortality patterns. However, it appears to be particularly extreme in the cases of *C. prestonianus*, *C. saintelupei* and *D. scottiana*, where mature palms represent less than 1.5% of recorded individuals. It is well documented that palms provide important natural resources for local communities (Dransfield & Beentje 1995, Hogg et al. 2013a, Antonelli et al. 2022), even at immature life stages, making them vulnerable to exploitation and unsustainable harvesting. In Sainte Luce, some 94% of households rely on lobster fishing as a primary source of income (SEED Madagascar 2021b), a sector that is heavily reliant on palms, and predominantly juvenile palms, for the manufacture of lobster pots. Whilst adult palms from all species are evidently being harvested by surrounding communities for use as construction materials, juvenile palms associated with the fishery are seemingly being harvested at a more substantial rate, with significant impacts on demographic structure. Crucially however, important natural history information such as survivorship is still lacking for the majority of palm species

Ultimately, a combination of consistent harvesting pressure, across all life stages, combined with a slow developmental schedule, appears to be driving population declines. This constitutes a problem since the standard approach to conserve and bolster wild palm populations is to collect and germinate seeds in a nursery before transplanting the young palms back out into appropriate forested area in large numbers. However, given the existing number of immature palms

already present, a new approach is evidently required. Protection and monitoring of adult and sub-adult palms may provide a potential solution, in conjunction with a moratorium or quota-based system for harvesting specific species. Implemented at the community level, backed with sufficient evidence and sensitivity, such an approach could prove effective in the long-term.

Conclusion

The findings of this study confirm that all six threatened palm species are represented by low numbers of mature individuals in Sainte Luce, with three species (*B. madagascariensis*, *C. prestonianus* and *C. saintelupei*) having fewer than 100 mature palms remaining and a fourth (*D. brevicaulis*) with fewer than 400 individuals. The two species for which temporal data is available (*B. madagascariensis* and *C. saintelupei*) both show serious and rapid population declines. Demographic trends for the other species are not yet discernible but may also show decline given the extent of habitat loss, natural resource use and increasing human demands. Given that population size is generally based on the number of mature individuals within an area, it is clear that at least three of the focal species are seriously imperilled in Sainte Luce and face extirpation. Yet, the relatively high number of immature palms, particularly in the protected forest fragments S8 and S9, offers a glimmer of hope.

Ultimately, the effectiveness of the designated protected areas and collaboration with community resource users will determine the future of palm diversity in Sainte Luce. However, a recent series of community focus groups (SEED Madagascar 2024) consistently reported that people have begun to disregard forest protections and enter the protected forest fragments in search of resources as they become scarcer in the community resource zones. This pressure on the protected areas can only be expected to increase post mining, with the anticipated loss of the two largest community resource zones (S6 and S7) during the exploitation process. Thus, there is evidently a pressing need for conservation practitioners to work with both community members and industry to determine how best to meet future community needs whilst also ensuring the protection of the palm populations.

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Palm Profile

Palmiche (*Sabal mexicana*) in Guanacaste, Costa Rica



1. In Guanacaste, the name *palmiche* refers to a palm (*Sabal mexicana*) commonly found in the grasslands and dry forests of the province.

This profile is based on observations made by the author in the rural communities of Ortega and Bolsón, located in the Canton of Santa Cruz, Guanacaste Province, Costa Rica, in April 2018. In the Guanacasteco dialect of Spanish, *palmiche* refers to a palm (*Sabal mexicana* Mart.) found throughout the region's dry forests (Fig. 1). This palm is a significant but overlooked part of the region's biodiversity.

Despite Guanacaste's rich tradition of palm use, the presence of *Sabal* in the region remains largely unexamined in botanical literature (e.g., Uhl & Dransfield 1987, Zona, 1990, Henderson, Galeano, Bernal 1995). There are, however, brief mentions of *Sabal* in Costa Rica, including the *palma de sombreros*, recorded as

“half-cultivated near the dwellings of the people of the Pacific coast... unknown in Costa Rica in a wild state... employed for making every-day hats” in the early 20th century (Standley 1937: 126).

Specific references to *Sabal* in Costa Rica are limited to *S. mauritiiformis* (POWO 2025). Additionally, Tropicos lists only two records of *Sabal* in Costa Rica, *S. mauritiiformis* and *Sabal* indet. (2025). The latter is perhaps *S. mexicana*, with a distribution known to extend from the southern United States to Nicaragua. Until now, *Sabal mexicana* has not been reported in Costa Rica. However, the province of Guanacaste is bordered to the north by Nicaragua, and the presence of *S. mexicana* in



2. The leaf bases of *palmiches* lend a distinctive appearance to their stems, though, with age, these features can disappear as with this exceptionally mature individual, which measured just over 12 meters in height.

this province is not surprising. The Canton of Santa Cruz is merely 120 kilometers away from the Costa Rica-Nicaragua border. In contrast to *Sabal mexicana*, *S. mauritiiformis* has been observed in the provinces of Puntarenas and Limón (GBIF 2025). The two species can be

distinguished by their reproductive and vegetative characteristics. The strongly costapalmate and filiferous leaves, along with the inflorescence, branched to three orders, are characteristic of *S. mexicana* and distinguish it from *S. mauritiiformis*, whose



3. Detail of a *palmiche*-roofed *rancho*. If well-made, these structures are waterproof and can last for several years.

inflorescence is branched to four orders. Other characteristics observed in the field, such as buoyant fruits and mature reproductive individuals without aerial stems, further support this identification (see Zona 1990).

Palmiches are often found along the margins of fields and forests. In environments with heavy canopy cover, stem development can be stifled, leading to individuals that appear acaulescent even into reproductive maturity. When forests are cleared for agriculture or in locations such as the borders of fields and forests, abundant sunlight allows for stem development. These stems can appear with or without persistent leaf bases, a feature that

typically diminishes with age (Fig. 2). Mature *palmiches*, ranging from less than a meter to 12 meters in height, are typically found in less disturbed areas. Local fauna, such as pigs, turkeys, ducks, and raccoons, consume its fruits. Its large fronds provide cover for wasp nests, which take advantage of the shade and pollinate its flowers in return (pers. obs.).

Historically, *palmiche* fronds were the primary material used to construct *ranchos*, small wooden structures covered with palm thatching (Fig. 3). This practice has declined since the late 20th century, and modern materials like corrugated metal sheets have almost entirely replaced traditional roofing.



4. *Chutiles*, or the young emergent fronds of *palmiche*, can be woven and fashioned into various goods, including hats (left and center) and plates (right), among other domestic items for the tourist market.

However, a local company does cultivate *palmiche* to make palm-thatched roofs, especially for the tourist industry. Along the Ruta Nacional Terciaria 920, as it passes towards Ortega, lives the artisan Don Machena Rosales, who continues to craft with *palmiche*. He uses juvenile emergent fronds, known locally as *chutiles*, collected from uncultivated *palmiches* to create goods like *sombreros* (hats), *hueveras* (egg holders), and *canastas* (baskets) that are primarily sold to tourists (Fig. 4). The origin of the term *chutil* can be traced back to the Nahuatl *xochitl* (flower) and denotes shoots or flower buds in the local dialect (Agüero Cháves 1996, Tulio Gardela 2001).

A demographic survey (n=860) of *palmiches* across five sites in Bolsón and Ortega, along with one site in the nearby community of Santa Bárbara, revealed that juveniles, including seedlings, comprised 90% of the population. In contrast, only 89 palms were reproductively mature, with most falling into smaller height classes (0.5–2.5 meters). Very few exceeded 6 meters. This skewed size distribution raises questions about seedling recruitment. The steep decline in larger-sized individuals could result from anthropogenic disturbances or poor light availability, as *palmiche* is often found in the understory of dry forests. Local *palmiche* populations are shaped by traditional land-use practices, like slash-and-burn agriculture, though *palmiche* does display some level of fire tolerance. However, this resilience may not be enough to counter the threats posed by agricultural expansion and urban development. These factors could significantly impact population

size and the traditional knowledge of *palmiche*'s use. Therefore, further studies are crucial to understand the historical and contemporary presence of *palmiche* in Guanacasteco life, encourage its conservation, and support the communities living alongside it.

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Jack B. Fisher (1943–2024)



Last October, Jack Fisher lost his battle with Parkinson's disease. Among his friends and colleagues, he will be remembered as a gentle, kind man, who was always willing to help other researchers in their exploration of the botanical world. Among the botanical community at large, he will be remembered for his many contributions to our understanding of tropical plant anatomy and morphology.

A native of New York City, Jack obtained his B.S and M.S. at Cornell University and his Ph.D. from the University of California at Davis. His post-doc at Fairchild Tropical Botanic Garden morphed into a permanent position, which he held until his retirement in 2009. Jack was that rarity in academia: a scientist who spent his entire career at one institution. For over 30 years, Jack studied plant morphology and anatomy, taking

advantage of a ready source of subjects from FTBG's living collections of palms and other tropical plants. Readers of this journal will recognize Jack's name from his contributions to studies of propagating Lethal Yellowing-free coconut palms via tissue culture, the effects of growth hormones on coconut palms, the flowering of *Corypha umbraculifera* (estimating that it bore 24 million flowers!), arbuscular mycorrhizae on native Florida palms and branching in *Nypa*. Jack and collaborators also studied several unusual features of calamoid palms. They elucidated the extraordinary fusion of inflorescences to stems and leaf sheaths in rattans, where the inflorescence base appears to be attached eccentrically to the leaf sheath of the following leaf due to the early "capture" of the inflorescence primordium as the stem rapidly elongates. They also described the strange morphology and development in *Salacca* where inflorescence buds are "captured" by the sheath of the subtending leaf and ultimately break through the back of the subtending leaf at maturity, a bizarre arrangement thought initially to be unique to *Salacca* but subsequently shown also to occur in *Kerriodoxa*. Jack and associates investigated vessel element length in rattans by allowing cut rattan stems to take up dilute latex paint. The latex particles are small enough to be taken into the vessels but not small enough to pass from one vessel to another. By carefully cutting thin sections from the rattan, Jack could see where the latex stopped and measure the extraordinary length of the vessels. Before he retired, he co-authored *The Anatomy of Palms* (Oxford University Press, 2011) with Barry Tomlinson and Jay Horn.

His interest in the anatomy of climbing plants extended beyond the palm family. Jack produced numerous publications on lianas, including vessel length, wound healing, and fiber distribution. He collaborated with botanists from around the world, and in 2003,

for his many contributions to botany, he was recognized as a Distinguished Fellow of the Botanical Society of America, the highest honor the BSA bestows.

Jack had a particular knack for turning problems into opportunities. In the 1980s, when LY was devastating palms in South Florida, Jack used his skills to study the anatomical symptoms of the disease. In 1992, when Hurricane Andrew felled hundreds of palms and tropical trees in FTBG, Jack collected and preserved hundreds of palm specimens. Through his contacts in the woodworking world (Jack was an accomplished wood-turner), he arranged for the fallen trees to be milled into exotic lumber that was auctioned to eager collectors. Some of the wood was given to artists and used in works that were displayed at Fairchild for many years.

Our memories of Jack are not for his many publications but as a colleague and friend. Jack generously allowed one of us (SZ) to use the equipment in his lab for anatomical studies of palms and was always ready to help decode a morphological term or decipher an anatomical structure. In 2005, in the aftermath of Hurricanes Katrina, Rita and Wilma, Jack gave SZ his first lessons in using a chainsaw to dissect fallen palms. Although by nature a soft-spoken man, Jack had a hidden talent: He could imitate the raucous vocalizations of peacocks and call them to him.

Upon retirement, Jack and his wife, Karen, moved to Ferndale, Washington, where he enjoyed gardening, wood-turning and bee-keeping. He will be remembered for his extraordinary work in tropical botany, especially palms, and his grace and dignity in the face of a devastating disease. He will be much missed.

SCOTT ZONA & JOHN DRANSFIELD

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